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Special Issue

ISSUE No. 3

IN THIS ISSUE:

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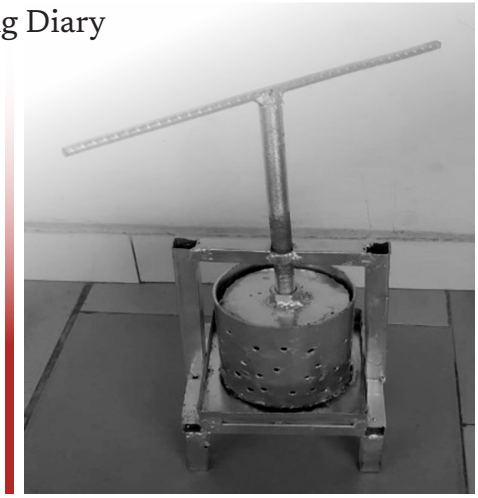

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Editor's Note

I am beyond thrilled to have been appointed the new Editor-in-Chief for the Ashesi SEED Journal. After attentively following the release of the first 2 amazing issues, I have been motivated to carry on this honorable task of providing a medium for researchers and inventors, to showcase their ground-breaking work. It's true what they say, "The days are long...but the years are short." During each long day of 2022, scientists, engineers, entrepreneurs, and designers, were faced with challenges, and they decided to rise above them by finding commendable solutions to their problems. My team and I are honored to present to you (drumroll please)...The 3rd SEED Journal Issue! The year 2022 did come quickly, but we are slowing down the clock to appreciate the special innovations that have taken place. This features a profile of two of the inaugural Ashesi Capstone Award winners, the Ashesi International Genetically Engineered Machine (iGEM) team's successful trip to Paris – and their stellar performance amongst reputable schools such as: Cornell, Harvard, and Yale. We will also provide you with some personal interviews from world-class entrepreneurs and innovators, from Ashesi University and the University of Ghana. The scientific articles – centered on biomedical engineering, IoT, and more – are certainly the icing on the cake. Enjoy it cherished readers!

This issue promises to be exciting, informative, and remarkable.

"Even if the days appear long...I believe that anything worthwhile takes time...and when the time comes, and you have remained true to yourself, it will be a satisfying end."

Editor-in-Chief
Michael A. Boateng

Contributors' Notes

David Asante-Asare
Editor, SEED Journal

Africa has an enormous amount of untapped potential. Yet, for varied reasons, this potential remains untapped. Thus, how can the Africa we envision come to fruition if our capabilities remain unexplored? The SEED Journal was therefore established to promote exceptional African research across varying fields of science and technology. This 3rd issue is the epitome of the exceptional capabilities of young African researchers. From the journal topics on the Design and Implementation of an Automatic Pet Feeder to the Automatic Diagnostics of COVID-19 using Deep Learning, steps have been taken in the right direction to ensure Africa's contribution to the world's pool of knowledge. This 3rd issue also brings to light young entrepreneurs with rapidly growing startups, such as *Yonkopa Park, Trestle Academy, Sokolata, and AIY.*

To think that these were all from the undergraduate level is just mind-blowing. I can promise that every single paper and entrepreneur interview will stir an unending desire for research and innovation. Enjoy your journey as you walk through the minds of these authors and entrepreneurs in this 3rd issue.

Elena Rosca (PhD)
Faculty Reviewer

Dear Students, Faculty, Staff, and Ashesi. Community,

I hope this note finds you well and healthy. We made it through a year of readjustment back to in-person interactions. Really excited to be able to have discussions over a cup of coffee, or a plate of Red Red 😊.

We have collected great work from students and our community over the past year, and we hope you are just as excited as we are to read some of the exceptional work our community is creating. We have endeavoured to solve community problems, such as designing a sustainable water pump for our neighbouring Berekuso community; or investigating the application of Natural Language Processing technologies in Africa. We even stretched to investigate the Design of IOT-based wearable electrocardiograms, amongst many others.

My utmost gratitude goes to our team, who has worked very hard on this issue, especially to our Chief Editor, Michael Boateng, for his extraordinary determination and great work and motivator–the most heartfelt thanks to all our faculty reviewers and to the Writing Center, who worked with the students to perfect their writing.

I hope you will enjoy this issue and find it interesting, stimulating, and valuable. Also, please allow me to CONGRATULATE all our graduating seniors and wish them all the best in their future endeavours!

"Research is formalised curiosity; it is poking and prying with a purpose." and some of those endeavours are captured in this issue. Please enjoy...

By
Daniel Amoshie, Marshall Dzwene, Munashe Nyazenga and Simbarashe Tanyanyiwa

Design, Fabrication and Testing of a Torsional Compression Thread-based Gari Screw-type Press

ABSTRACT

Gari is a popular type of food in Africa obtained from the dry frying of dewatered cassava pulp. Unfortunately, small scale Gari producers in Africa are hampered by adoption of inefficient and inappropriate pressing methods. This delays Gari production and results in low quality products. The purpose of this study is to design, fabricate, and test a torsional thread-based cassava pulp mechanical dewatering screw press which will provide a cheaper way of pressing cassava compared to the modern methods which are too expensive for the ordinary farmer due to the complexities involved in their processes and the components used in manufacturing them. The aim is to make a more hygienic system by enclosing the cassava pulp in a confined cylindrical space and providing a way of trapping the liquid emanating from the compressed cassava pulp during pressing. The screw will make it easy to drive and press the cassava pulp. The research also gives details of the manufacturing processes, tools, materials, that will be used if the product is fabricated. Cassava was not utilized in the testing process, rather, a wet napkin to test the pressing mechanism by reducing its moisture content. It was found that the machine could dewater 2 kg wet a napkin with 70 % to 15 % moisture in about 3 minutes. The maximum stress reported on the screw shaft handle was 2.773 ×107 N/m2 which was less than the yield strength of the material used for the simulation.

Keywords: *Dewatering, Cassava, Press, Gari, Torsional, Ferritic*

1. INTRODUCTION

Gari, the most commercialized cassava product in Ghana, continues to increase in production due to the increasing urban demand and export market potential [1]. Cassava is a plant that originated in South America but is now grown in most African countries [2]. Small-scale Gari processing methods in Ghana are primarily traditional, leading to a limited range of finished products from cassava [3].

Old and inefficient local gari pressing methods are time-consuming (taking up to 4 days or more), less hygienic, and result in poor/low product yields. Existing methods need to ensure product quality consistency or scale economies [3].

Current dewatering operation is mainly carried out manually in rural communities. One of the approaches is a "twisting sack to effect dewatering" method, where the wet cassava mash is placed in a porous sack and manually twisted to squeeze out the excess water [4]. Another approach is placing a "heavy stone on top of mash sack," where wet cassava mash is put inside a porous sack, and a heavy stone is placed on top of the sack to press out the excess water [4]. These methods are labor-intensive and time-consuming, especially for large-scale production.

Additionally, modern methods are too expensive for the ordinary farmer due to the complexities involved in their processes and the components used in manufacturing them. An example is the design and fabrication of an electric motor driven press (cassava dewatering machine) by O.P. Akinmolayan et., which uses an electric motor and a screw press where cassava mash is fed into a hopper, and the screw press applies pressure to the mash, forcing the water out through the perforations on the press. The narrow range of processed products and poor processing technologies could also affect the commercialization of the crop in Africa [3].

Based on the challenges with current approach to gari dewatering, this project therefore aims to design, fabricate, a mechanical gari dewatering system which will provide a cheaper way of processing cassava. Another goal is to create a more sanitary system by enclosing the cassava in a confined cylindrical space and providing a method of trapping the liquid emitted from the compressed cassava pulp during pressing to make the whole process more hygienic. The research gives details of the manufacturing processes, tools, materials, that will be used if the product was to be fabricated. Cassava was not utilized in the testing process, rather a wet napkin to test the pressing mechanism by reducing its moisture content.

2. EQUIPMENT AND METHODS

One of the top priorities of this research study was to identify the best material for making the gari press. Several factors were considered when deciding on the materials that will be used to construct the gari press. Such factors include mechanical strength, corrosion resistance, impact resistance, and cost.

2.1. EQUIPMENT

In this study, SolidWorks 2019, was used to design and perform mechanical analyses on the desired solution concept. The scrap materials used in making the low fidelity prototype of the desired solution concept were obtained from Kumasi, Ghana. Microsoft Excel was used to plot graphs the collected data, for further analysis.

2.1. METHODS

2.1.1. BRAINSTORMING

Several solution ideas were generated during a brainstorming session to address a problem. Sketches were drawn to conceptualize the designs. Four design ideas were presented. The first design idea was a hydraulic jack gari press, which would use a hydraulic cylinder on a sliding piston to force liquid out of cassava pulp as shown in Figure 1a. The second design was an electric motor drive press, which would lower a pressing lid slowly to press liquid out of the cassava pulp using an electric motor and gear as shown Figure 1b. The third design was a torsional compression thread based gari screw-type press, which would use a thread connected to a handle to press cassava pulp and force liquid out through perforated holes as shown in Figure 1c. The fourth design was a centrifugal press, which would rotate cassava pulp at high speed to separate it from liquid using centrifugation shown in Figure 1d.

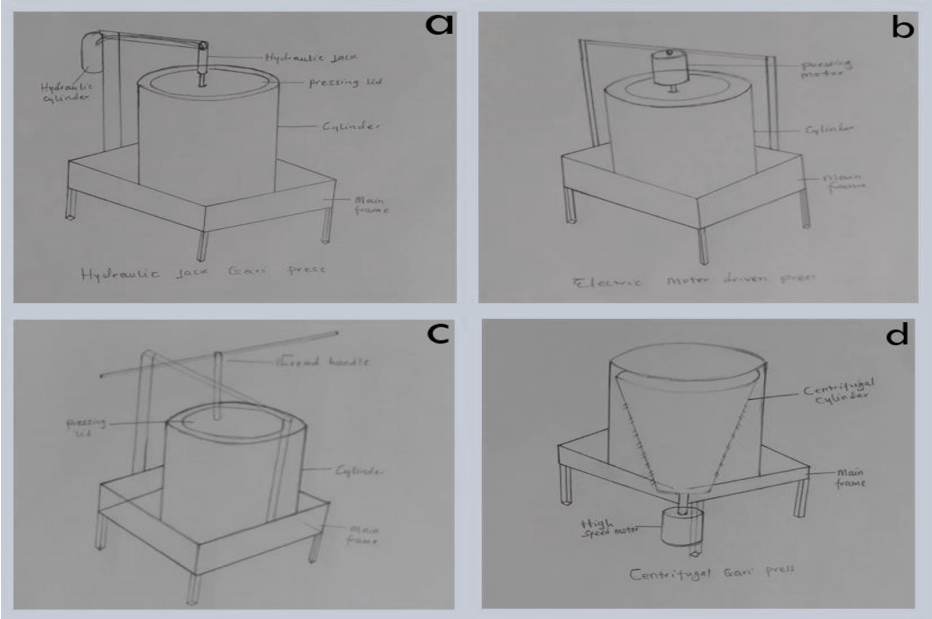

Figure 1*: (a, b, c, d) show the four sketches of the design solution ideas for the identified problem (hydraulic jack gari press, electric motor driven press, torsional compression thread based Gari Screw-type Press, centrifugal press)*

2.1.2. SELECTION

After evaluating the different concepts from the brainstorming session, a torsional compression thread based Gari Screw-type press was selected the final design solution. This design was chosen for its numerous benefits. Firstly, this type of press applies torsional force to compress the cassava pulp, which is highly effective in removing excess water and ensuring high-quality Gari. Secondly, the screw-type press allows the cassava pulp to be confined in a cylindrical space during pressing, resulting in a more hygienic process that reduces the risk of contamination. The screw also simplifies the process of driving and pressing the cassava pulp, which is important for small-scale Gari producers.

Furthermore, the torsional compression thread-based Gari screw-type press is more cost-effective than modern methods that involve complex processes and expensive components. This makes it a more viable option for small-scale Gari producers in Africa who may have limited financial resources. In summary, the torsional compression thread-based Gari screw-type press is the best design for Gari dewatering due to its effectiveness, hygiene, ease of use, and cost-effectiveness.

The prototype was designed to take a load of about 20KN. Since load is transmitted under compression, the screw was made from Ferritic Stainless steel with yield stress of 200 N/mm. The screw was subjected to the equation given by,

$$Load\ (W) = \frac{A_s \times \delta_y}{F\ S}$$

Where W is load, As is the area of screw, δ_y is yield stress and F Sis the factor of safety.

$$20000 = \frac{\pi\ d_s^2 \times 200}{4 \times 2}\ at\ F\ S = 2$$

$$d_s = 15.96mm$$

This informed the choice of screw diameter for building.

2.1.3. SOLIDWORKS ENGINEERING DESIGN

2.1.3.1. 3D ISOMETRIC

As mentioned earlier, SolidWorks 2019, was used to design the torsional compression thread based Gari Screw-type press. The SolidWorks design is shown in Figure 2 below.

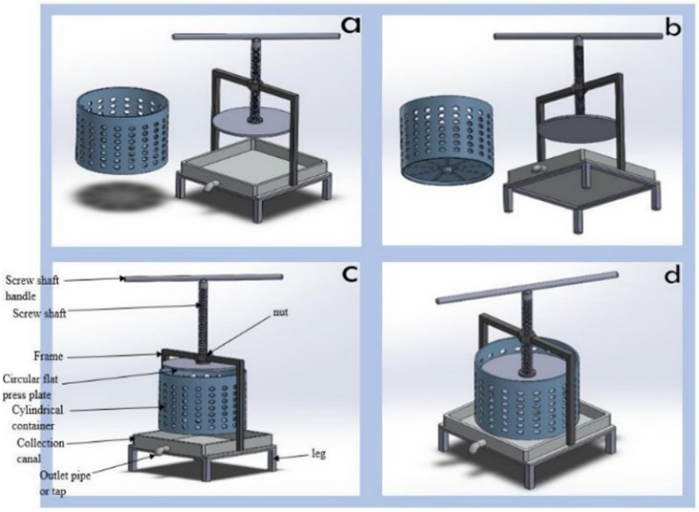

***Figure 2**: Shows the SolidWorks Design of the Gari Press (a-b) 3D Views of the Different Components of the Press (c) Exploded View of the Gari Press (d) Fully Assembled Gari Press*

2.1.3.2 THIRD ANGLE AUTOGRAPHIC VIEW

The fully assembled SolidWorks Design of the Gari Press by dimension (See Figure 2), can be put in a box with a vertical height of 723.41 mm, a horizontal width of 350 mm and a horizontal length of 370 mm. The cylindrical container has a diameter of 300 mm and a height of 280.78 mm, while the circular plate connected to the central screw shaft has a diameter of 280 mm. The frame with the mid-joint nut for the screwing system has a vertical height of 427.50 mm and is 30 mm above the cylinder to give room for screwing. The cylindrical container has circular perforated holes (10 mm in diameter) which allow liquid from the cassava pulp to seep through during mechanical compression into the collection canal. The collection canal is large enough (370 mm by 350 mm by 50 mm) to hold the liquid emanating from the compressed cassava through the perforated holes for a while as it flows out through the connected outlet tap (10 mm in diameter). The screw shaft handle (12 mm thick) is what will provide the required torsional force to drive and press the cassava pulp.

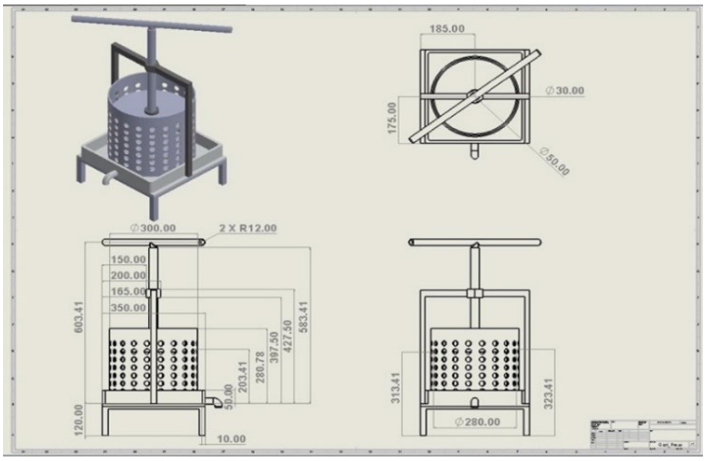

***Figure 3**: Shows the 3rd angle autographic projection with all detailed drawings and dimensions in mm.*

2.1.4 COST ANALYSIS

Before prototyping and simulation, a cost analysis of the gari press was conducted to determine the total amount required to make the gari press by breaking down the costs into unit costs of the respective part's dimensions and material type.

***Table 1:** Cost analysis for the Gari Press*

Part	Dimensions (±0 0 2 ~0 0 3	Material Type	Unit Price ($)	Cost ($)
Frame (40 × 4 0 square tubes)	1.70 m length, 0.04 m thickness	Ferritic Stainless Steel	4.57/m	7.77
Flat circular press plate	0.3 m outer radius, 0.03 m thick	Ferritic Stainless Steel	10.99/ kg/m	10.99
Screw shaft	0.05 m radius, 1m height	Ferritic Stainless Steel	1.94/m	1.94
Perforated Cylindrical Container	0.3m inner radius, 0.84 m height	Ferritic Stainless Steel	11.21/ m	11.21
Outlet Pipe/Tap	0.05 m thickness	Brass	9.35	9.35
		Total Cost	**38.06**	**41.26**

2.1.5. MECHANICAL SIMULATION

Selective simulations were performed on the Gari Press. A mechanical simulation was conducted on the frame with the mid-joint nut for the screwing system and the screw shaft handle (See Figure 2). It was necessary to determine the response of the screw shaft handle and the frame with the mid-joint nut for the screwing system when an equivalent torsional force of 120 N was applied during the screwing process on the Gari Press. Quantitative stress data was then obtained from the simulated results by probing across the screw shaft handle, near the joint.

2.1.6. PROTOTYPE FABRICATION

A prototype of the Gari Press was fabricated to mimic the 3D model presented earlier in Figure 2. Parts were welded together. Major parts used include a cylindrical container, screw shaft, round bar, metal plate, nut, and square tubes.

3. RESULTS & DISCUSSION

3.1. MECHANICAL SIMULATION

From the simulation conducted on the T-shaped screw shaft of the gari presser, assuming a torsional force of 120 N, the maximum stress reported on the screw shaft handle was 2.773 ×107 N/m2. This strength was less than the yield strength of the material used for the simulation (ferritic stainless steel) ~ 1.723 ×108 N/m2, which implies that under static torsional loading, the T-shaped screw shaft of the gari presser (made from ferritic stainless steel) would sustain the applied force without plastic deformation. Therefore, it would not yield due to any evidence of permanent plastic deformation, which leads to failure. Quantitative stress data was also obtained from the simulated results by probing across the screw shaft handle near the joint (Figure 4a). The graph (Figure 4b) suggested higher stresses near the join where the screw shaft connected with the screw shaft handle. Stress distribution was found to increase from 2×106 N/m2 to 1.25×107 N/m2.

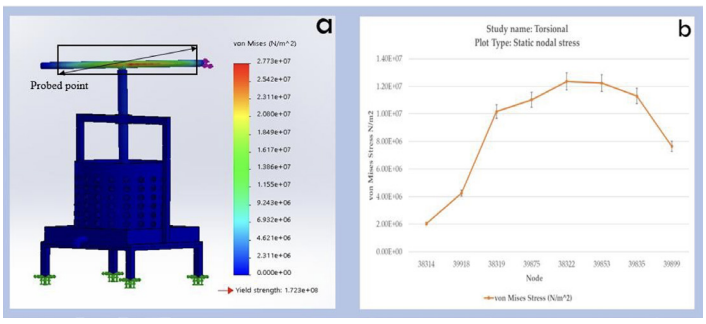

***Figure 4**: (a) Qualitative Model of the Simulation of the Gari Press after applying a Torsional Force of 120 N and (b) Quantitative Data Obtained from probing across screw shaft handle near the joint shown in (a)*

An upward reaction force was then induced on the circular press to counter the net downward force, and to determine the response of the frame with the mid-joint nut for the screwing system. The maximum stress reported on the frame with the mid-joint nut was 2.348×106 N/m2 which is less than the yield strength of the material used for the simulation (ferritic stainless steel) ~ 1.723 ×108 N/m^2. Quantitative stresses near the fixing point, where the threads flashed with the middle nut. Stress distribution was found to increase from 1x105 N/m2 to 2.1x105 N/m2. However, the result was reduced at the midpoint of the screw, halfway between the two points where the threads flashed with the middle nut, to a value of about 1.55 × 105 MPa.

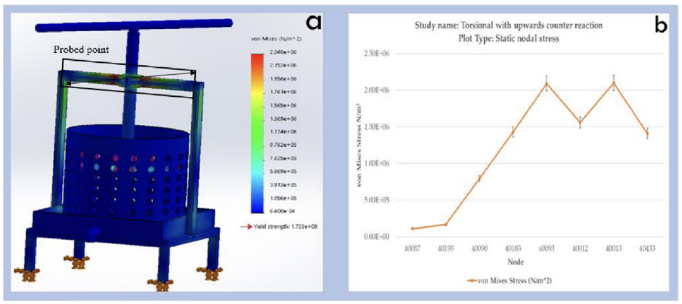

***Figure 5**: Qualitative model of the simulation of the gari press after applying a torsional force of 120 N and an upward reaction force was then induced on the circular press to counter the net downward force (b). Quantitative Data Obtained from probing across the frame with the mid-joint nut for the screwing system shown in (a)*

3.2. MANUFACTURING PROCESS

The design is quite simple. The joints in the frame are welded, first to the nut in the middle, then to the main four-legged frame. The T-shaft screw with a welded handle is then screwed into the mid-joint nut with a circular press plate attached to its bottom that easily fits into the cylindrical container, which is welded as part of the main four-legged frame. The curved surface of the cylindrical container is perforated to allow collection of drained fluid emanating from the compressed cassava pulp into the collection channel, then out through an outlet pipe to trap the liquid for other uses. The cylindrical container is welded from beneath, to hold casava during the pressing process. Tools required: Spare parts – None; Fuel Type – None; Pressure Source - Screw. Materials: Ferritic Stainless steel for the whole design and Brass for the outlet pipe or tap.

***Figure 6**: (a) Prototype of the torsional compression thread-based gari screw-type press (cassava pulp mechanical dewatering machine*

4. CONCLUSION

From this project, it was found that a mechanical dewatering screw press provides a cheaper way of processing cassava compared to modern methods. Also, it was discovered that the moisture content of cassava pulp is dependent upon the pressure applied, volume of cassava, and mass of cassava which are parameters that can be considered for further research. However, further research should be done on how to increase the quantity of gari that can be produced from cassava per batch.

One of the major lessons learned was the procedure for selecting the suitable materials by considering their mechanical properties. Simulation and 3D modeling prior to fabrication proved to be of high importance when it comes to working with different materials to produce a final product. Stainless steel was selected based on its BCC structure (high tensile strength) and its moderate ductility, derived from solid solution strengthening and strain hardening. Stainless steel was also selected due to its excellent resistance to corrosion, weldability, and its relative cheapness. discovered that chromium is what makes stainless steel stainless. Chromium is also a ferrite stabilizing element. Chromium causes the austenite region to shrink, while the ferrite region increases in size.

ACKNOWLEDGMENTS

Much appreciation and thanks go to Dr. Danyuo Yiporo and Mrs. Miriam Abugre, our project supervisors, for their unwavering support throughout this project.

REFERENCES

[1] Oduro I., Ellis, W. O., Dziedzoave, N. T., & Nimako, Y. K. (2000). "Quality of gari from selected processing zones in Ghana," Food Control, vol. 11, no. 4, pp. 297–303, Aug. 2000, doi: 10.1016/S0956-7135(99)00106-1.

[2] Olusegun, H. D. & Ajiboye, T. K. (2009). The Design, Construction and Testing of a Vertical Squeeze Cassava Pulp Dewatering Machine. Journal of Applied Sciences Research, 5(10): 1285-1297

[3] Akinmolayan, O., Anjorin, S., Odunfa, K., Akintan, E., & Ajayi, O. (2018). The Design and Fabrication of an Electric Motor Driven Press (Cassava Dewatering Machine). Retrieved from https://imeetmcon.com.ng/wp-content/uploads/2019/08/44.pdf.

[4] Kolawole, O.P., Agbetoye, L.A.S., & Ogunlowo, A.S. (2011). Evaluation of cassava mash dewatering methods. Journal of Bioinformatics and Sequence Analysis, 3(2), 23-30. Available online at http://www.academicjournals.org/JBSA ISSN 2141-2464.

[5] Oti, E., Olapeju, O., Dohou, S., Moutairou, E., Nankagninou, D., Komlaga, G. A., & Loueke, G. M. (2010). Training manual processing of cassava into gari and high-quality cassava flour in West Africa. Retrieved from https://issuu.com/coraf/docs/cassava

[6] Okegbile, O.J., Hassan, A.B., Mohammed, A., Abdullahi, A.A., & Jimoh, D.S. (2017). The design of a pedal-driven pulverizing and sieving machine for dewatered grated cassava. International Journal of Engineering Research in Africa, 32, 14-23.

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Internet of Things: The Budding Area of Mobile IoT Technologies (LTE-M and NB-IoT)

ABSTRACT

This paper explores the growing field of mobile IoT technologies and looks at the requirements and characteristics of these technologies. With a deeper focus on Long Term Evolution for Machines (LTE-M) and Narrow Band-Internet of Things (NB-IoT), we look at how different industry operators and governments have provided service for these technologies. The paper also looks at edge computing an issue that arises with Mobile IoT Technologies. In cases where solutions have been developed, we explore the design and deployment process. Findings proved that mobile IoT Technologies specifically LTE-M and NB-IoT will be a great asset to IoT Technologies.

Keywords *- Mobile IoT, Narrow Band-Internet of Things (NB-IoT), Long Term Evolution for Machines (LTE-M), IoT Technologies, Edge Computing, Low Power Wide Area Networks (LPWAN).*

1. INTRODUCTION

The mobile industry has developed and standardized a class of dedicated cellular technologies. These Mobile IoT networks support devices requiring broad coverage, a long battery life, and low cost, yet secure, connectivity across rural and urban locations [1]. The Internet of Things, which connects uniquely identifiable things to the Internet, keeps growing and evolving. Several devices around the world are being connected. Different communication mediums are required to connect these devices. Connecting these devices come with different requirements. Some require long-range communication, others fast-speed communication, and others, low power communications.

2. CHARACTERISTICS OF IOT

The Internet of things is vast, and therefore, one cannot simply use one definition to exhaust what it entails altogether. However, certain vital characteristics define the IoT. These are things, connectivity, data, communication, intelligence, and action [2]. Things refer to anything that can be connected, be it living or inanimate. These range from electronic devices to plants, animals, human beings, and even trees. Connectivity refers to the ability to connect several things. Several sensors aid in connectivity Retrieving data from several connected devices is crucial to IoT. Devices are in different proximity, and communication is required among them to enable effective sharing of information. Intelligence is gathered from the data retrieved through various analysis mediums and techniques. An example is machine learning. Having all this info without working on it makes IoT almost useless. Acting on the intelligence from the data gathered and stored is a driving force to IoT.

3. REQUIREMENTS

Despite the promising features, IoT implementations are a bit challenging due to the variety of connected devices. Every IoT implementation should involve edge computing, data ingestion and stream processing, management of devices, analytics, and integration with business systems. IoT has specific standards. These are ZigBee, IPv6, LoRaWAN (Long Range Wide Area Network), and Constrained application protocol (CoAP) [3].

These standards offer different services such as low power and long-range communication. However, in recent times certain technologies have been developed to address specific peculiar issues like edge computing. Cellular networks have evolved massively in this area. Cellular networks have progressed rapidly to ensure stable and reliable connectivity to the billions of connected devices. Certain standard technologies known as Mobile IoT technologies have been dedicated to this purpose. Mobile IoT refers to low power wide area (LPWA) 3GPP standardized, secure operator managed IoT networks in the licensed spectrum [4]. In recent years, this industry of mobile IoT has been budding. This may be attested to the several advantages mobile IoT brings. Mobile IoT technologies offer long-range communication and low power consumption, and they ensure connectivity in rural and urban areas. Additionally, Mobile IoT networks offer high security. Mobile IoT uses a dedicated spectrum band to avoid interference, and SIMs (Subscriber Identity Module) have closed circuits integrated into them [1].

4.KEY ENABLING TECHNOLOGIES OF EDGE COMPUTING

Edge computing is a distributed technology architecture in which client data is processed at the network's periphery, as close to the originating source as possible. A critical issue that arises from both Mobile IoT technology and IoT technologies, in general, is Edge Computing. Today's businesses are awash in an ocean of data, and vast amounts of data can be routinely collected from sensors and IoT devices operating in real-time [5]. With the rate at which data comes in, the traditional computing paradigm built on a centralized data center and everyday Internet is not well suited to moving endlessly growing real-world data streams. Some challenges with the traditional managing method are bandwidth limitations, latency issues, and unpredictable network disruptions. Edge computing is a modern way of dealing with processing large amounts of data promptly. Instead of transmitting raw data to a central data center for processing and analysis, edge computing moves some portion of the storage and compute resources out of the central data center and closer to the source of the data itself. Edge computing can be problematic if the right resources are not available[4]. However, there are certain technologies that make edge computing easier. Some of these technologies are Amazon Web Services (AWS), Greengrass, EdgeX, Cisco IOx. Additionally, certain groups in the industry are currently playing a major role in facilitating edge computing. Some of these are; EdgeX Foundry, ETSI Multi-access Edge Computing (MEC), and Living Edge Lab [6].

ETSI initiated Multi-Access Edge Computing (MEC) to promote and accelerate the advancement of edge-cloud computing in mobile networks. MEC can satisfy the communication requirements of ultra-high reliability and ultra-low latency in 5G-enabled vehicular networks since it provides an Internet service environment and cloud computing capability for wireless access networks[7].

The MEC reference architecture consists of two functional areas -- Host and Management -- with the management layer comprising both host and system-level administrative entities. Combining these functional elements provides the foundation required to operate a distributed environment for instantiating and scaling mobile applications and services in a highly granular and dynamic manner[8]. Figure 1 shows the pictorial view of the MEC architecture [9].

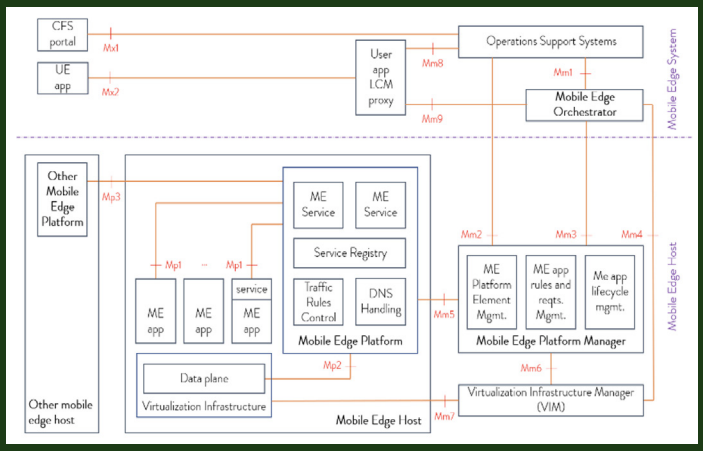

***Figure 1**: Multi-Access Edge Computing reference architecture, per ETSI GS MEC 003 v1.1.1*

5G network slicing is another key enabling technology of Mobile IoT. 5G network slicing is the use of network virtualization to divide single network connections into multiple distinct virtual connections that provide different amounts of resources to different types of traffic[10]. This technology greatly helps in flexibility in providing service. There is higher protection of data due to the segregation of connections. An added advantage of this technology is that problems can easily be identified and fixed. Figure 2 shows a pictorial view of a 5G network that has been sliced [11].

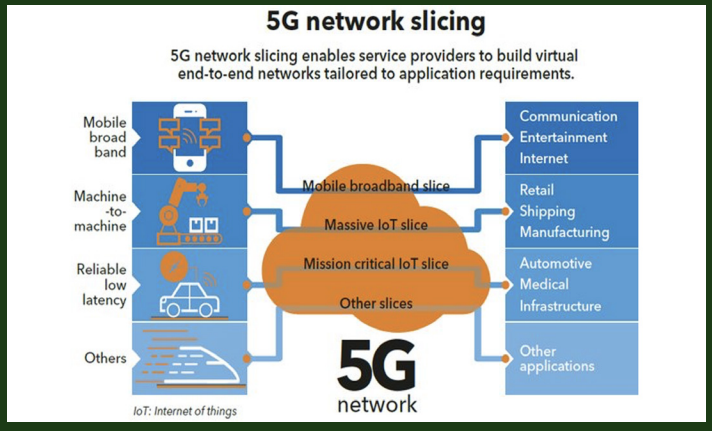

***Figure 2**: 5G network slicing*

5. LTE-M AND NB-IOT

LTE-M and NB-IoT are technologies designed for IoT applications that are low cost, require long battery lives, use low data rates, and usually operate in mostly inaccessible locations. This is a deviation from traditional IoT technologies such as Wi-Fi, GSM and Bluetooth. Both LTE-M and technologies are based on open standards, and the hardware for both technologies is simplified and easy to use. Although both LTE-M and NB-IoT are suitable for IoT communications, they have features that make them more suitable for a use case. Hence, certain conditions should be considered before using either of them. Table 1 shows the features, advantages, and disadvantages of LTE-M and NB-IoT [12].

Table.1 *– Features, Advantages and Disadvantages of LTE-M and NB-IoT*

Conditions	LTE-M	NB-IoT
1. Voice Readiness	LTE-M is designed for voice with Voice over LTE and can also be used for Voice over IP with full-duplex	Not suitable for this function
2. Remote control devices.	LTE-M is needed for a fast and consistent response	NB-IoT can handle use cases where a delay of minutes is acceptable.
3. Moving Devices	LTE-M is the better choice for moving devices as it has been designed for this from the start.	NB-IoT is designed for static devices it can lead to interruptions if devices are moved.
4. SIM LOCALISATION-EUICC	LTE-M is more suited for this function because, The bandwidth of LTE-M is also more suitable for transmission of SIM profiles	Not all operators support the combination of NB-IoT and SMS which means that eUICC cannot be initiated in many networks.
5.Internet Competence	LTE-M is using standard IP-protocols which makes it straightforward to develop applications.	NB-IoT is using tailormade protocols requiring specific application development and competence.

6. OPERATORS IN GHANA

According to research from Bundle Comm, the major mobile operators in Ghana are; Vodafone Ghana (Ghana Telecom, OneTouch), MTN Ghana (formerly ScanCom, Spacefon Areeba), Tigo Ghana (Millicom Ghana, Mobitel), Merger with Airtel Ghana, Expresso, Airtel Ghana (Zain/Celtel, Westel), Glo Mobile, Mobile Virtual Network Operators (MVNOs), M2M. Figure 3 shows regions Vodafone's implementation of NB-IoT, LTE-M, and LPWA are available[13]. Currently, South Africa is the only country in Africa where Vodafone has implemented NB-IoT. Ghana is not included in this list.

Additionally, Zariot is a global IoT and M2M SIM with signaling security that has both tri-cut and embedded SIMs, eUICC. Currently, Zariot has partnered with InfoSource Limited is a leader in the Internet of Things (IoT) on the African Market and the preferred African Partner for Zariot [14].

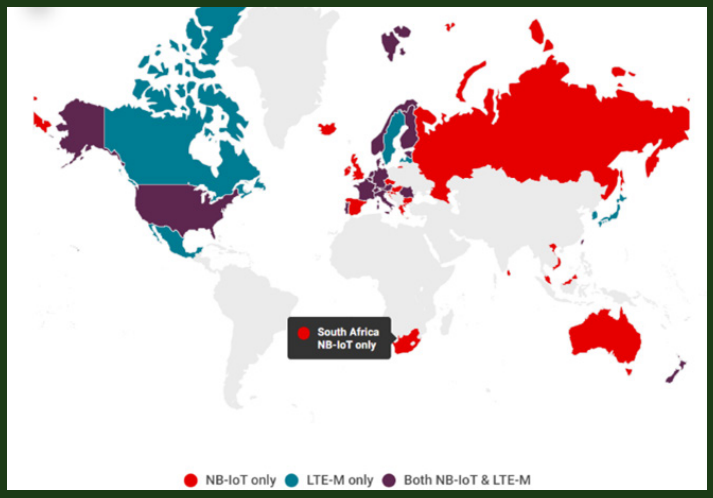

Figure 3*: Vodafone implementation of NB-IoT & LTE-M*

7. OPPORTUNITIES FOR IOT PROFESSIONALS

IoT professionals have an essential role in the cellular arena since the field adopts IoT systems to improve the quality of service. According to GSMA intelligence, the total IoT market will be worth $1.1 trillion In 2025. Some examples of roles that IoT professionals in this field may assume are IoT Foundation Roles (connectivity and service management), IoT Service Enablement Roles(infrastructure provider, IoT security and ecosystem orchestration) and IoT Solutions Roles (big data, analytics, and AI) [15].

8. FREQUENCY BANDS

The National Communications Authority is mandated by the Electronic Communications Act, 2008, Act 775 to "regulate the radio spectrum designated or allocated for use by broadcasting organizations and providers of broadcasting services

per the standards and requirements of the International Telecommunications Union (ITU) its Radio Regulations as agreed to or adopted by the Republic." The ITU has three regions, and Ghana is in region 1. According to the Planned bands for Maritime mobile: 415 - 495 kHz; 505 - 526.5 kHz; 1 606.5 - 1 625 kHz; 1 635 - 1 800 kHz and 2 045 - 2 160 kH [16].

9. GOVERNMENT AND IOT DEPLOYMENT

Considering the future of IoT and its potential economic benefits, Governments should take specific steps to make the widespread use of IoT deployment a reality. Some governments have made positive advancements already. Some exciting areas of IoT deployment in the US are pedestrian safety and advanced disaster warnings. For pedestrian safety, companies like Iteris and Cisco are working together with officials from Las Vegas to build an intelligent roadway system that combines edge-processing, video detection, and analysis software that tracks the movement of bicycles and pedestrians. The government officials aim to use internet-connect traffic sensors with the IoT system to reduce congestion and traffic jams during travel times. In advanced disaster warnings, on Jan. 03, 2019, AT&T initiated an app that quickly alerts Los Angeles Country residents of possible earthquakes. This application seeks to leverage ground sensors to detect seismic activity exceeding 5.0 magnitude and send alerts to citizens [17].

10. COMPARING CELLULAR IOT TECHNOLOGY TO WIRELESS TECHNOLOGY

Finally, how do these Cellular technologies compare with other Wireless technologies for IoT implementations? They have certain constraints, and the type of IoT implementation informs the choice of communication medium. Wi-Fi transmits data in a medium range. Its range is about 46m indoors and 92m outdoors [18]. Wi-Fi is typically used in the home or at the workplace for internet access. Wi-Fi can be used in specific applications like a smart home thermostat, a security system for the home, sensor-based lighting, and others. Although Wi-Fi cannot transmit at very long distances, Wi-Fi offers high speed and bandwidth in the transmission of information. Cellular, on the other hand, can transmit long-range. Cellular is a vast area network that transmits data over miles. Cellular is deployed in several IoT applications. When a user uses google maps or listens to music, cellular is the driving communication force. However, a tradeoff with cellular technology is that it consumes much power compared to Wi-Fi. Wi-Fi and Cellular technologies are deployed based on what the situation demands. Table 2 shows a comparison between Wi-Fi and Cellular Technology[19].

Table.2 *– Comparison of Wi-Fi and Cellular Technology*

	Wi-Fi	**Cellular**
Range		
Bandwidth	Wi-Fi has a high bandwidth	Cellular has a good bandwidth slightly higher than Wi-Fi
Battery Life	Wi-Fi can consume power for the battery to last about 7 days	Cellular consumes more battery power
Network Type	Wi-Fi is a local area Network (LAN) which cannot transmit longer than 300feet	Cellular is a wide signal area Network (LAN) and can be transmitted anywhere there is a signal.

CONCLUSION

Mobile IoT Technologies specifically NB-IoT and LTE-M are promising areas in the Internet of Things. These technologies offer long range, low power and low bandwidth opportunities as compared to Wireless IoT technologies. Governments should therefore invest heavily into these technologies as this will greatly help with development.

REFERENCES

[1] G. Awasthi and C. T. Solutions, "The Five Essential IoT Requirements and How to Achieve Them," Cognizant, p. 11, Feb. 2019.

[2] G. Association, "Internet of Things," Internet of Things. https://www.gsma.com/iot/mobile-iot-introduction/ (accessed Nov. 26, 2021).

[3] A. S. Gillis, "What is IoT (Internet of Things) and How Does it Work?" IoT Agenda. https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT (accessed Nov. 26, 2021).

[4] "What is IoT? The Internet of Things defined and explained," i-SCOOP. https://www.i-scoop.eu/internet-of-things-guide/ (accessed Nov. 26, 2021).

[5] T. Harwood, "IoT Edge Computing | 2019 Overview of Software, Devices and Use Cases," Postscapes. https://www.postscapes.com/iot-edge-computing-software (accessed Nov. 26, 2021).

[6] "IoT Solutions – infoSource Ghana Limited." https://infosourceghana.com/iot/ (accessed Nov. 26, 2021).

REFERENCES

[7] S. J. Bigelow, "What Is Edge Computing? Everything You Need to Know," SearchDataCenter. https://searchdatacenter.techtarget.com/definition/edge-computing (accessed Nov. 26, 2021).

[8] X. Ma, J. Zhao, Y. Gong, and Y. Wang, "Key Technologies of MEC Towards 5G-Enabled Vehicular Networks," in Quality, Reliability, Security and Robustness in Heterogeneous Systems, Cham, 2018, pp. 153–159. doi: 10.1007/978-3-319-78078-8_16.

[9] S. Dredge, "What is Multi-access Edge Computing (MEC)?" Metaswitch. https://www.metaswitch.com/knowledge-center/reference/what-is-multi-access-edge-computing-mec (accessed Nov. 26, 2021).

[10] D. Kypuros and W. Caban, "Overview of edge computing and MEC," Red Hat, Jan. 09, 2019. https://www.redhat.com/en/blog/overview-edge-computing-and-mec (accessed Nov. 26, 2021).

[11] Sd. Studios, "What Is 5G Network Slicing?" SDxCentral, Jan. 08, 2018. https://www.sdxcentral.com/5g/definitions/5g-network-slicing/ (accessed Nov. 26, 2021).

[12] Telenor Connexion, "A Guide To Mobile Iot: How To Choose Between Lte-M And Nb-Iot For Global Deployments", 2020.

[13] Vodafone, "Narrowband-IoT (NB-IoT)." https://www.vodafone.com/business/iot/managed-iot-connectivity/nb-iot (accessed Nov. 26, 2021).

[14] T. Taleb, K. Samdanis, B. Mada, H. Flinck, S. Dutta, and D. Sabella, "On Multi-Access Edge Computing: A Survey of the Emerging 5G Network Edge Cloud Architecture and Orchestration," IEEE Communications Surveys Tutorials, vol. 19, no. 3, pp. 1657–1681, 2017, doi: 10.1109/COMST.2017.2705720.

[15] G. Association, "Opportunities in the IoT: Evolving roles for mobile operators," Internet of Things. https://www.gsma.com/iot/resources/iot-opportunities-report/ (accessed Nov. 26, 2021).

[16] National Communications Authority, "Public consultation on the licensing of frequency in the 800mhz band (i.e., digital dividend)" p. 38, May 2015.

[17] "How local governments are leveraging IoT." https://www.perle.com/articles/how-local-governments-are-leveraging-iot-40182510.shtml (accessed Nov. 26, 2021)

[18] B. Mitchell, "How Far Will Your WiFi Reach?" Lifewire, Nov. 05, 2020. https://www.lifewire.com/range-of-typical-wifi-network-816564 (accessed Nov. 26, 2021)

[19] B. Ray, "WiFi Vs. Cellular: Differences & Uses for M2M Applications | Blog | Link Labs," Link Labs, Nov. 13, 2014. https://www.link-labs.com/blog/wifi-vs-cellular-differences-for-m2m (accessed Nov. 26, 2021)

Interview 01

Ashesi D:Lab Electric Vehicle

Q: Tell us about the D-lab E.V project. A brief history (is it backed by an SDG?) and how you (Nice) found yourself here? What was the need that was identified, which birthed the whole idea?

A: EV began in 2021, inspired by a desire to push our minds to a challenge. With such a huge campus, largely in the mountains, having a mode of transportation might be beneficial for students to simply go from one location to another without requiring gas refill everytime you need to use it. We considered doing something new, something difficult for a novice, something distinctive, and decided to create a genuine electrical automobile.
Thanks to the design lab summer mobile project, we began with a team of engineering students who collaborated with alumni to bring the concept to reality. We also included non-engineering students, who were initially focused on the research aspect of the project. They were intended to form a business strategy, If the project is successful, how could it be useful? What should be improved? How should it be promoted? And so forth. In 2021, everything revolved on the design skeleton, bringing ideas, expanding everything, and so on. The real construction began in 2022. Nonetheless, the Ashesi Electric car is not intended to address transportation problems in our daily lives or to be available on the market once completed. However, this project allows students to put their mechanical, electrical, and computer engineering skills to the strain. From creating CAD models in SolidWorks to welding metal sheets in the actual world, this initiative has poured math and physic theory from the papers on which it is based into the real world.

Q: What is your role(s) in the project and how have you grown as an entrepreneur (has your major helped in any way)?

A: I found myself in the project at the very beginning. I was just being my normal self and started a conversation with a random person in mechanical engineering lab, who later became the team lead of the project. I thought he was student, but upon discussing, he told me he was an alumni and we exchange contact. After month of not talking, he reached out to me and told me about an engineering project, they(with his team) planned to do and if I would be interested to be part of it. I was still in my first year, and of course I agreed, and the rest is history.

Q: What were some of the challenges that you faced at the beginning of your project?

A: To start with, the team had many project happening. At a point, I did not know what I was doing, I was just following instructions, and I was placed in the business team. We were to find how to market the business, once it takes off and how to find sponsors, partnerships, do business plan and so on. At that time, it was easy, since I was taking a course which was requiring the same thing. Later on, there was a pause, since some coordinators could not keep on with the project and the team lead had other business to take care off. The team scattered in one word, but after half a year, he contacted me and asked me to do some work for them. I did it, and later I do not remember how exactly but I became the coordinator of the project, and it was now taken under the D-Lab. I am doing computer science, and coordinating an engineering project seemed out of context for me, but with the team lead encouragement and D-Lab support, I did it.My major did not really help me with that, but the various course I have taken did help me. I got to practice the leadership skills, I learnt new technical words, and got to assist engineers in every step of the making. That was more than I could expect.

Interview 01

Ashesi D:Lab Electric Vehicle

Q: If you could give your past self some advice, what would it be?

A: The Ashesi Design Lab is an initiative which combines the concepts of design thinking and design making; design thinking or strategy design for problem-solving, and design making or fabrication for making things more tangible and building out the creative outcomes of the different processes involved in both concepts. It gives students the space to be creative and to showcase what they are capable of. It is also support students in project that involves innovation mostly and give students the opportunity to practice their leadership skills, by coordinating, partaking, helping in various project. The Ashesi D: Lab started work in September 2015.

Q: Are you open to the idea of collaborating with another company/ team?

A: I would not be the best person to provide theses details, rather the person who first came up with the idea. But if I was that person, I would say the whole vision of a fully EV will be a vehicle that used solar panel or other sources of energy to generate self powered electricity with low cost to its user, with a possible automated system.

Interview 01

Ashesi D:Lab Electric Vehicle

Q: Talk to us about the D-lab/ Ashesi Entrepreneurship Center and the opportunities that it is opening for your project/ entrepreneurship journey.

A: The challenges I faced was low self esteem. At first, we were like 2 ladies in an all men team, and team changed and it was all graduate students with me being the only undergraduate in my second year and lastly it became an all males team with one female coordinator. In all the context, I was questioning myself what I was doing, and felt helpless sometimes since I thought they knew more than I do. Just kept reminding myself, that I was invited to the project not like I chose it; so eventually someone saw that I could bring something on table and that is why I am there. I tried for a long to appreciate that opportunity, and turn the event to my advantages. The team I coordinate, had only 3 undergrad students(me included) and the rest were alumni, so I was thinking that telling them what to do or monitoring them was kind of disrespect, whereas they were okay with that since my only goal was to meet the deadlines and meet D-Lab's expectation. I guess, believing in myself was my biggest challenge, others were not that major.

Q: What does a fully established Electric Vehicle look like (its prospects and advantages)?

A: The advice would : just because you are not them, does not mean you do not fit in. Do let any opportunity pass by you, just because you thought people involved are better than you or are more experienced than you. You really can do better than what you think, and be serious in all you do, because you do not know who is watching. Additionally, stay in touch with people you meet, opportunities come along that way.

Q: Any other interesting things you would want us to know?

A: Yes, of course. Collaboration that what made the project moving so far. Without the involvement of the D-Lab, I doubt there would have been much to do. We really look forward to improve more, I am very interested to take up the same steps again and additionally apply my computer science skills to the project. May be we can have an AI powered electric car, I mean all can happen. If there are universities, companies, organizations out there who would like to see in depth what the team did, I bet it would be a celebration on our side.

Q: What advice would you give to any new entrepreneurs or people looking to become entrepreneurs?

A: One interest thing to know .All credit goes to the amazing team behind the Electric Vehicle : Michael Danquah, William Akuffo, Paul Adori, Peter Kwao, Frederick Kojo Acquah, Ernest Samuel, Obed Babington, Jedidiah Mortey, Michael Danquah's technical team.
Special thanks to : Dr. Gordon Adomdza, Dr. Nathan Amanquah, Nicholas Tali, Emmanuel Wanye, Heyford Asamoah.

I do not think I am yet to be called an entrepreneur, if you consider its definition. But I would like to say for someone who is out there : you may think your idea sounds unreal or crazy, just start it, your first step can be writing it down, the rest will follow. Take as an example the team, behind the ELECTRIC VEHICLE idea.

Interview 01

Ashesi D:Lab Electric Vehicle

By
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Efforts to Apply Natural Language Processing Technologies in Africa

ABSTRACT

The primary objective of this paper is to investigate the developments and advancements made in Automatic Speech Recognition (ASR), Natural Language Processing (NLP), and Text-to-Speech (TTS) technologies for African languages and problems. The paper addresses the challenges the African continent faces in implementing these technologies. Additionally, the paper proposes a novel concept that combines computer vision, NLP, and TTS to aid visually impaired individuals in Ghana.

Keywords *- Automatic Speech Recognition(ASR), Natural Language Processing(NLP), Text-to-Speech(TTS), Hidden Markov Model and Gaussian Mixture Model(CD-HMM/GMM), Deep Neural Networks(DNN), Convolutional Neural Networks(CNN).*

1. INTRODUCTION

The world has undergone a significant transformation, shifting from manual tasks to an era where machines can learn and perform these tasks with remarkable accuracy. This era is known as Machine Learning (ML). Within ML, Automatic Speech Recognition (ASR), Natural Language Processing (NLP), and Text-to-Speech (TTS) are subsets that enhance human interactions with computer systems. The impact of these technologies is evident in voice-based tools such as Alexa, Siri, and Google's Home Assistant. These tools can be used for various purposes, including playing music, setting reminders, asking questions, shopping online, and more. However, these technologies are mostly available in popular Western languages, notably English, and some Eastern languages, leaving African languages and problems underrepresented.

This paper aims to showcase the efforts being made across Africa to apply and use NLP tools and technologies on the continent, with a specific focus on Automatic Speech Recognition (ASR), Natural Language Processing (NLP), and Text To Speech (TTS) and their applications to native African Languages. Furthermore, this paper presents a creative idea on how these technologies can be used to address African problems and languages.

2. CHALLENGES ENCOUNTERED IN AFRICA

Before we get into the current efforts to introduce these innovations in Africa, we need to discuss the obstacles preventing them from being implemented. There are currently 6900 languages spoken worldwide [1], and out of them, 2000 are spoken in Africa alone [2]. Unfortunately, African languages lack documentation and datasets [3], and their resources are dispersed and often challenging to access, as pointed out by Abbot and Martinus [3]. Additionally, the scarcity of data for African languages that can be used to train models discourages most researchers from attempting to do so [4]. For instance, ASR models require 100,000 hours of recorded speech to create an accurate model, which is not available for most native African languages [4]. Finally, code-switching presents a challenge for machine learning engineers in building a multilingual model for African languages [4]. The challenges faced by African languages hinder the adoption and implementation of ASR, NLP, and TTS technologies. In the next section, we will discuss the efforts being made to address these challenges, as it is crucial to improve the accessibility and effectiveness of these technologies in Africa.

3. EXISTING EFFORTS IN AFRICA

Despite the challenges, startups and researchers have been working to apply these technologies to African problems. In this section, we will discuss the various strides that have been made across the continent. We will explore these efforts in three subsections: ASR, NLP and TTS.

A. Automatic Speech Recognition

ASR is the task of mapping waveforms to the appropriate string of words [5]. In the African ASR ecosystem, Gauthier, Besacier, and Voisin have developed a system with a vowel

length constraint for Hausa and Wolof languages [6]. Their systems for both languages made use of the hidden Markov Model and Gaussian mixture model (CD-HMM/GMM) and deep neural networks (DNN). They modeled four ASR systems, two for each language, while ensuring they considered vowel duration for the languages [6]. The Wolof ASR system obtained a word error rate (WER) of 31.9% and a character error rate (CER) of 12.9% for the CD-HMM/GMM acoustic model [6]. Similarly, on the CD-DNN-HMM acoustic model, they obtained a WER of 27.7% and a CER of 10.5% [6]. The Hausa ASR system performed better on both acoustic models. The system achieved a WER of 12.9% and a CER of 3.7% for the CD-HMM/GMM acoustic model. On the CD-DNN-HMM acoustic model, it achieved a WER of 7.9% and a CER of 2.1% [6]. However, the ASR systems do not seem to be fine-tuned for longer duration models [6], and hence the performance may decline on such duration models. Still, Gauthier, Besacier, and Voisin's work laid the groundwork for other developers to use their ASR systems as baseline acoustic models to build upon.

Their work also resulted in a speech corpus for Wolof and the first-ever large vocabulary continuous speech recognition system [6]. In the future, the Wolof speech corpus may be used for NLP and TTS subtasks. An ASR system was also applied to Nigerian Pidgin English. Pidgin English, a variant of the structured English language, is commonly spoken across West Africa [7]. The Nigerian pidgin system was developed using the neural architecture called the NeMo toolkit [7]. In the implementation, the developers utilized two ASR architectures called Jasper and QuartzNet. Their model takes a speech recording and predicts the corresponding text, making it a speech-to-text system [7]. The team obtained a WER of 0.997% for the Jasper model with no data augmentation and a WER of 0.987% with data augmentation [7]. Similarly, they reported a WER of 0.772% for the QuartzNet with data augmentation and a 0.777% WER with no data augmentation [7].

According to [7], this ASR system was developed with the hope of building the first speech-to-text benchmark for Nigerian pidgin. Hence the team open-sourced their code and data to motivate further research on the language. Thus, their ASR model can be used as a benchmark due to the excellent results achieved for the WER.

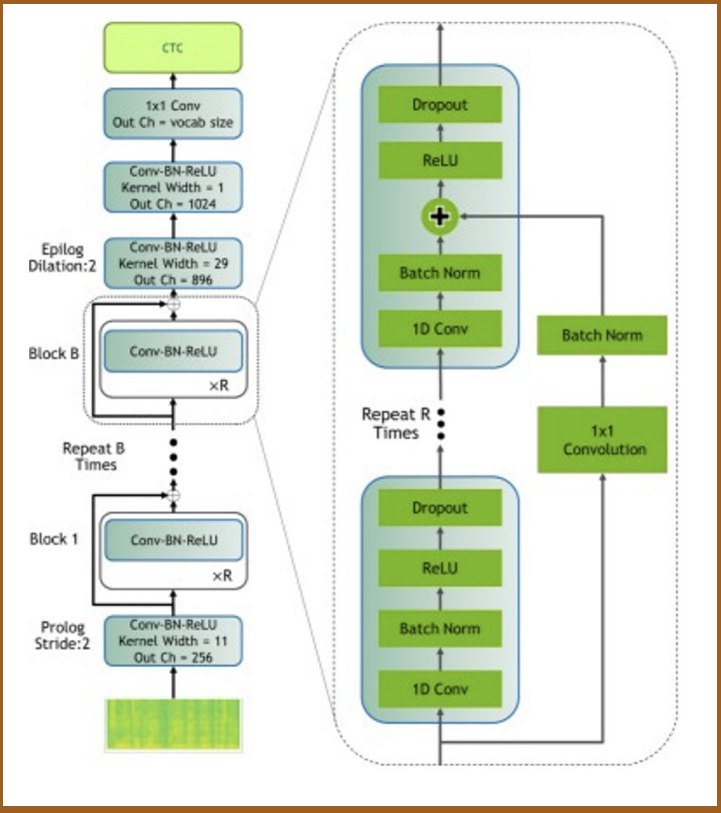

Fig. 1. *Jasper Architecture [8]*

B. Natural Language Processing

NLP is an area that has seen a lot of applications with regards to African languages. NLP involves the application of computational techniques to the synthesis and analysis of natural language [5]. In Ghana, an NLP team has released a model called ABENA, which can perform some tasks using the Twi language [10]. Twi is a language spoken by a specific group of Ghanaians called the Akans. The ABENA model provides contextual word embedding for Twi [10]. Learned embeddings from the model show fairly accurate word embeddings when visualized. ABENA was then applied to sentiment classification, and it was discovered that the model's accuracy always lay in a range between 83% to 100% [10]. Although the results of ABENA look promising for the Twi language, it was discovered that the model had varying religious bias. The bias occurs due to data that emanates from religious context used for the model's training [10]. However, this current work presents an avenue for NLP research for Twi and other Ghanaian Languages.

Another NLP-focused team in Ghana is a promising startup called Nokwary Technologies. Nokwary's mission is to use NLP to build conversational WhatsApp bots for a variety of Ghanaian businesses [11]. Conversational bots are a subset of NLP that deals with dialogue systems. Nokwary employs NLP to make advanced technology accessible to Ghana's impoverished communities [12]. The company has created a WhatsApp banking app for Twi speakers that allows them to purchase airtime using natural language interaction in

Twi [12]. Through this, Nokwary's product is helping many Ghanaians have access to financial services. Due to the fact that Nokwary has been able to apply NLP to Twi, it is possible they could do so for other African languages. The obstacle hindering them from doing so is most likely the lack of documented data mentioned earlier. Should the needed data required be obtained, it is possible to envision them evolving into a prominent provider of financial solutions across Africa. Given the lack of curated data discussed above, Nokwary's secrecy with plans to make their dataset available publicly to help the budding NLP community in Ghana. Furthermore, since their NLP models are designed for businesses, their performance cannot be assessed externally.

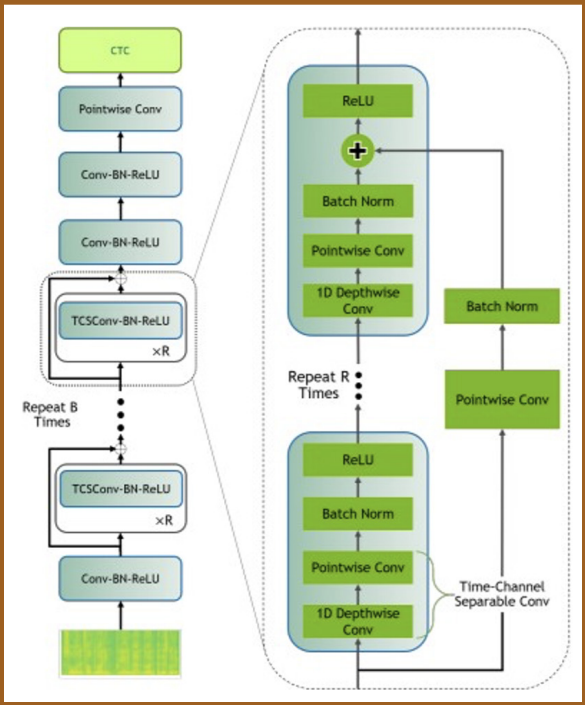

Fig. 2. *QuartzNet Architecture [9]*

C. Text To Speech

The task of text-to-speech (TTS) is the reverse of automatic speech recognition. In TTS, we aim to map a piece of text to an acoustic waveform [5]. TTS has many applications in assistive technologies; however, most of these solutions have not yet been applied to African languages. The only country that seems to be developing a TTS system is South Africa, where Qfrency TTS voices have been integrated with an augmentative and alternative communication (AAC) system [13]. This system allows users to communicate by inputting a text in English, which is then translated into a specified South African language and read out by the Qfrency TTS voice [13]. Alternatively, the text can be directly translated from the South African language and read out. However, the researchers discovered that users had trouble pronouncing words in their native languages, which impacted the intelligibility of the system [13].

In addition to AAC, TTS solutions have been integrated with accessible Zulu books in South Africa. The system is capable of reading epub versions of books, but users have described the monotony of the Qfrency TTS voices as a downside.

4. CREATIVE IMAGINATION

ASR, NLP, and TTS technologies can provide accessible information for visually impaired citizens in Ghana who speak English or other local languages. The idea is to build a system that can caption an image taken by a visually impaired person and then read the caption back to the user in English or any local language of their choice. However, in this project, I will consider Twi since it is the Ghanaian language that has been extensively worked on. The idea lies in the area of computer vision, natural language processing, and text-to-speech.

The direct impact of such a project will be to aid visually impaired people to navigate their environment easily by creating a mental picture of what they hear through a captioned photo. This idea can also benefit Ghanaian schools for the blind, as teachers can use the system to depict accurate images of the world around them. For example, a teacher can point out an image from a textbook, take a picture of it, wait for it to be captioned, and read out for students. This idea can be achieved in the following steps.

The first step is to caption the image using convolutional neural networks (CNN) and a transformer model. The CNN will generate a feature representation of the image, which becomes an encoding for the image. This encoding is then passed to the transformer model to generate a word embedding, which is further passed to a decoder to obtain a caption. Hidden in the decoding stage is a language model that uses word embeddings to generate sentences in English.

The generated caption is passed to the TTS system, which has three phases: encoding, decoding, and vocoding. The encoding phase will first take the caption and transform it into character embeddings by passing it through CNNs and a bidirectional LSTM. The decoder takes this and predicts a log mel spectrogram for these final encodings, which is then sent to the final stage where the mel spectrum is passed through a WaveNet to get waveforms of the mel spectrum, which will be read to a user.

If a user prefers the captions to be read in Twi, it could be done in two ways. The first is to generate the captions in Twi directly before the TTS stage. The other is to translate the generated English captions before passing them as input to the TTS system, and the most efficient approach will be chosen.

5. CONCLUSION

While efforts to apply ASR, NLP, and TTS technologies to African languages do exist, the low resource levels of these languages present challenges for researchers in this area. Nevertheless, there have been various approaches applied to African languages, such as the ABENA model we discussed for Twi in NLP. In addition, the idea of providing image captioning for visually impaired Ghanaians could be of great benefit to the education sector. Teachers could use the system to

accurately depict images from textbooks, for instance, by taking a picture and having it captioned and read out to students.

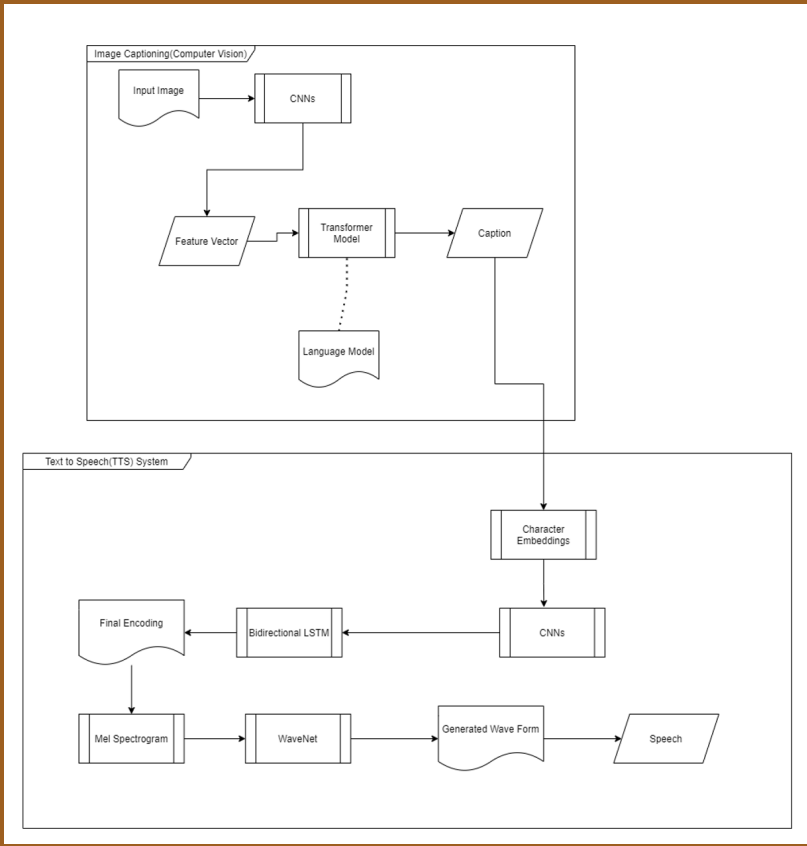

Fig. 3. *High level structure of creative idea*

REFERENCES

[1] L. Besacier, E. Barnard, A. Karpov, and T. Schultz, "Auto- matic speech recognition for under-resourced languages: A sur- vey," Speech Communication, vol. 56, pp. 85–100, Jan. 2014, doi: 10.1016/j.specom.2013.07.008.

[2] David M Eberhard, Gary F Simons, and Charles D Fennig, Ethnologue: Languages of the worlds, Twenty Second Edition.

[3] J. Abbott and L. Martinus, "Benchmarking Neural Machine Translation for Southern African Languages," Proceedings of the 2019 Workshop on Widening NLP, Association for Computational Linguistics, Florence, Italy, pp. 98-101, 2019

[4] A. L. Dahir, "African languages are being left behind when it comes to voice recognition innovation," Quartz. https://qz.com/africa/1475763/african-languages-are-lagging-behind-when-it-comes-to-voice-recognition-innovations/ (accessed Apr. 14, 2021).

[5] D. Jurafsky and J. H. Martin, Speech and language processing: an introduction to natural language processing, computational linguistics, and speech recognition. India: Dorling Kindersley Pvt, Ltd., 2016.

[6] E. Gauthier, L. Besacier, and S. Voisin, "Automatic Speech Recognition for African Languages with Vowel Length Contrast," Procedia Computer Science, vol. 81, pp. 136–143, 2016, doi: 10.1016/j.procs.2016.04.041.

[7] D. Ajisafe, O. Adegboro, E. Oduntan, and T. Arulogun, "Towards End-to-End Training of Automatic Speech Recognition for Nigerian Pidgin," arXiv:2010.11123 [cs, eess], Oct. 2020, Accessed: Apr. 14, 2021. [Online]. Available: http://arxiv.org/abs/2010.11123.

[8] J. Li et al., "Jasper: An End-to-End Convolutional Neural Acoustic Model," arXiv:1904.03288 [cs, eess], Aug. 2019, Accessed: Apr. 14, 2021. [Online]. Available: http://arxiv.org/abs/1904.03288.

[9] S. Kriman et al., "QuartzNet: Deep Automatic Speech Recognition with 1D Time-Channel Separable Convolutions," arXiv:1910.10261 [eess], Oct. 2019, Accessed: Apr. 14, 2021. [Online]. Available: http://arxiv.org/abs/1910.10261.

[10] P. Azunre et al., "Contextual Text Embeddings for Twi," arXiv:2103.15963 [cs], Mar. 2021, Accessed: Apr. 14, 2021. [Online]. Available: http://arxiv.org/abs/2103.15963.

[11] "Nokwary Technologies: AI is here – Artificial Intelligence and What- sApp Banking in Ghana and Africa." https://nokwary.com/ (accessed Apr. 14, 2021).

[12] "Hey Google! Hey Alexa! Hey Nokwary! AI in Ghana – AI and NLP in Ghana and Africa." https://nokwary.com/blog/2020/05/25/hey-google- hey-alexa-hey-nokwary-ai-in-ghana/ (accessed Apr. 14, 2021).

[13] G. I. Schlu¨nz et al., "Applications in accessibility of text-to-speech synthesis for South African languages: initial system integration and user engagement," in Proceedings of the South African Institute of Computer Scientists and Information Technologists on - SAICSIT '17, Thaba 'Nchu, South Africa, 2017, pp. 1–10, doi: 10.1145/3129416.3129445.

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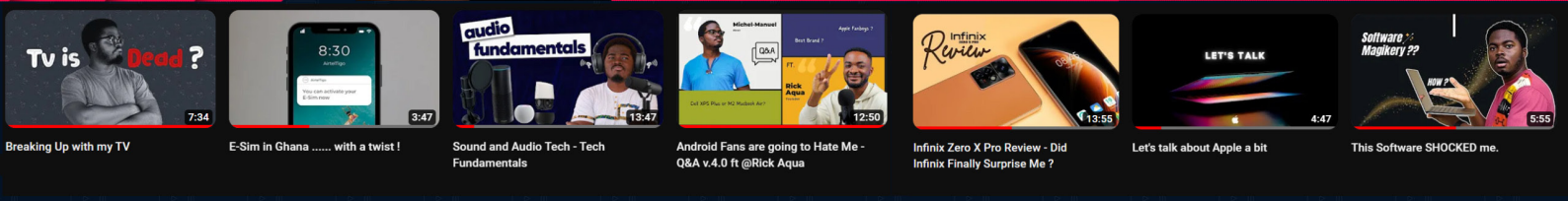

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A Portable Design of a Maize Drying Machine

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ABSTRACT

Most Ghanaian maize farmers incur losses in their business. This is due to the burden that comes with post-harvest grain management. The inability of the farmers to dry these grains effectively leads to its spoilage. Maize harvested in the first planting season of maize is susceptible to destruction by weevils and other insects due to the high moisture content. To prevent the problem of post-harvest losses in the maize farming business, a maize drying machine is designed to effectively dry it before storing the grains. This paper concentrates on the calculations, design processes and procedures on specific nature of chosen design parts. The machine makes use of an induction motor that is controlled by an electrical control unit to continuously stir the grains. A blower with the necessary heating element is used to supply the grains with air. Also, there is a temperature and humidity sensor at the bottom of the machine to detect if the maize is dried. The design prevents overheating of the grains during the drying process, and reduces the manpower expended by the farmer.

Keywords *- Direct On-Line, Moisture Content, Post-Harvest Losses.*

1. INTRODUCTION

Maize is a high value crop that serves as source of food, employment, as well as raw materials for many industries. It is a versatile crop that can be used for many purposes. In some places, especially Africa, it is well known for its medicinal purposes. The leaves, cob, grains, and stalk can be used in the production of high-quality non-food products [1]. In some countries, maize is used as livestock feed. Though maize is a very essential grain, its post-harvest management, especially in the first planting season, has been a problem for most farmers in the country due to the inability of the grains to effectively dry. If the crop is left out on the field to dry, it will begin to deteriorate because of the slow rate at which it dries up. For this reason, it is harvested with high moisture content, and made available for purchase, to be cooked or consumed. This has a negative effect on the farmer since he loses some profit when he sells without processing it. In this paper, the focus will be designing an appropriate machine that is able to dry the maize grains efficiently to reduce post-harvest losses faced by farmers and help to increase their income. In the simulation, the Cambridge Engineering Selector (CES) software is used for material selection, Proteus software used to simulate sensor circuits, Electrical Control Techniques Simulator (EKTS) to simulate the motor, and SolidWorks for the design and simulations of some selected body parts. The maize dryer in this paper has a long funnel-like shape as its outlet. This design allows for more grains to be poured out of it after the drying process. There are embedded sensors to measure the temperature, and moisture content of the grains throughout the drying process. After drying, the grains move along the chamber through the funnel shaped outlet, which concentrates the dried grains to a single exit point.

2. LITERATURE REVIEW

In a maize drier design done at the Federal University of Technology, the manufacturers prioritized on using horizontal style of drying grains [2] as it is cheaper than the vertical or tower style. The tower style used in this paper allows for different levels of aeration as the grains are passed from one level to another. Also, the horizontal style used in the design done by the Federal University that make use of conveyor belts tends to be slow and malfunctions. The tower style used in this paper allows gravity to push the grains down in the outlet. The wet grains must be dried if the inlet air conditions are drier than the wet grain. This

implies that the dampness contained in the inlet air can be taken out by raising its temperature, accordingly, expanding its capacity to eliminate moisture from the wet grain. This is an easier and more efficient method of drying the grains to prevent post-harvest losses.

In [3], Mark Angelo et al designed a humidifier-dryer machine to enhance the drying up of grains in post-harvest management. The machine is operated by a programmable microcontroller that monitors the temperature and moisture content of the grains continuously for maximum drying. However, the system does not give users feedback on the amount of moisture still accumulated in it at any given time.

Hidayat et al. have proposed a Wireless Sensor Network (WSN)-based grain drying machine for the monitoring of the humidity and temperature of grains [4]. This system can monitor the drying process more accurately and in real time and is energy efficient because its node is well equipped with a power source in the form of a battery system. Although the WSN-based grain dryer does not require wiring and can be used in most places, the problem of uniform drying is not addressed in this design.

The Academy of National Food and Strategic Reserves Administration developed a rotary drying machine that starts with grain drying quality and uses mechanical ventilation to lower moisture content to address the problem of excessive moisture in grain drying that farmers confront [5]. It can dry a lot of grain at once and has a special rotating feature. Its drying mechanism involves using the fan to move dry outdoor air into the ventilation network duct. The vent hole on the duct forces air into the chamber because of the difference in pressure, altering the grain pile's microenvironmental properties. Dry air and moist grain heat interchange each other by removing the moisture in the grain into the surrounding environment throughout this operation. This new system can rotate its chamber to aid in balancing the moisture content of the grain after the drying process. However, the entire system is bulky and cannot be easily transported to other places.

3. DESIGN METHODOLOGY

3.1. Software Used

SolidWorks, CES, EKTS and Proteus were the software used in this project.

3.2. Design

For the design of the maize dryer, the CES software was used in the selection of the right materials for the durability of the machine. After the selection of the right materials for the body of the machine, a sketch was produced for the proposed design, and the final design was rendered in SolidWorks.

3.3 Description

The maize dryer is a rectangular like structure, that has its lid perforated to allow vapor to leave the chamber. The same top serves as the inlet of the machine. The machine has a shaft or an agitator that continuously stirs the maize inside the chamber. There is an electric motor placed at the back which is linked to the agitator through v-belt and gears to cause rotation of the shaft. This motor is powered through the control panel right under it. At the back of the main drying chamber is the blower which has been connected into the inner part of the chamber to supply heat and air for the drying process. Under the rectangular drying chamber is a small space that contains a sensing unit which provides information on temperature and moisture content level within the dryer's chamber. If the humidity content is getting closer to 0, the temperature and the humidity content of the chamber are displayed on an LCD screen placed on the top left of the front view of the machine. This will prompt the user to open the outlet to collect the dried maize.

3.4 Selection Of Materials

In selecting the material for the main body of the maize dryer, the priority was to get a very hard material that has a low thermal conductivity with a low price. The rationale behind the material selection criteria was to get a material that will resist the internal heat of the machine that will escape into the environment, and also to get a very hard material that will take years before it fractures [7]. The CES software was then used to determine the right material for the given purposes. Thermal conductivity was plotted on the y-axis against the price of the material in Ghanaian Cedi. The outcome of the graph was that lead alloys and stainless steel had a better thermal conductivity with a very moderate price as compared to the rest of the materials. To make a choice between these two materials, a further plot of hardness on the y- axis against price on the x-axis was done. From the graph, stainless steel had a very high hardness than the lead alloys. To further confirm this, non-linear force simulation was done in SolidWorks.

3.5. Design Specifications And Calculations

Average mass of maize grain = 0.72kg Bulk density = 591.630kgm^3 [1] A bag of maize is 100kg.

From Density, ρ = mass/ Volume , Volume, V =mass/ ρ = 0.72 / 554.190 = 0.001299m^3

If 1 is 0.00171698m^3 then 100 will be 100 x 0.001299m^3 = 0.1299 m^3.

For a given height of 700mm, the length of the square base will be sqrt(0.1299/0.7) = 0.430 Hence the base was made from the dimension, 430 x 430 mm.

3.6. Amount of Heat to Effect Drying

HD = CaTcMR, where Ca is the air specific heat capacity which is approximately = 1.005 kJ/kg°C
MR is the amount of moisture to be expelled, which is approximately = 22.29kg
Tc is the temperature difference between the environment and the heating chamber, 43- 32°C = 11 degree Celsius.
HD = 323.469kJ
Hence, a heater that can produce almost 324kJ of heat is used [3].

3.7. Power Needed by the Motor for Operation

The power needed for rotation the agitating/stirring shaft with full load (*Pps*) is as follows: *P*m = Torque x Angular velocity of shaft
But,
Torque (ĩ) = total weight x radius of the shaft.(ĭ*w*) = (*Wc+ps+sp*) x *bsp* (30)
where, ma = Weight of maize = 140 N.
(Using a higher threshold as a safety measure).*s* = Weight of stirrer shaft = 70 N.

Rs= Radius of shaft = 0.100 m.
Torque = (140 + 70) x 0.100 = 21 Nm.
Angular Velocity (*w*) v/r = N x 6 where, = Speed of stirrer shaft in rpm (set to 2.5 rpm =)
w = (2.5 x 6) = 15 rad/s.
*P*m = 21 x 15 = 0.315 kW the paddle/stirrer shaft [2]

3.8. Non-Linear Simulation Procedure of Main Body

Simulation of the main body part was performed with SolidWorks to confirm that indeed the stainless steel is harder and better than the lead alloys. A non-linear simulation was done on the body using a Solid type of Mesh. The selected body part was locked to hinges by four Jacobian points which consists of the top, bottom, right and left faces of the selected body. A resultant force of 560N was applied to the outer face when the material was made of lead alloys, and another one with the same simulation specifications was done with stainless steel as the material. The simulation was then run for 11 seconds to see the results.

3.9. Static Simulation of the Inner Lining of the Heating Chamber

A static simulation of thermal effect was performed with SolidWorks on the glass lining inside the inner part of the chamber. At first, a fiber glass of thickness 3mm was used in the simulation. All the four side faces were locked and a temperature value of 120 degree Celsius, which is twice more than the temperature at which the maize is likely to dry, was applied on the surface. The same procedure was used on a fiber glass with thickness of 10mm and the results from both simulations were observed.

3.10. Methodology in Building the Sensor Circuit

The circuit was built using an Arduino Uno R3 and a DHT sensor to read the temperature and moisture content level. In Arduino IDE, the code was written such that the user is alerted when the moisture content approaches 0. When the maize is put inside the chamber and the machine is started, the circuit switches on and the DHT reads the moisture content and temperature values at the onset of the operation. The moisture content and temperature values are then printed on a screen every 3 seconds. If the moisture content value is left with about 10 %, the message "Maize almost dry, moisture content is 'X'%, Temp. = 'Y'%" is printed. X and Y refer to the values at any given time within that range. Finally, when the moisture content is zero, the message "Your maize is dry, remove from chamber" is printed.

3.11. Mode of Operation of the Machine

Immediately the machine is switched on, the blower, the sensor circuit and the electric motor starts. When the motor starts, the gear on the motor has small teeth as compared to that on the agitator. Hence, there is a very large gear ratio produced which triggers the agitator gear and the agitator itself. The rotation automatically causes the shaft or the agitator to rotate at a very top speed as both are linked with the gears. The breadth of the spikes of the agitator is well calculated (5mm less than the breadth of the machine) to prevent the spikes from touching the inner lining of the chamber (fiber glass) to prevent it from frictional effect, and tear and wear of the machine. The agitator's movement continuously stirs the maize to ensure that the heat is evenly distributed as they are being dried from the air and heat supplied by the blower. In the blower, a centrifugal fan blows on some heating elements within it to produce heated air. This kind of air picks up the moisture from the grains in the heating chamber and expels it in the surroundings through the perforated top. This process continues until the humidity and temperature sensor placed in the bottom of the design senses the moisture content is getting close to 0 and the temperature within the chamber has also exceeded 43°C. If the moisture content value is left with 10 %,the farmer is prompted as a message is printed on the screen. Finally, when the moisture content is zero, the message "Your maize is dry, remove from chamber" is printed. The humidity and the temperature are displayed on the screen on the top left corner of the front view. This will prompt the farmer to manually turn off the machine, open the outlet, which is closed with a sheet of metal, and collect the grains.

3.12. Functionality and Implication of Design and Simulation

1. The top of the machine was perforated to prevent the moisture from accumulating in the chamber to ensure a faster and uniform drying

2. Inner lining of chamber was made of a fiber glass to prevent conduction from taking place and for energy conservation.
3. The fiber glass (lagging material) lining in the chamber was simulated to find the right thickness that can withstand the maximum heat that will be generated in the chamber.
4. The body and the agitator were made of stainless steel because it costs less, has a very high hardness to resist fracture and has a moderately low thermal conductivity.
5. Sensors were used to determine when the grains are fully dried and prevent overheating of it.
6. Right size of heater used to ensure energy conservation.
7. Bearings used to firmly hold the rotating agitator made of stainless steel at both ends to prevent the agitator from swinging while stirring the grains.

4. RESULTS AND DISCUSSION

In this section, the results of the various aspects of the project are discussed.

4.1 Material Selection

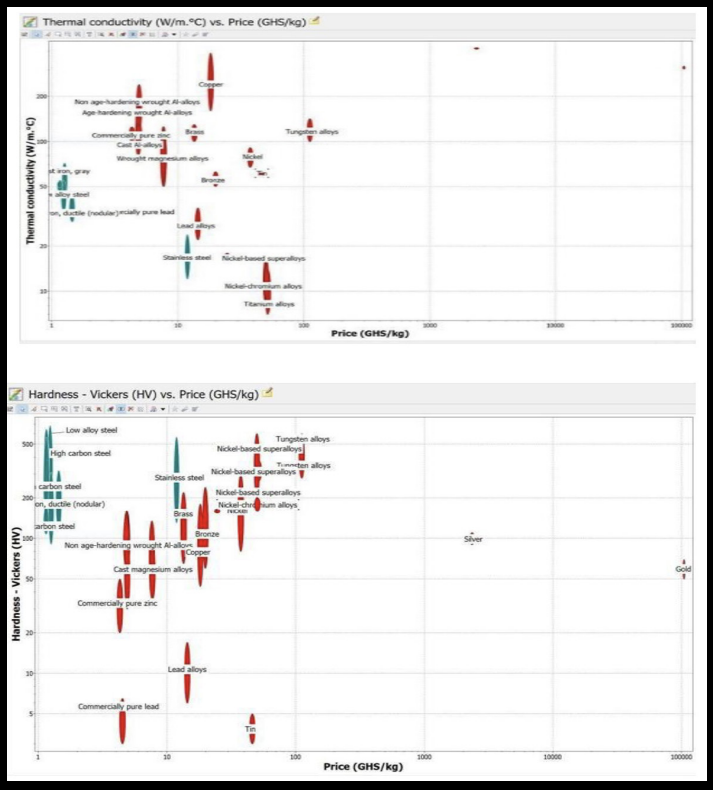


Figure 1: *CES Graph*

From Fig 1, it can be seen that in terms of hardness, low thermal conductivity and low cost, stainless steel appears to be better than the lead alloys. This means that the stainless steel can resist high forces to prevent deformation and with the low conductivity level, it will absorb no or minimal heat from the system. Fig 2-5 also shows the different views of the maize dryer designed using SolidWorks.

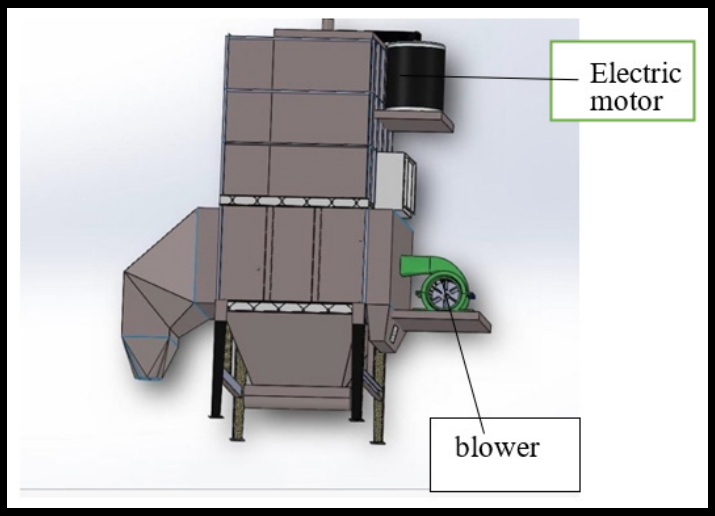


Figure 2: *Side view of the Maize Dryer*

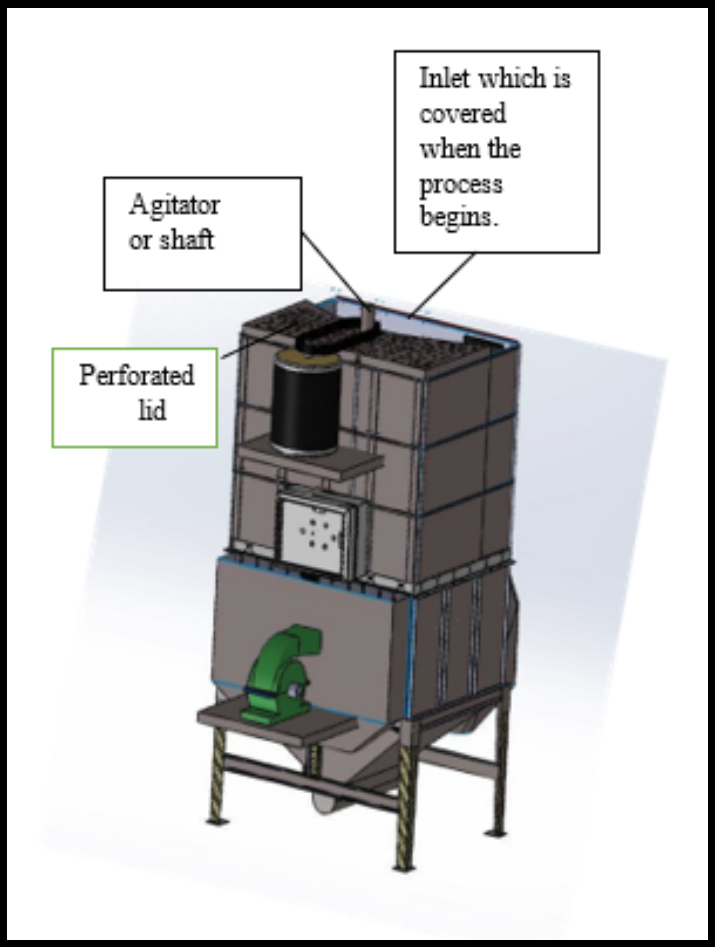


Figure 3: *Isometric view of the Maize Dryer*

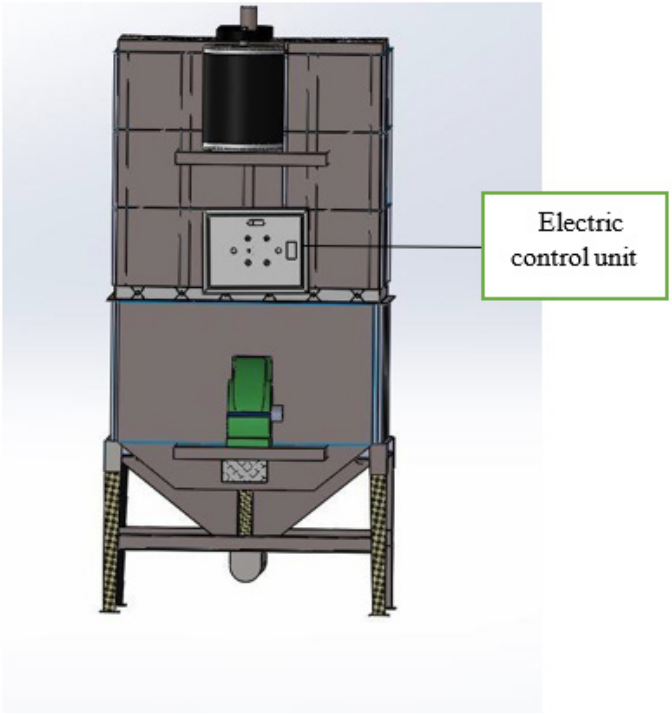


Figure 4: *Back view of the Maize Dryer*

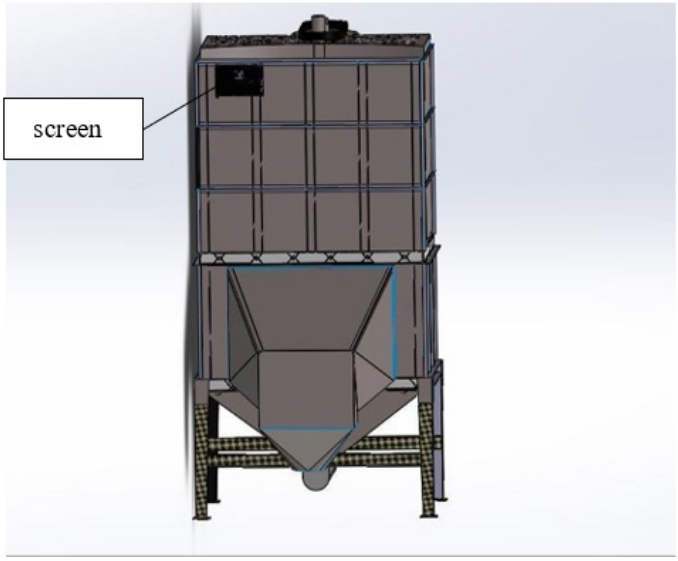


Figure 5: *Front view of the Maize Dryer*

4.2 Simulation of Main Body Part

Figures 6 and 7 show the results from the non-linear force simulation in SolidWorks performed on the main body part to choose the material that is hard, has low thermal conductivity and a low price. The simulation was done for both stainless steel and lead alloys. After locking the four edges face to hinges and applying a force of 560N on the part, the stainless steel was able to resist fracture and deformation to a larger extent as compared to the lead alloys. It was, therefore, clear that the lead alloy is very weak and cannot withstand higher number of forces applied in any direction. The stainless steel was therefore used in the final design.

4.3 Simulation of Fiberglass

Figure 8(a) shows the resulting deformation effect from the SolidWorks simulation of the lagging material, fiber glass with a thickness of 10mm. The applied heat temperature, 120°C was used. This temperature is twice more than the required temperature. Such temperature was used to monitor the worst-case scenario that can occur and lead to the failure of the machine. After applying thermal heat of 120°C (393 K) on one side of the glass, it was observed there was no deformation on the glass. It stayed as strong as without any heat applied. But for the glass in Figure 8(b), which had a thickness of 3mm, there was a total deformation. Hence, the final design had a fiber glass of thickness 10mm as the lagging material.

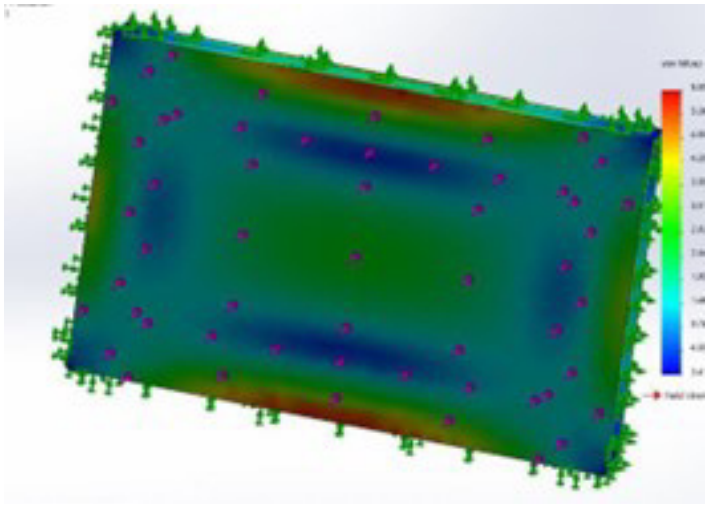


Figure 6: *Lead alloy*

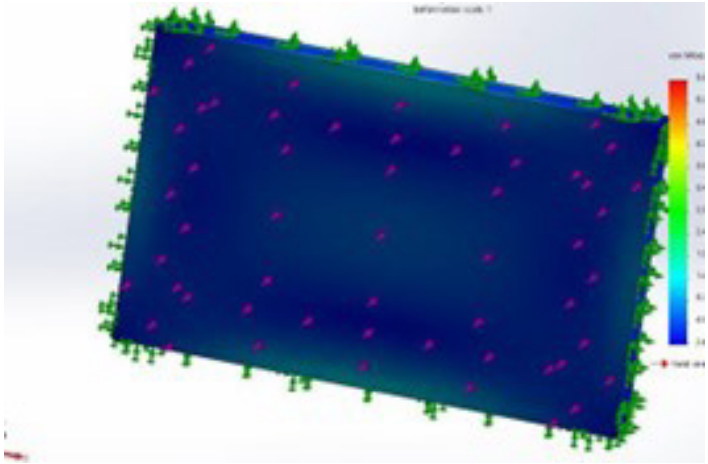
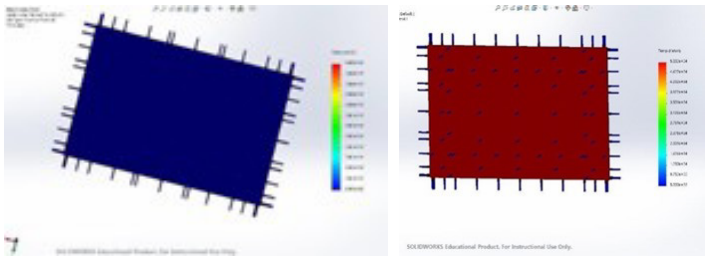


Figure 7: *Stainless steel*



(a) (b)

Figure 8: *(a) 10mm Fiberglass. (b) 3mm Fiberglass*

4.4 Function of the Induction Motor

The shaft placed in the center of the cylinder is meant to guarantee even spread of the heated air in the cylinder due to its stirring motion together with its branch-like extensions at either side. This shaft is driven by an induction motor.

4.5 The Design and Operation of the Motor

This motor is designed using the Direct On- Line method of starting with only forward controls as that is all that would be needed. With this method, there was the application of full line to line voltage at the start. The motor was then operated by controlling the energizing and de-energizing of the motor coils. When the start button is pushed, the coil becomes energized, the normally open contacts close and allow current to flow through them. The motor keeps functioning after the push button is released because the auxiliary contact is engaged when the start button is pushed initially. To switch off the motor, the stop push button is pushed and the coil de- energizes and all the contacts open once again thereby causing the motor to go off. This method of starting motors is best used for a smaller motor application. Since this maize dryer is being designed for small scale farmers and there are not much control requirements, the direct on-line method is ideal due to its simplicity [8]. Thermal relays and fuses are also employed in the design for protective purposes but are not seen in Figure 9 schematic due to the limitations of the software used.

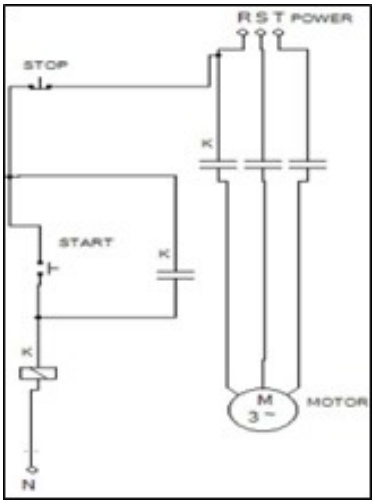


Figure 9: *Design schematic of the induction motor*

4.6 Operation in Conjunction with the Shaft

The power source of the motor is the same source from which the main heating element and the blower get their power from. Once the main power is switched on, the heat exchanger and the blower immediately start operation. The start button of the motor is then pushed after a few minutes to begin agitation of the shaft and to enable even circulation of the heated air.

4.7 Simulation of Sensors

The sensors to determine the temperature and moisture content in the chamber were programmed in Arduino as shown in Fig 10.

DHT_sensor_for_maize_dryer §

```
// intialisation of DHT sensor
#include "DHT.h"
#define dht_1 2
#define DHTTYPE DHT11
DHT dht(dht_1, DHTTYPE);

void setup() {
  Serial.begin(9600);
  dht.begin();
  delay(2000);
  //Initial readings when maize is placed in chamber
  float humid = dht.readHumidity();
  float temp = dht.readTemperature();

  Serial.print("Initial conditions of chamber");
  Serial.println("Moisture content(chamber)= ");
  Serial.println(humid);
  Serial.println("temperature(chamber)= ");
  Serial.println(temp);
  Serial.println("°C");


}

void loop() {
  delay(2000);
  //condition for dry maize
  if (humid < 1.0 && humid > 0.0) {
    Serial.print("Maize is dry, remove from chamber");
    Serial.println("Moisture content(chamber)= ");
    Serial.println(humid);
    Serial.println("temperature(chamber)= ");
    Serial.println(temp);
    Serial.println("°C");
  }

  // condition for when maize is almost dry
  else if (humid <= 10.0 && humid >= 1.0) {
    Serial.print("Maize almost dry");
    Serial.println("Moisture content (chamber)= "
    Serial.println(humid);
    Serial.println("temperature(chamber)= ");
    Serial.println(temp);
    Serial.println("°C");
  }
  else {
    Serial.print("Maize not dry yet")
    Serial.println("Moisture content = ");
    Serial.println(humid);
    Serial.println("temperature= ");
    Serial.println(temp);
    Serial.println("°C");
  }
}
```

Figure 10: *Arduino code for sensors built with Proteus*

5. CONCLUSION AND FUTURE WORK

As was discussed, the CES software helped in settling on which material to use for the design. The material selection was pivotal as the success of the simulation is dependent on the material chosen. From the simulations, it was observed that Stainless Steel was better resistant to the force which was applied to it as compared to Lead alloy thus was chosen. The simulation for the fiber glass proved that the 10mm thickness was more desirable. Adopting the maize dryer would improve the financial gains of the farmers as it would reduce post- harvest losses of their crops. For future works, integrating machine learning models into the system will help to predict when the maize will dry even before the process is started. This will go a long way to save time in supervision of the drying process.

ACKNOWLEDGEMENT

A very special thank you to Mr. Richard Akparibo and Emmanuel Asare for their encouragement and advice in making this project a success.

REFERENCES

[1] B. Fashina , A. Olanrewaju, and A. Sanusi. (2013). Design parameters for a small-scale batch in-bin maize dryer. Agricultural Sciences. 04. 90-95. 10.4236/as.2013.45B017.

[2] E. O. R. Ayodele, “Design and Construction of Electric Corn Dryer,” 2016.

[3] M. A. C. Purio, J. D. P. Matanguihan, S. K. R. Peña, G. M. V. Principe and E. J. T. Tabada, "Solar-Powered Paddy Grain Humidifier-Dryer," 2016 IEEE Region 10 Conference (TENCON), Singapore, 2016, pp. 3414-3419, doi: 10.1109/TENCON.2016.7848688.

[4] S. S. Hidayat, A. Suharjono, T. Prasetyo, Jumi, A. Roihatin and A. S. Alfauzi, "Development of Two-In-One Type Drying Machine and Grinder Control System Based On Wireless Sensors Network," 2018 International Conference on Applied Science and Technology (iCAST), Manado, Indonesia, 2018, pp. 750-753, doi: 10.1109/iCAST1.2018.8751611.

[5] Y. Jin, Z. Zhang, D. Yang, H. Zhang and J. Yin, "Design of A New Type Horizontal Rotary Drying Chamber," 2021 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS), Xi'an, China, 2021, pp. 270-273, doi: 10.1109/ICITBS53129.2021.00074.

[6] Timothy, V.O, Adegbenro and K.R., Saliu, “ Development of maize - on - cob- dryer for small scale farmers. Scientia Agriculturae,” 2016, 172 - 178. 10.15192/PSCP.SA.2016.14.1.172178.

[7] M. Kriang-Krai, “Mobile maize dryer development at farm and cooperative/collector levels,” 2015.

[8] K. Stanislav, O. Petr and P. Pavel,” Simulation of Start-Up Behaviour of Induction Motor with Direct Electronic Engineering,” 2018, 15. 10.15598/aeee.v15i5.2342.

Interview 02

Ashesi iGEM Team Interview

Q: What can you tell us about iGEM?

A: The International Genetically Engineered Machine (iGEM) Foundation is an independent, non-profit organization dedicated to the advancement of synthetic biology, education and competition, and the development of an open community and collaboration. This is done by fostering an open, cooperative community, and friendly competition. iGEM's biggest program is the iGEM Competition. The iGEM Competition gives students the opportunity to push the boundaries of synthetic biology by tackling everyday issues facing the world. The major competition will take place in Paris (France) this year, after two long years of online presentations. The team and I simply cannot wait.

Q: What is your project about?

A: The background to the project is that: the global growth in raw material consumption has skyrocketed over the years. This trend has been driven by the evolution of technology (from the 1700s – 2000s). In the local setting, the prospects of gold mining have attracted illegal explorers (with very little patriotism) to unearth these precious minerals and cause: the destruction of arable land, the death of locals, deforestation, ground water pollution...the list is endless. We aim to design a bio-sensor that can reduce environmental degradation. We seek to engineer a number of E-Coli that separately detects the presence of Au and some selected pathfinder elements, that signal gold prospects in a location. These bacteria will be co-cultured to serve in a multifunctional biosensor which only produces a bioindicator when pathfinder elements or Au are found on the earth's surface. To ensure containment of the biosensor, we are also designing several layers of security: a UV-triggered autolytic kill-switch, and a hydrogel capsule.

Q: Does your field of study play a significant role in your ability to deliver results for your tasks on the team?

A: Not necessarily. Well as a CS major, it does when you think about the programming aspects. For example, deriving differential equations for models and solving them using MATLAB tools. However, a lot of the concepts are generally new. As is typical with new things, you just have to be willing to go far and beyond, to push yourself out of your comfort zone. That's what I love about iGEM.

Q: How as the journey been?

A: It has been a real eye-opener. We have had various sessions with other iGEM teams and schools, such as: University of Exeter (U.K), Stony Brooks (U.S.A) and Goethe University Frankfurt (Germany). We were also able to meet and discuss our project with head geologists at the Minerals Commission of Ghana. It has been exciting meeting these different people and interacting with them. It appears our project is very relatable, as galamsey (illegal mining) is rampant in several countries – including Ghana. We have begun wet-lab work, and I must say I enjoy putting on the lab-wear and gloves! It was especially fun to travel to France with my friends. Dr. Rosca is such an amazing Principal Investigator. In our spare time, she took us to see wonderful monuments in Paris. These included: The Eiffel Tower, the Louvre, the Arc de Triomphe, and many others! The most exciting part of the journey was presenting to distinguished judges at the event – my team and I presented our project with confidence and poise. During the team booth display, several other teams from around the world came to us and were genuinely excited by our project and flashy electronics. It was super motivating and inspiring!

Q: Any major challenges you on this journey?

A: All the members of my team have a background in Engineering (Mechanical/Electrical), or in Computer Science, so it was challenging to familiarize ourselves with the biological concepts at first. But I truly believe that we have made headway and learnt very effective research methods – a great skill to have. It was also difficult incorporating the feedback from the Minerals Commission. They advised us to explore ways to make our bio-sensor capable of working underground. Our initial concept was that the sensor will be sprayed on the earth surface, and detect these selected path finder elements. It does seem however, that the brainstorming sessions with the team is very effective. We have been able to come up with a containment structure for the biosensor, that will ensure elements are detected underneath the surface. We will accomplish this by implementing a 3-D printed staff that holds the bacteria, and has a distinct shape, to allow it to increase surface area underground (for more interaction with pathfinders).

Q: What was your aim in this competition?

A: To design and prototype the gold biosensor, and to compete with other iGEM teams on a global level. I was also looking forward to making lasting networks with my teammates and other iGEMers as well. Ashesi has participated three times in this competition (since 2017), and have won back-to-back silver medals. This new 2022 team also wishes to go above and beyond, to capture another medal for Ashesi University – spoiler alert we did!

Q: Anything else you would like us to know?

A: For more information on our project, please check our amazing Wiki page:
https://2022.igem.wiki/ashesighana/#

By
Joel Semanu Akorli

Engineering Department
Ashesi University

Design of Internet of Things (IoT) Based Wearable Electrocardiogram

ABSTRACT

An electrocardiogram is a recording of the electrical activity of the heart. It is a crucial technology for the early detection and diagnosis of heart-related issues such as heart arrhythmia and other abnormalities in the heart. Most ECG machines, both the handheld single lead devices and standard 12 lead ECGs found in hospitals make use of adhesive gel electrodes which are uncomfortable for long periods among other issues. These devices are also quite expensive for the average Ghanaian. The standard ECGs found in hospitals also lack remote capability and the ability to transfer and store results instantly over the internet. This project explores the design of a wearable, low-cost, IoT device that will cater to each of these limitations. Textile electrodes sewn into a shirt are used in place of the gel electrodes to avoid irritability and the wearing off of electrodes in long-term usage. A design based on a low-cost microcontroller, the esp8266 together with other circuit components is employed to ensure the system is affordable and has remote capability. Digital processing techniques are also implemented both in real-time and through post-processing in MATLAB to provide alternative means of processing the signal from the electrodes. Results obtained from testing show that the prototype could provide accurate ECG results remotely both in real time and for storage and was comfortable and affordable for the user.

Keywords *- MATLAB, Electrocardiogram, Electrodes, Printed Circuit Board.*

1. INTRODUCTION

1.1 Background

It is often common knowledge and studies also prove that cardiovascular diseases are one of the main causes of death around the world. “In 2015, 2,712 630 resident deaths were registered in the United States, and 10 leading causes accounted for 74.2% of all registered deaths. Of the 10 leading causes of death, heart disease was No. 1” [1]. One of the primary means of early diagnosis of heart disease and irregularities in the functioning of the heart is using electrocardiograms. An electrocardiogram provides information about the heart rate and rhythm by recording the electrical activities of the heart. It is an effective tool and procedure for detecting abnormal heart rhythms and checking on the general conditions of the heart.

1.2 Problem Definition

In this project, one of the key issues being tackled was cost. “Compact personal-use ECG devices’ costs start at about $50 and go up to $300 or more depending on the brand and model. Clinical and hospital-grade ECG monitors typically begin at around $200 and can go up to several thousand dollars each” [2] and this is quite expensive for the average Ghanaian. Therefore, for patients in need of constant monitoring, the price of the ECG becomes a major hurdle for them. Also, the standard 12-lead ECGs cause some discomfort to patients in prolonged usage due to the irritation caused by the adhesive gel electrodes. Comfort is not the only issue with these gel electrodes as it may affect the signal quality during long-term monitoring [3]. As the gel dries up it loses some amount of contact with the skin and begins to produce inaccurate readings. Most standard ECG machines are also not cloud-enabled and do not offer easy access, storage, and retrieval of ECG information remotely. However, it is vital to be able to keep a record of a patient's reading since this can be useful in diagnosis.

1.3 Objectives of the Project Work

• Design of an alternative ECG device/product that would be more affordable: One of the major goals would be to significantly reduce the production cost and selling price of this device to make it more accessible to the Ghanaian community. Although it will be less costly, there should be no trade-offs in terms of accuracy and quality of readings as this would defeat the entire purpose of the test. The goal is for the average Ghanaian to be able to accurately monitor their heart without significant financial loss.

• Provide more comfort: As discussed earlier the current 12 lead ECG machines make use of adhesive gel electrodes which cause discomfort to patients among other issues. A better, more suitable, and more comfortable material could replace these gel electrodes which would provide equally accurate readings. Alternatively, necessary modifications or improvements could be made to these gel electrodes which would solve all pertinent issues.

• Long-term monitoring without any hitches – To avoid the risk of making readings at times where the issue may not be visible, this project should be able to offer prolonged monitoring over an extended period. With this in place, diagnoses can be made with more certainty, and patients already requiring long-term monitoring can also make use of this product.

• IoT Enabled: The product should be able to communicate with cloud services such that the ECG information may be stored and viewed on any device at any time. The stored data can then be analyzed to make the necessary derivations and conclusions.

2. MATERIALS AND METHODS

2.1. Introduction and Technical Approach

The goal of this project is to design and implement an IoT-based wearable and affordable ECG device to provide both short-term and long-term monitoring for people who have limited access. This product will make use of textile electrodes instead of gel electrodes to provide more comfort. It will also be very affordable and accessible to the average Ghanaian. It will provide accurate and reliable readings and will keep a record of all readings for long-term patients for future referral. To create an ECG, firstly the signal needs to be obtained from the body using electrodes. There are different systems for electrode placement, therefore for this project Einthoven's triangle, consisting of 3 electrodes, is the chosen system. This theory depicts an imaginary equilateral triangle having the heart at its center which is formed by lines that represent the three standard limb leads of the electrocardiogram. These leads are the right arm (RA), left arm (LA), and left leg (LL). Einthoven's Law explains that Lead II's complex is equal to the sum of the corresponding complexes in Leads I and III and is given as II = I + III making them electrically equilateral [4]. Based on this theory a three-lead ECG can be generated which according to a study done by the Scandinavian Journal of primary health care has an accuracy level of 96.6% [5]. After the signal from the electrodes has been obtained it needs to undergo signal conditioning which includes amplification and filtration of the signal before conversion into digital form. There are two ways of achieving this, either through analog signal processing or digital signal processing and for the purposes of this project, each of these methods is going to be used and implemented.

2.2 General System Requirements:

Cost: The system needs to be affordable for the average Ghanaian such that more Ghanaians will have access to vital diagnostic information about heart diseases to prevent critical illness and untimately death.

Lightweight and comfortable: The system needs to be lightweight since it is going to be worn for extended periods. Itchiness and electrodes coming off must also be guarded against by using textile electrodes instead of gel electrodes. This is essential as discomfort due to heaviness or itchiness may disrupt the ECG readings and result in an inaccurate diagnosis.

Long-term monitoring: The product must be suitable for long-term monitoring by providing reliable and accurate readings and having a system in place to keep a record of these readings and to make them easily accessible.

Abnormality detection: The system should be able to detect abnormalities in the rhythm of the heart by extracting information about the peaks of the graph.

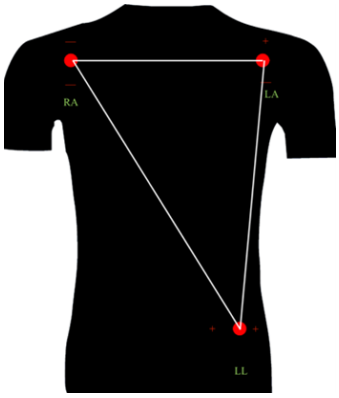


Figure 2.1:*Proposed shirt design showing electrode placement*

2.3 Analog Signal Processing System Design

2.3.1. Requirements

• High input impedance to prevent distortion of the measured signal.

• High common-mode rejection ratio to suppress common-mode interference.

• The system should be small (<15cm2) to ensure portability.

• High sensitivity (10mm/mV) for high responsive to weak ECG signals

• High accuracy of measurements and precision as well.

• Low power consumption.

2.3.2. Materials

• Textile electrode
• LM358 OpAmp
• ESP8266 Microcontroller
• Voltage Regulator (LD11117V33)
• Power Source (Lithium-Ion Battery)
• Resistors
• Capacitors

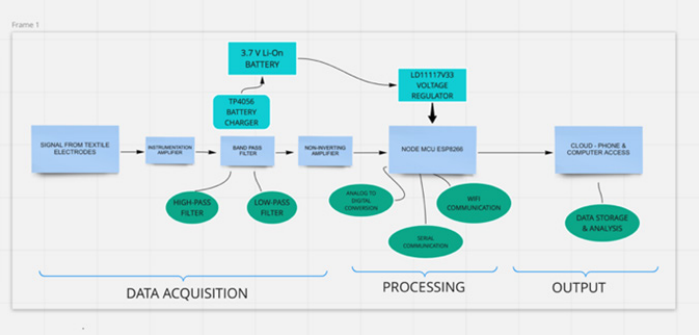


Figure 2.2: *System block diagram*

2.3.4. Circuit Design

The circuit diagram was designed using NI Multisim software. Figure 2.3 shows the various connections between the components listed in Section 2.3.2

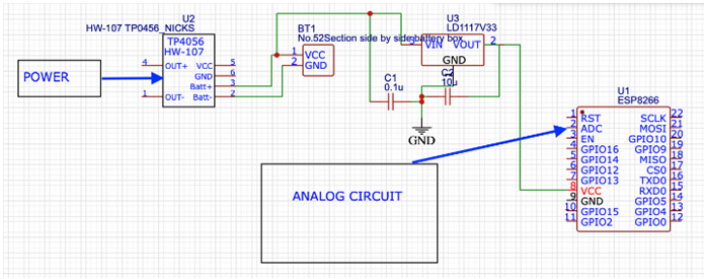


Figure 2.3: *Diagram showing connections between components*

2.3.5 System Operation

The system operates in stages as depicted by figure 2.2. First, the signal obtained from the electrodes is usually very small at about 1-10 mV and a frequency range of 0.05 - 100 Hz, hence it is amplified by an instrumentation amplifier with a gain of about 200. This brings the voltage to around 1.5V given a typical signal of about 7 mV. An instrumentation amplifier was chosen because it has a high input impedance and a high CMMR which is useful for capturing data from low voltage signals and restricting common-mode interference. The signal is then passed through a low pass filter to help remove higher frequency noise with a cut-off frequency of about 33 Hz. An active 2nd order low pass filter was chosen because they provide better roll-off and a voltage gain as well. The signal then goes through an active high pass filter to eliminate DC offsets that arise because of muscle noise. The cut-off frequency is set to about 0.48 Hz. Subsequently, the filtered signal goes through a non-inverting amplifier with a gain of about 2. It then arrives at the analog input of the ESP8266 for analog to digital conversion. After the digital version of the signal is obtained, the application transport protocol, MQTT together with the chosen communication technology, Wi-Fi is used to publish the data to an online cloud service for storage, further analysis, and easy access on any device.

2.3.6 IoT Architecture

A. Sensor/ECG tracking node:

The ECG nodes, which are the electrodes are responsible for obtaining the bio-signals from the patient's body and transporting it through wires to the circuit. The signals are typically very noisy hence most of the noise is eliminated and the signal is amplified before being sent to the processing unit by the analog circuit.

B. Signal processing unit:

The microcontroller receives the signals from the previous stage in this unit. To transform the incoming signals to the digital realm, the esp8266 was employed as an intermediate stage. Because the ESP8266 is used as an analog to digital converter, the system is less susceptible to noise than if a specialized ADC system had been used, which would have resulted in more contamination of the bio signals received.

C. Cloud Server & GUI:

When the framework receives a large amount of Electrocardiogram data from the tracking node, an IoT cloud provides a speedy and appropriate way to deal with the stored data in the cloud and to display the ECG signal as needed. As a result, an Internet-of-Things cloud is used, based on the method of website assistance, cloud, and data storage. The ECG information can be retrieved by going on to the Internet cloud and using a web browser on any operating system to access a specific web site. As a result, all smart devices, including smartphones, desktops, and laptops, may access the Internet-of-Things cloud [3]. The customers can also get historical data as well as a real-time ECG signal.

2.4 DSP Implementation

2.4.1. Post Processing Using MATLAB

With this approach, after the raw signal is received through the ADC input of the microcontroller it is sent straight to MATLAB through the ThingsSpeak platform for filtering and feature extraction. As explained in section 3.4.1, it is passed through a high pass filter and a moving average filter to obtain the filtered signal. The notch filter may be used if the system was connected to the main power supply rather than a battery source. A script for sending and receiving the signal in MATLAB from the microcontroller is first executed. Afterwards, some features are extracted from the filtered signal mainly using the find peaks function in MATLAB. These include the R peaks, S peaks and Q peaks to form the QRS complex. These features are very useful in giving an accurate diagnosis of heart-related issues such as heart arrhythmia. R peak detection in ECG is one such method that is widely used to diagnose heart rhythm irregularities and estimate heart-rate variability. The heart rate is also calculated using the R peaks.

Based on what was discussed in this chapter, the prototype was developed.

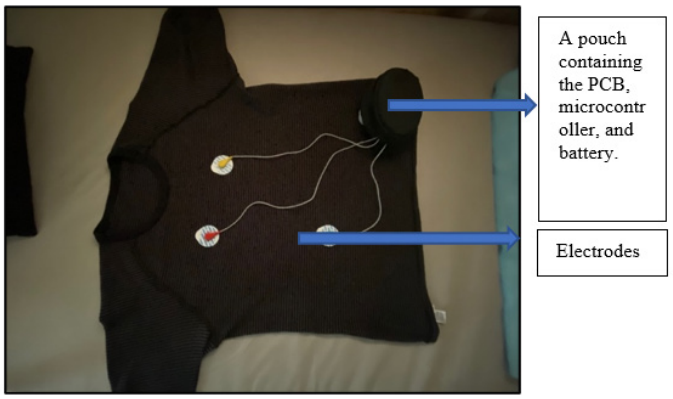


Figure 2.4: *Wearable ECG prototype*

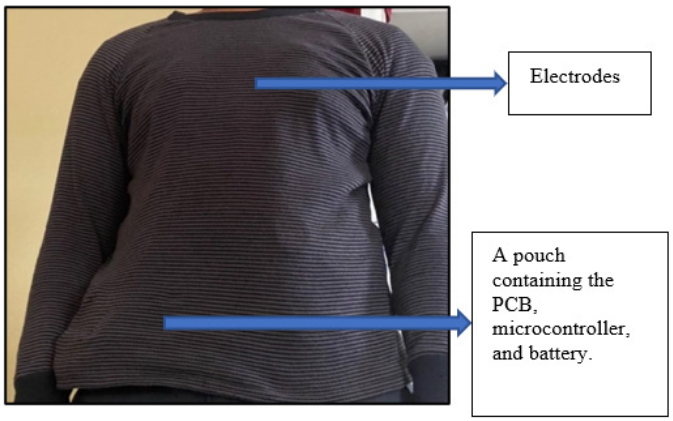


Figure 2.5: *Subject wearing prototype 1*

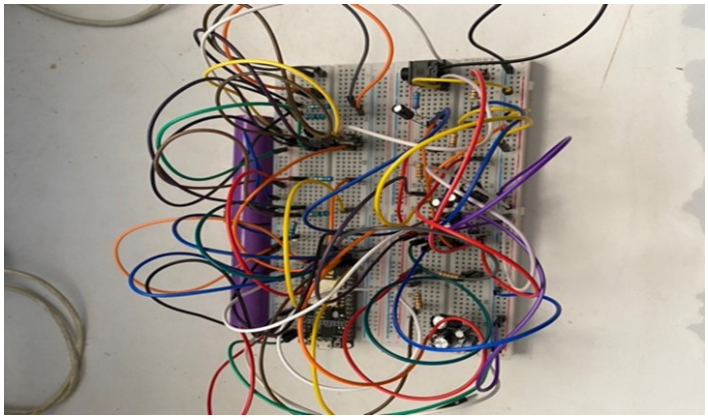


Figure 2.6: *Breadboard circuit*

After approval was obtained from the Institutional Review Board (IRB), the prototype was tested as seen above. The documents required for IRB approval included a consent form that explained the testing procedure to the prospective subject. The breadboard was used in place of the PCB temporarily as the PCB had not arrived at the time.

3. RESULTS AND DISCUSSION

3.1. Software Simulation Results

3.1.1. ASAP System

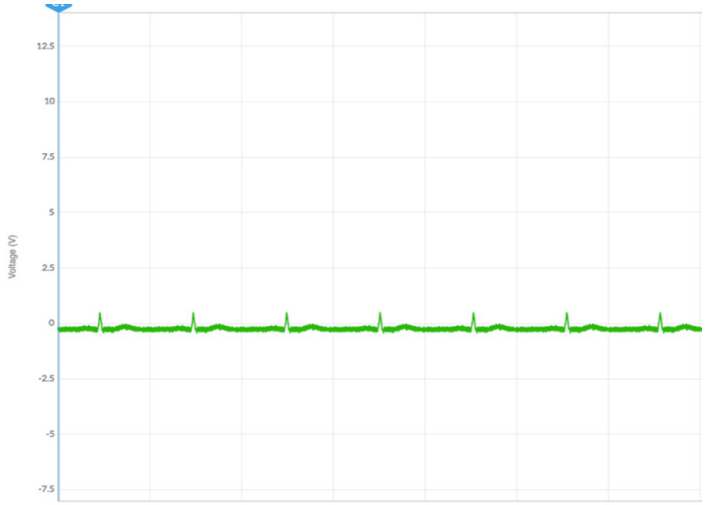


Figure 3.1: *Original signal*

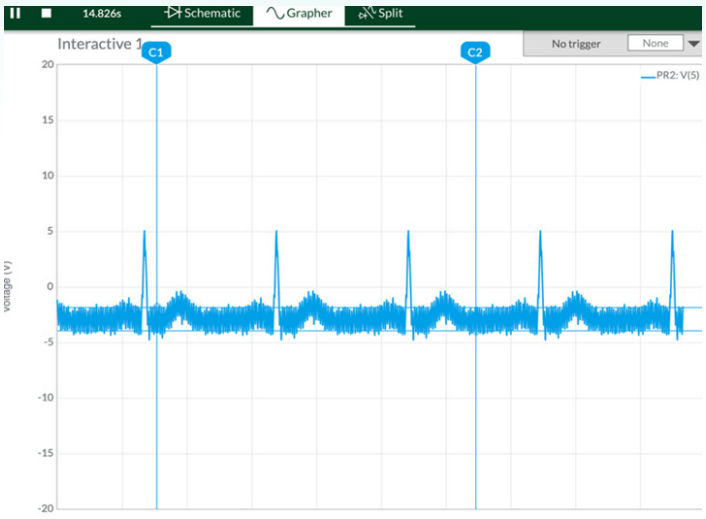


Figure 3.2: *Amplified signal*

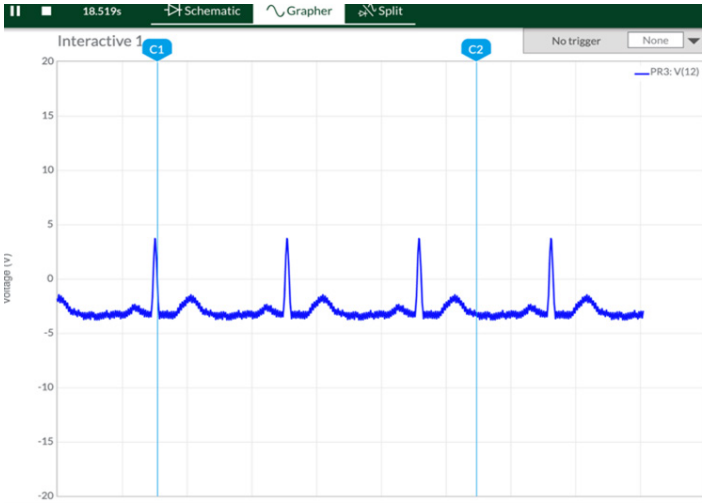


Figure 3.3: *Filtered signal*

Before the prototype was developed, simulations were ran to ensure the circuitry would work as desired. In Figure 3.1, the original signal which was obtained from an online database is displayed and is shown to contain a lot of noise. This noise is caused by electrodes capturing more than just the electrical activity of the heart. The primary electrical components captured are the myocardium, muscle, skin-electrode interface, and external interference. In figure 3.1 the amplified signal which has been passed through the instrumentation amplifier is displayed. Since this signal was obtained from an online database for simulation purposes, its original voltage was about 800 mV, and this led to an adjustment in the gain of the instrumentation amplifier to 5. As can be seen on the axis of the graph, the signal voltage increased from about 800 mV to 4 V due to this gain. In figure 3.2 the low-frequency noise and high-frequency noise have been removed from the signal leaving the filtered signal.

3.1.2. DSP System

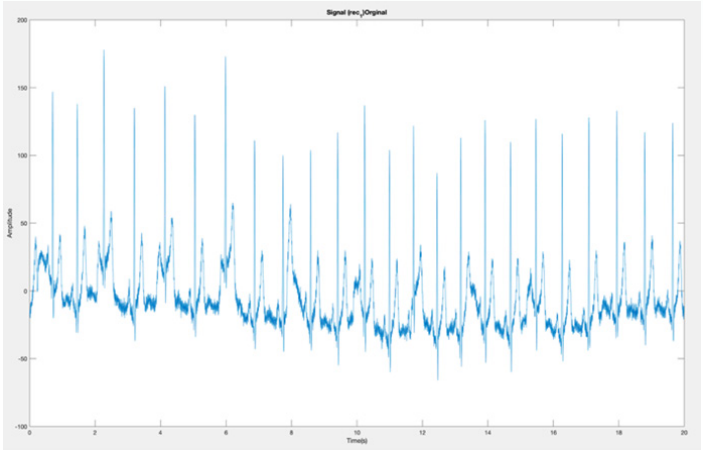


Figure 3.4: *Original signal*

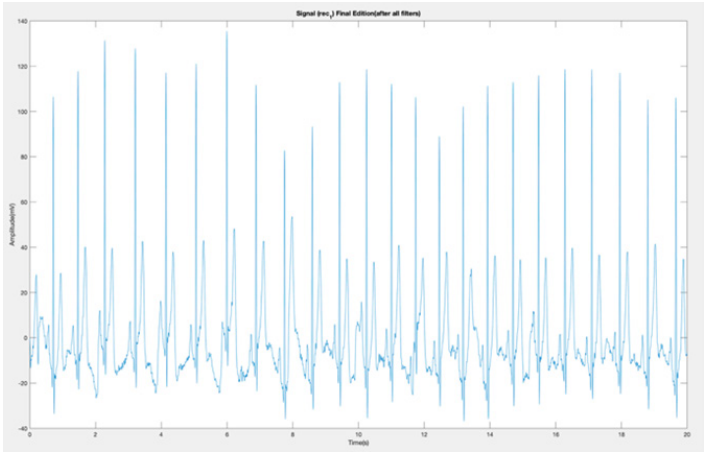


Figure 3.5: *Filtered signal*

The notch filter was also applied here since there was some power line interference (50 Hz) as the signal was obtained from a device in Russia where the power line frequency is 50 Hz. The signal is noticeably much clearer and more refined compared to the analog processing simulations. A contributing factor to this is the internal tolerances and impedances in the analog components such as the OpAmp which has been incorporated in the simulation software.

3.2. Physical Implementation Results

3.2.1. ASP System

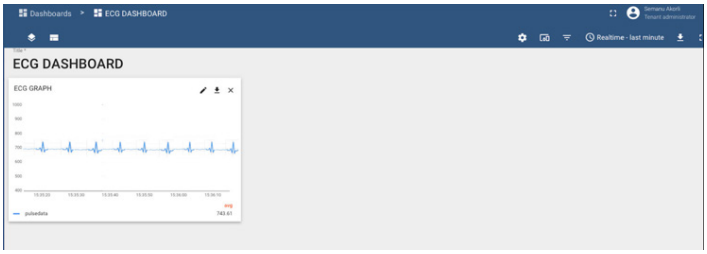


Figure 3.6: *Results on ThingsBoard dashboard*

Here the ECG information is displayed on the dashboard in real-time. Past recordings are also kept and can be accessed for up to 30 days. The waveform is not exactly as desired here since there is some latency in sending the data to the dashboard. Also, there is little amount of processing power since the resources being used to process the data are from a free cloud-based provider. The QRS complex can be seen with each of the Q, R, and S waves identifiable.

3.2.2. Post-Processing with MATLAB

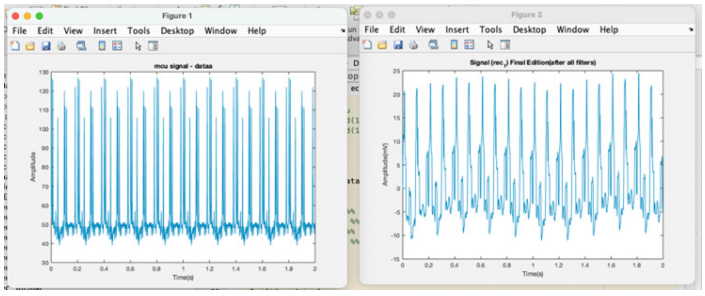


Figure 3.7: *MCU Signal before and after filtering in MATLAB*

The signal obtained in MATLAB is also much improved since the processing of the signal was done on the local computer rather than a free cloud-based processor which allocates very little processing power.

3.2.3. Data Analysis

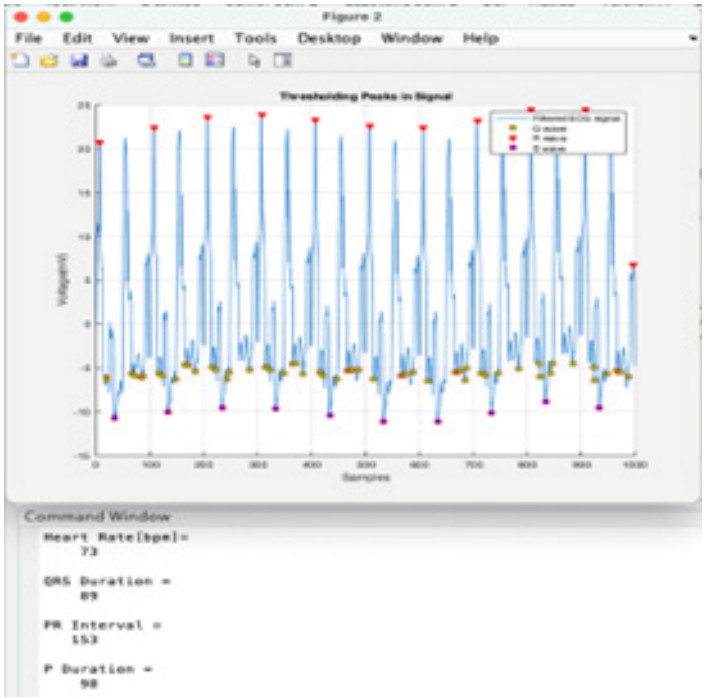


Figure 3.8: *Results showing QRS Complex and other features*

Here the same functions used in extracting information from the simulated signal are used here on the filtered signal from the prototype with a few adjustments made for the size since the simulated signal is much larger. The size of the signal can be increased by taking the measurements over a longer period as this data was obtained from tests completed within 5 minutes.

3.4. Statistical Analysis & Comparison to Standard ECG

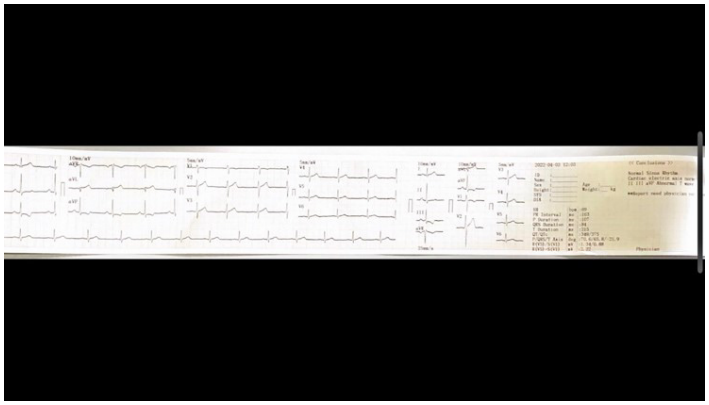


Figure 3.9: *ECG Results obtained from a standard 12 lead ECG Device*

A 12 lead ECG test was performed on the same subject as was used in testing the prototype at the Ntambea health center and the results above were obtained. The ECG test for the prototype was performed three times to determine the precision of the measurements. To determine the accuracy of the results obtained in the prototype, the PR interval, QRS duration, T duration, and heart rates were compared to those obtained in the standard ECG test to determine if these values were accurate. Values obtained from the standard test as shown in Figure 5.11: are as follows: Heart rate: 69 beats per minute, PR Interval: 163 ms, QRS Duration: 84 ms, P Duration: 107 ms.

3.4.1 Test for Precision

With Standard Deviation (S.D) given as:

$$SD_{sample} = \sqrt{\frac{\sum(x_1 - \bar{x})^2}{n-1}} \qquad (1)$$

In this formula, x1 represents an individual measurement while $\bar{x}$ is the mean of all measurements within a sample. The number of sampled individuals is represented by n.

Mean given as:

$$\text{Mean } (\bar{x}) = \frac{\sum x}{n} \qquad (2)$$

Table 3.1: *Values obtained from each test and their standard deviations*

	PR Interval (ms)	QRS Duration (ms)	P duration (ms)	Heart Rate (bpm)
Test 1	153	89	98	73
Test 2	158	86	102	70
Test 3	159	84	103	71
Mean±S.D	156.67±3.215	86.33±2.490	101±2.646	71.33±1.528

The values obtained for the standard deviation show that the precision of the device is good, hence it can be relied upon to give consistent measurements.

3.4.2. Test for Accuracy

It can be observed from the results above that the error for most of the tests is not significant however the means of the measurements provide a higher likelihood of avoiding the highest errors. Hence going forward the mean of at least 3 measurements can be relied upon as accurate and appropriate for diagnosis and referral.

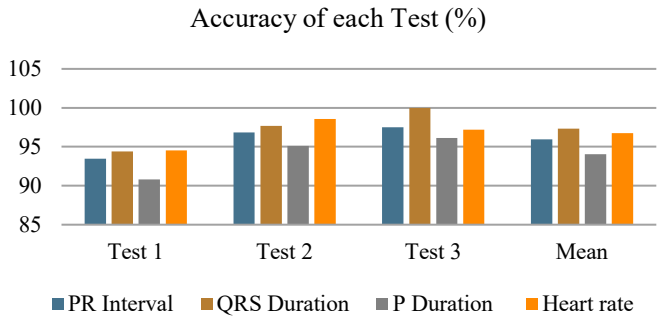


Figure 3.10: *Chart showing the accuracy after each test and the mean*

4. CONCLUSION

The ECG recorder prototype that was designed in this project is suitable for long-term monitoring, is affordable and has IoT capabilities for display and storage. The design consists of two alternative systems, an analog circuit, and a digital signal processing system to process the signal obtained from the electrodes. The analog circuit made up of resistors, capacitors, OpAmp, and other components formed amplifiers and filters which were used in processing the signal. The system was powered by a 3.7V Lithium-ion battery and the microcontroller employed was the ESP8266. The overall weight of the system was 37 grams which is light and a good weight for the user. The overall system was placed at the bottom of the shirt to help keep the shirt straight and in good form. An IoT architecture made up of Wi-Fi as the communication protocol and MQTT as the application transport protocol was used to send the electrocardiograph obtained from the system to an online platform for viewing and storage for future referral. The DSP system had two distinct features, the ability to process and filter the signal in real-time and the option to transfer the signal instantly to MATLAB for post-processing. Important information such as the heart rate, PR interval, QRS duration, and T interval were extracted and sent to the online dashboard to be used for diagnosis by a certified medical professional.
Statistical analysis showed that the results obtained from the prototype were precise and accurate.

ACKNOWLEDGEMENT

I would like to specially thank and honor my supervisor, Dr. Elena Rosca whose constant technical advice, knowledge, guidance, and unwavering support were pivotal to my journey throughout the undertaking of this project.

REFERENCES

[1] E. J. Benjamin et al., 'Heart Disease and Stroke Statistics—2018 Update: A Report from the American Heart Association, Circulation, vol. 137, no. 12, Mar. 2018, doi: 10.1161/CIR.0000000000000558.

[2] F. Salehi, T. Kazemi, and M. Hajihosseini, 'The importance of electrocardiography parameters in healthy Iranian children', ARYA atherosclerosis, vol. 13, no. 3, pp. 159–160, May 2017.

[3] Zimlich Rachael, 'Best ECG Monitors for At-Home Use in 2022', Healthline, Jan. 2022.

[4] R. Lynch, 'ECG lead misplacement: A brief review of limb lead misplacement', African Journal of Emergency Medicine, vol. 4, no. 3, pp. 130–139, 2014, doi: 10.1016/j.afjem.2014.05.006.

[5] E. Buch, 'What You Should Know About Personal ECG Devices', Medical & Biological Engineering & Computing, vol. 51, no. 5, pp. 485–495, May 2013, doi: 10.1007/s11517-012-1031-6

Interview 03

Ashesi Engineering Diary

Bio

Nancy Mma-Ngaare Mba is a final-year Electrical and Electronics Engineering student. She comes from Bongo-Dua in the Upper East region of Ghana. Nancy enjoys solving problems and leads two initiatives at Ashesi University, which she started. She currently runs Magnificent Smiles Foundation (MSmiles), a startup that provides Mentorship, STEM, Robotics, ICT and exposure visit experiences to children and young adults at orphanages and foster homes in Ghana. Likewise, started and currently co-leads the Ashesi Engineering Dairy Initiative. Through the Dairy, she hopes to work with various departments, engineering, and computer science students at Ashesi to organize speaker forums, field trips, and other programs to ultimately enrich the experiences of Engineering and Computer Science students.

Nancy M-N Mba
Program Institutor & Co-Director
The Ashesi Engineering Dairy
EEE C2023

Bio:

Eunice Tachie-Menson, an electrical and electronics engineering graduate from Ashesi University, is very passionate about working on social impact projects and developing initiatives and programs that enhances the career development of others. She enjoys mentoring and coaching others, as well as conducting research, volunteering, and teaching. Eunice co-leads the Ashesi Engineering Diary initiative, which she hopes will help engineering students identify their specific interests and career options in engineering.

Eunice Linah Tachie-Menson
Co-Director
The Ashesi Engineering Dairy
EEE C2022

Q: What is the mission/vision of the Ashesi Engineering Diary?

A: The Ashesi Engineering Dairy Initiative, a student-led initiative aimed at promoting meaningful conversations and fostering personal and career development among engineering and computer Science students at Ashesi University. Our primary objective is to create a platform that facilitates engaging discussions on engineering-related topics. Through our carefully curated programs, we strive to provide invaluable networking opportunities for current undergraduate students, graduate students, alumni, and potential employers through online and in-person speaker forums, field trips and other initiatives. By bringing together these different stakeholders, we foster an environment where connections can be forged, knowledge can be shared, and careers can be advanced.

Q: What motivated you to start the Ashesi Engineering Diary?

A: The Ashesi Engineering Dairy started on 10th January 2022 by **Nancy Mma-Ngaare Mba** when she organized a virtual speaker forum with support from Dr. Nathan Amanquah (main speaker), the Head of the Engineering Department. The theme for this forum was, **"What I wish I knew before my second year of Engineering at Ashesi"**. This event brought together engineering students including freshmen to engage speakers on their experiences as Ashesi students and upcoming engineers. The speakers shared their failures, lessons learnt, resources on specific courses and exciting projects they are working on. As students later shared the invaluable lessons and insights they had gained from the event, Nancy saw every reason to continue organizing the forums and has since worked with Eunice and other students to organize other forums.

Q: What are some past events you have organized and how would you say the A.E.D has influenced students or your target audience?

A: The team has organized multiple speaker forums and one industrial field trip.

The **first** forum, titled, *"What I wish I knew before my second year of Engineering at Ashesi"* provided valuable insights and advice for navigating the challenges of the engineering curriculum. It was a forum filled with wisdom and shared experiences.

Our **second** forum, "A Chat with an Alum," focused on the transition from campus life to the professional world. Through open and candid conversations with Nana Akua Sereboo, an Ashesi Alum, students gained valuable perspectives on topics such as national service and transitioning into industry. It served as a bridge between the academic and professional realms, providing guidance for their future endeavors.

The **third** forum, organized in collaboration with the Student Energy Club and Ashesi Career Services, explored the exciting realm of "Energy Careers after Ashesi." This event shed light on the diverse opportunities in the energy sector and inspired students to consider the immense potential within this field.

In the first half of 2023, we also organized an educational and insightful field trip to the Akuse Hydroelectric Power Plant with funding and support from the Office of the Provost at Ashesi. This experience allowed students to witness firsthand the practical applications of engineering principles and the impact of sustainable energy solutions. As students have shown interest in our initiative and have suggested key themes for forums, they would like us to address.

Q: What support have you received from Ashesi in sustaining this initiative? Has there been any faculty or authority figure that has aided the E.D to progress?

A: Dr. Nathan Amanquah, the Dean of the Engineering Department, has been extremely supportive of this initiative since its inception. The provost's office at Ashesi led by Prof. Angela Owusu Ansah funds our in-person events. The Career services of Ashesi University also collaborated with us to organize our first in-person speaker forum. We would like to express our gratitude for their assistance.

Q: What is next for the A.E.D?

A: Our vision for the future of the Ashesi Engineering Diary Initiative is ambitious yet inspiring. We are committed to organizing more captivating speaker forums, establishing an Engineering Students Association/Club, and facilitating enriching field trips.

For each incoming engineering class, we intend to organize forums like our very first one. These events will provide an invaluable opportunity for engineering and computer science freshmen to learn from their seniors and continuing students. We will invite speakers from various majors to share their academic and internship experiences, as well as provide practical tips to excel in their coursework. Moreover, we will feature engineering students who are actively involved in extracurricular activities such as non-profit management, tech business, and conference participation.

To ensure the seamless execution of our plans, our next major endeavor is to establish an Ashesi Engineering Student Association (AESA). Under this association, our initiatives will thrive, promoting networking opportunities and creating a conducive environment for learning and growth. By actively engaging our program participants, we aim to foster a collaborative spirit that empowers them to collectively solve problems that directly affect their academic and professional journey. Through this association, we seek to inspire innovation, nurture leadership skills, and build a supportive community that propels our students toward success.

Featured

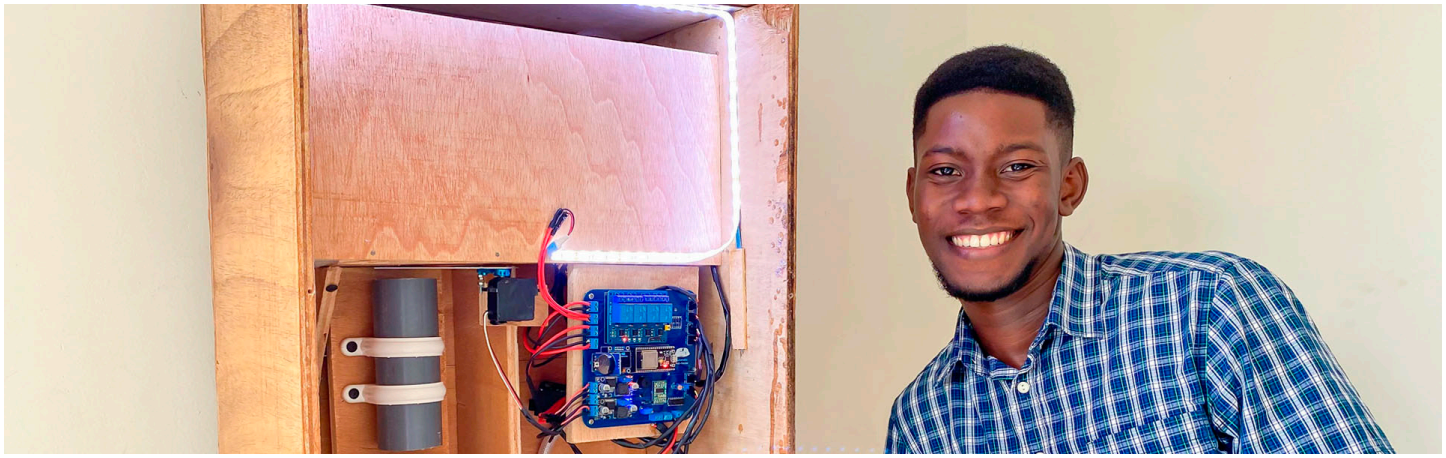
Capstone Diary

The AED **Capstone Diary** is an initiative designed to showcase the engineering capstone projects of graduating students at Ashesi University via the AED Social media pages. Through this initiative, we aim to highlight the incredible innovation, creativity, and problem-solving skills demonstrated by our talented engineering students.

The **Capstone Diary** serves as a testament to the culmination of their academic journey, featuring a diverse range of projects that span various engineering disciplines. From designing sustainable infrastructure solutions to developing cutting-edge technological advancements, these capstone projects exemplify the practical application of knowledge acquired throughout their time at Ashesi. As we get ready to fully roll out this initiative, we are thrilled to share two of the best engineering capstone projects featured in the AED **Capstone Diary**. These projects represent the exceptional talent and dedication of our graduating students at Ashesi University.

Featured

Capstone Diary



BEST Electrical and Electronics Capstone 2022 – Michael Boateng
Topic: A Multifunctional Automatic Dog-Feeder with Bluetooth and Wi-Fi Connectivity

Problem the project is addressing:

I believe that with an increasing number of households owning pets, there exists imminent time constraints in caring for them. These animals have high daily needs; and if not adhered to, they fall sick instantly. Consequently, costing owners hundreds of dollars for their rehabilitation. A modern meal delivery system could potentially solve this problem and address all the shortcomings of its predecessors.

Motivation behind project:

I'm a bit shy to talk about it (haha)...so uhm during the wake of covid I acquired a foreign dog. Her name was Tina. Yes, "was." I struggled a lot with coping with her strenuous meal preparations and medications. I lost her. I looked to technology to solve this particular problem. I did try to order available pet-feeders on the web. However, they were antiquated and flimsy. I decided to design a multi-meal-system, with water provision, medication dispensation, and pet monitoring available. This is set to satisfy distressed pets, and free owners of their time.

Main components used in the project:

- *ESP32 chip*: ESP32 chip - The central microcontroller is the brain of the entire product. It is equipped with Bluetooth, Wi-Fi, and the required GPIO pins.
-*The hardware*: This consisted of the motors to open hatches and mix the food as well. The load cell for weighing, and several other sensors for smart monitoring. The casing of the product housed many electronic components. All electronics (in one way or the other), were linked to my customized PCB.
-*The software*: This consists of the mobile app for regulating food amounts through voice command/ button control. The online monitor was coded using HTML, CSS, PHP, and MySQL, this was linked to the C program code running on the ESP32.

Major problems faced

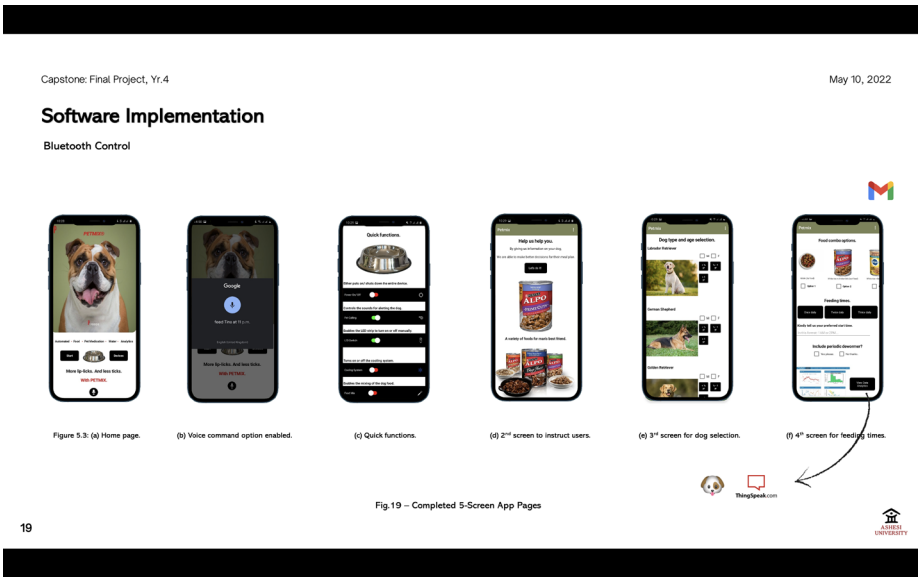
The coding of all 20 electronic components was particularly difficult. Not to mention the construction of the product itself. I always sought out advice from peers, workshop coordinators, and faculty (mostly during capstone sessions). It really helped me improve.

Advice for upcoming capstone students:

1. Start early - I started getting ideas for capstones during summer vacation.

2. Identify a topic that you are interested in - It does not need to have a fancy name; you just need to be passionate about solving a particular problem – and it has to be a **real** problem. One that will leave you feeling fulfilled in the end.

Link to demo of project: https://youtu.be/khQmykFBtg4



Featured

Capstone Diary

BEST Mechanical Engineering Capstone 2022 – Issahaku Walaman-i

Topic: Design and Implementation of a Dust Cleaning Machine to Reduce Dust Soiling on Solar PV Panels

Problem the project is addressing:

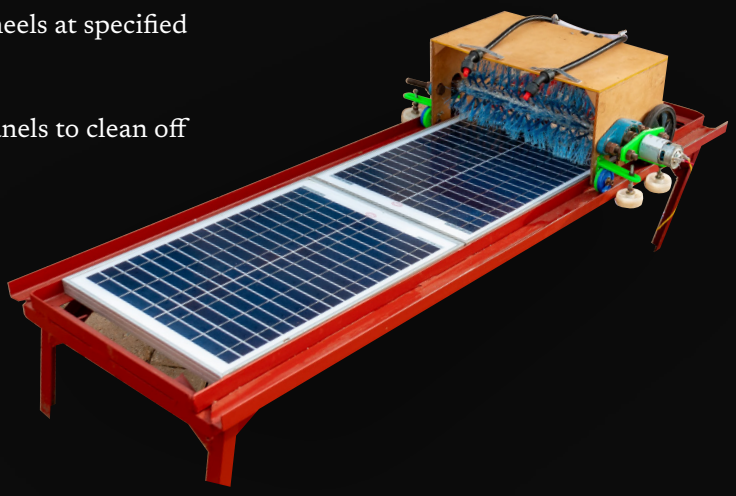
The capstone project addressed the problem of dust deposition on solar panels which reduced the amount of incident light reaching the solar cells and subsequently caused the solar panels to be relatively inefficient in power delivery. It also addressed the long-term costs associated with manual solar panel cleaning.

Motivation behind project:

With Ghana gradually introducing green technology to the national grid to supplement electricity supply, efficiency of such technologies is a requirement. This project was aimed at contributing to Ghana's renewable energy targets by motivating the adoption of green technology
by optimizing solar energy generation efficiency.

Main components used in the project:

1. Casing - To house other machine components and reduce the deposition of dust onto the cleaning brush.
2. Cylindrical Cleaning Brush - To sweep dust off the mounted solar panels.
3. Panel Mounting Rack - Platform on which the solar panels are mounted.
4. Wheels (Main and Supporting) - To move the machine linearly and also lock it onto the panel mounting rack.
5. DC Motors - To rotate the cleaning brush and the machine wheels at specified speeds.
6. Battery - To supply power to the machine components.
7. Water Pump - Sprays water at a specified pressure onto the panels to clean off dust debris.



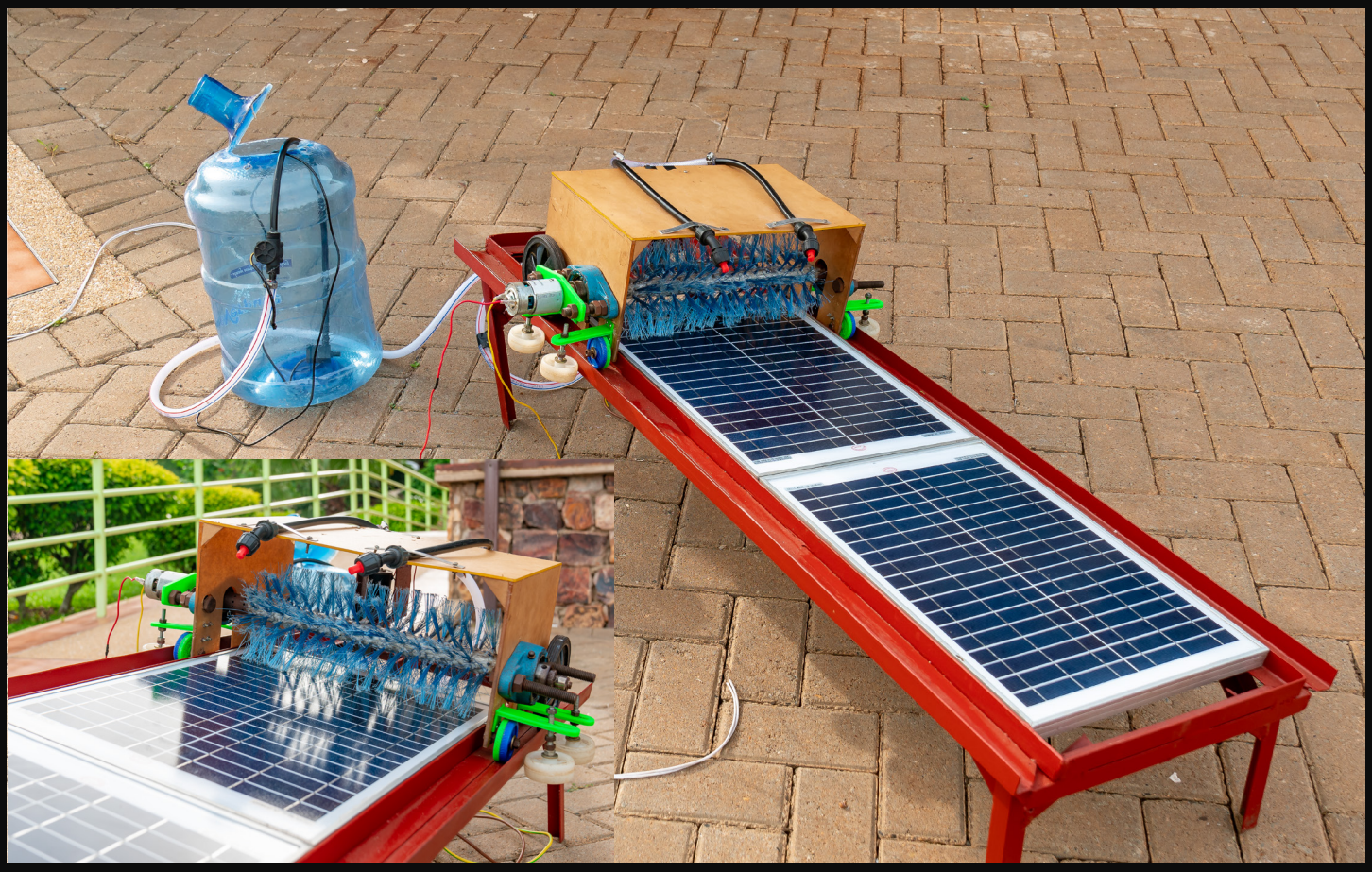
Major problems faced

1. Absence of designed components - Most components which were designed for were unavailable due to importation issues. This challenge was resolved using make-shift components and locally producing some components, including the solar panel cleaning brush and the casing.
2. Time and Budget Constraints - Given the bulk of the project, the time limit was insufficient and the budget for securing components was inadequate. I started early upon realizing this and put in extra hours to meet the deadline.

Advice for upcoming capstone students:

Be certain of your project choice, take some time to plan all key aspects of the project. Predetermine how you will be securing the appropriate components for your selected projects. Reaffirm your design choices. Start working early and use the Christmas break to make substantial progress. It initially looks complex, but it gets easier the more you put work into it. Lastly, do not just choose a project for the sake of it, choose a project that aligns with your career plans.

Link to demo of project: https://www.youtube.com/watch?v=F6LUlusQmOE



Final Note: Both projects have been presented at IEEE conferences, and have been published in the IEEE Xplore Digital Library this year! Congratulations Michael and Issahaku!

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Avoiding Bridge Failure: The Effect of Material and Bridge Structure type on Ultimate Bridge Strength

Avoiding Bridge Failure: The Effect of Material and Bridge Structure type on Ultimate Bridge Strength

ABSTRACT

Bridge failure can be catastrophic, hence the need to continuously improve bridge designs. But what material type or bridge structure type can be used to make the strongest bridge? The purpose of this research paper is to investigate how material type (wood, concrete, steel, etc.) and bridge structure type (beam, arch, and truss), in combination, affect bridge strength. In this research paper, a recommendation of the best material type and bridge structure type suitable for bridge construction will be made. A Static Stress Analysis Simulation was performed on several bridge designs of different materials and structures to determine the maximum von Mises stress for each, under normal bridge loading conditions. These bridges were first designed then simulated using Autodesk Inventor Software 2019 and based on the statistical results obtained from a Two-way Analysis of Variance ANOVA test at 95% significance level, the highest average maximum von Mises stress for bridges of structure type truss and bridges of material type steel suggest that under static stress analysis simulation conditions similar to ours, truss bridges and steel bridges are the strongest, hence are ideal for bridge construction. In this research study, we are interested in how the two factors – material type and bridge structure, in interaction, affect bridge strength.

Keywords- *Bridge strength, Bridge failure, von Mises stress, Static Stress Simulation analysis, Finite Element Analysis (FEA), Two-way Analysis of Variance (ANOVA), Tukey HSD (Honestly Significant Difference).*

1. INTRODUCTION

A bridge collapse, like that of the I-35W Mississippi River Bridge shown in Figure 1 below, can be a major disaster. Bridges that cannot hold enough weight to fulfill their intended purpose can be a serious threat to the public [2].

Figure 1: *The I-35W Mississippi River Bridge, which catastrophically failed during the evening rush hour on August 1, 2007*

The bridge catastrophically failed during the evening rush hour on August 1, 2007, collapsing into the river and riverbanks below. As a result, thirteen people were killed and over a hundred were injured [3]. The National Science Teaching Association (NSTA) later determined that a design flaw was the primary cause of the bridge's collapse [2].

Therefore, with the discussed problem in mind, this paper seeks to investigate how material type and bridge structure type, in combination, affect bridge strength with the aim of recommending to engineers the strongest material type or bridge structure type suitable for bridge construction under normal bridge loading conditions. Three main bridge structure types (beam, arch, and truss) were simulated using Autodesk Inventor software, while varying the material (wood, concrete, aluminum, steel, iron, and copper). The software uses pre-loaded scientific material information i.e., Yield Strength, ultimate Tensile Strength, Young's Modulus and Poisson's ratio to produce simulation results. All bridges will be put under fixed constraints, fixed moments, and a constant force of magnitude 5000N in the z-direction to determine the von Mises stress. The von Mises stress is a value used to determine if a given material will yield or fracture and would help us understand the ultimate bridge strength based on the two factors under study [4]. The higher the von Mises stress, the greater the bridge strength.

2. MATERIALS AND METHODS

From the main research question, the purpose of the experiment was to determine how two independent variables (material type and bridge structure type), in combination, affect a dependent variable (maximum von Mises stress); hence in the experimental design it was foreseen that a factorial test would be undertaken. Checking and testing of certain assumptions determined at a later stage whether a non-parametric or parametric factorial test was ideal for the experimental data collected.

2.1 MATERIALS

In this study, two similar laptops (Lenovo ThinkPad) with the same processor (Intel Core-i5), RAM (7.77 GB usable) and operating system (Windows 10, 64-bit) were used. A software tool, Autodesk Inventor Software 2019, was used to design and perform a Static Stress Simulation Analysis on three main bridge structure designs while varying material. RStudio was used for data analysis and the plotting of graphs, while Microsoft Excel was used to record, tabulate, and plot graphs from data collected before and after analysis.

2.2 METHODS

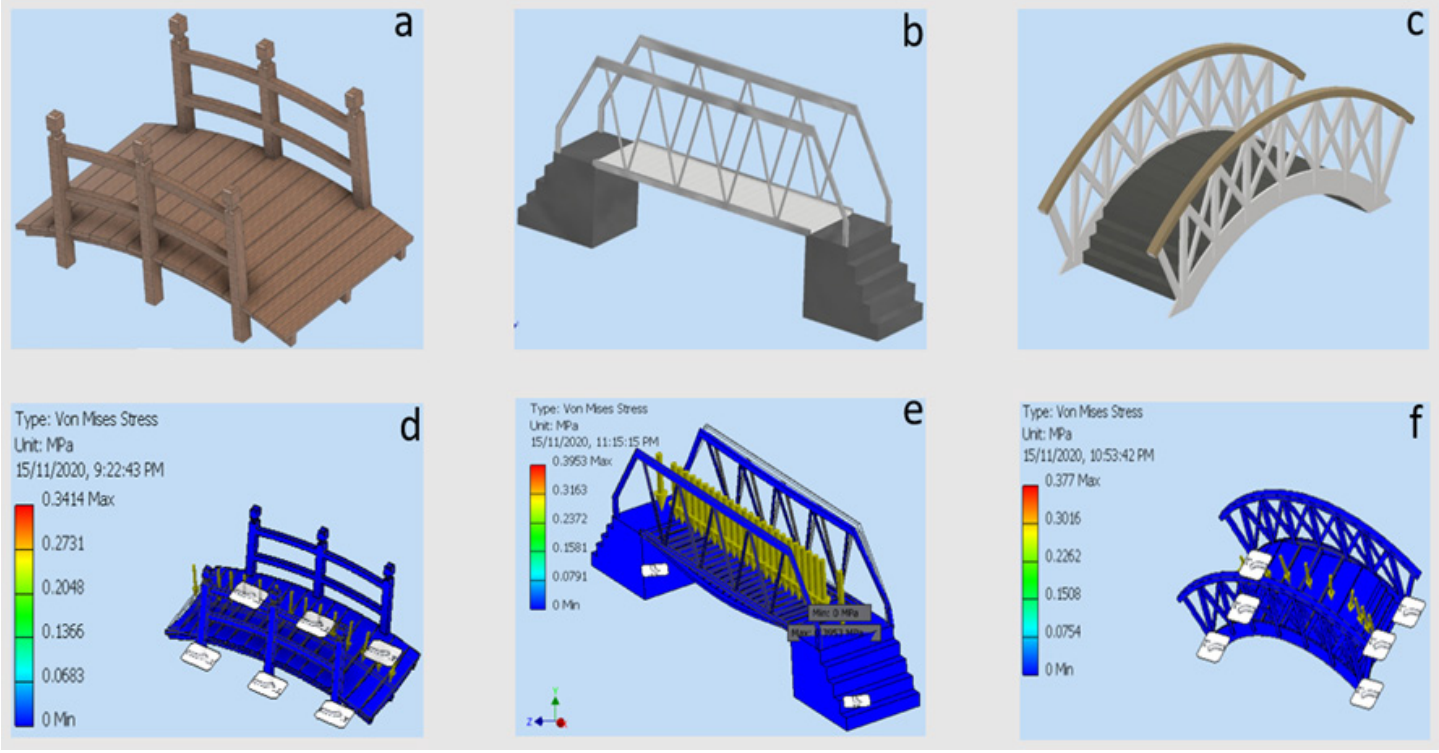

Figure 2: *(a, b, c) show the three designed bridges (beam, truss, arch) before simulation, (d, e, f) shows the three bridge designs (beam, truss, arch) with results after simulation*

A. Static Stress Simulation Analysis

Experimental Protocol - To determine which material or bridge structure type would make the strongest bridge, three bridges with different structure type were designed as shown in Figure 2(a-c) and simulated (simulation results are as shown in Figure 2(d-f)), while varying the material, using Autodesk Inventor Software to determine the maximum von Mises stress.

These materials are wood, concrete, aluminum, steel, iron, and copper. The type of simulation study performed on the bridges is Single Point Static Stress Analysis/Finite Element Analysis which evaluates structural loading conditions using pre-loaded scientific material information i.e., Yield Strength, ultimate tensile strength, Young's Modulus and Poisson's ratio to help determine the best bridge design through the stress values [3]. All bridges will be put under fixed constraints, fixed moments, and constant force of magnitude 5000N in the z-direction to determine the von Mises stress.

Varying bridge material- The same simulation on each bridge structure type was performed on two similar laptops (Machine A & Machine B) as discussed previously, with three repetitions on each machine under the same conditions while varying material type.

Afterwards, statistical analysis had to be performed based on the results obtained from this simulation to investigate whether the type of material used and/or bridge structure type had an effect on maximum stress of the bridge. To answer the main research question from the results of the statistical analysis, a comparison of the maximum von Mises stress of each bridge structure type under different types of materials helped in determining the material type and/or bridge structure type that would make the strongest bridge.

B. Statistical Analysis

After collection of experimental data from the Static Stress Simulation Analysis, the next step was to determine the most ideal statistical analysis based on the data collected, hence, a normality test was performed to determine whether a non-parametric statistical analysis or parametric statistical analysis was to be performed.

Test for normality- To check whether maximum stress, as the dependent variable, fitted a normal distribution (bull curve), we used Shapiro-Wilk normality test, a significance level of 0.05, to test if the maximum von Mises stress values are a simple random sample from a normal distribution. In other words, we formulated a null hypothesis (Ho) that the maximum von mises stress of all bridge samples are normally distributed. The Shapiro-Wilk normality test results are shown in Table 1 below.

Table 1: *Shapiro-wilk normality test*

Data	*W-value*	*p-value*	*Norm. Distributed*
von Misses Stress	0.96062	0.2247	yes

With the W-value very high (W-value = 0.96062) and the p-value > 0.05 (p-value = 0.2247) we failed to reject the null hypothesis implying that the data is normally distributed. To further verify normality, a histogram was made out of this dependent variable to visualize the normality assumption of the distribution.

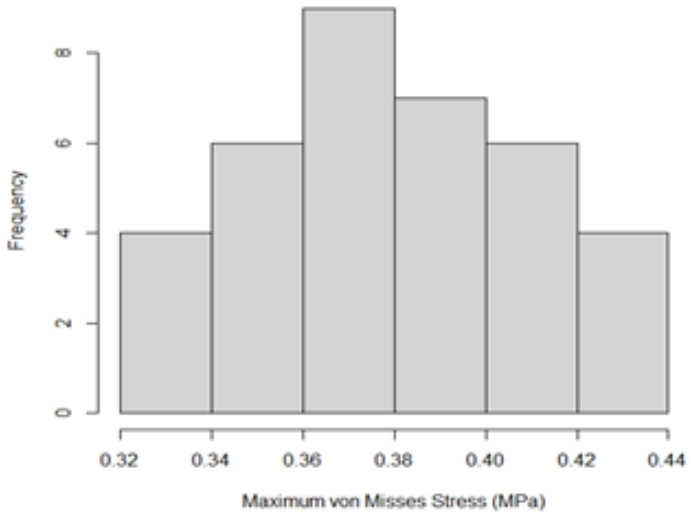

Figure 3: *Histogram for maximum von Mises stress*

The independent variable, 'Maximum von Mises stress', followed a bell curve with most observations grouped towards the middle of the distribution and few on the tails, so a parametric statistical analysis was to be conducted.

Two-way ANOVA test (with replication)- To investigate whether material and bridge structure type, in combination, affected maximum von Mises stress of the bridge a parametric test had to be performed as proven earlier. In our case, a statistical test that would help us analyze difference between the means of more than two groups was ideal. Since data had been collected on a quantitative dependent variable, maximum von Mises stress, at multiple levels of two categorical independent variables i.e., material type and bridge structure type, a two-way ANOVA could be used as the statistical test. This led to the formulation of two hypotheses (H0 & H1) that there is no difference in the average maximum von Mises stress for any bridge structure type and that there is no difference in the average maximum von Mises stress for any material type, respectively. Take note that, for the purpose of this research we are not interested in how the two factors in interaction have an effect on maximum stress hence bridge strength. As a result of that we said, μ_1=μ_2=μ_3 for material type and μ_1=μ_2=μ_3 for bridge structure type. The alternative hypotheses (Ha & Hb) were that there is a difference in the average maximum von Mises stress for any bridge structure type and that there is a difference in the average maximum von Mises stress for any material type, respectively, implying that $\mu_1 \neq \mu_2 \neq \mu_3$ for bridge structure type and $\mu_1 \neq \mu_2 \neq \mu_3$ for material type. In case differences existed, and further analysis of the data obtained was required, a Tukey HSD post-hoc test would be performed to compare the various groups and determine whether statistical significance exist between the individual groups.

3. RESULTS AND DISCUSSION

A. Static Stress Simulation Analysis

Data Collection- The raw data obtained from the Static Stress Simulation Analysis performed using Autodesk Invertor Software 2019 are shown in Table 2 with each value in each cell representing the average of three repetitions of each simulation on a single machine for a corresponding bridge structure type and material type.

Table 2: *Table showing raw data obtained from Static Stress Simulation Analysis*

			Materials					
			Aluminium	Wood	Copper	Concrete	Iron	Steel
Bridge Type	Beam	Machine A	0.322500	0.32394	0.34142	0.34890	0.35669	0.36315
		Machine B	0.320500	0.32383	0.34168	0.34856	0.35673	0.36312
	Arch	Machine A	0.367323	0.37206	0.37411	0.37905	0.38524	0.38696
		Machine B	0.367143	0.37239	0.37300	0.38008	0.38535	0.38696
	Truss	Machine A	0.395299	0.41560	0.41621	0.41682	0.42669	0.43961
		Machine B	0.395341	0.41579	0.41620	0.41685	0.42673	0.43977

Though further analysis through graphs had to be done to verify if differences actually exist in the maximum von Mises stress of the simulations replicated on the two different laptops (Machine A & Machine B) – to ensure that data obtained is consistent, from the table it is quite clear that the results obtained from the two computers is consistent. This is most probably because the simulations were replicated under the same conditions on each machine. But to obtain more meaningful explanations on the two main factors (material type and bridge structure type) under investigation, further statistical analysis had to be performed since conclusions cannot be drawn from this table alone. This prompted the use of the Two-way ANOVA, discussed in detail in the next section, to further observe whether significant statistical differences exist in the two factors.

B. Statistical Analysis

Two-way ANOVA test (with replication)- The Two-way ANOVA summary is shown in Table 3. It can be observed that both material type and bridge structure type explain a significant amount of variance in average maximum von Mises stress (p-values < 0.05).

Table 3: *Two-way ANOVA summary - A statistically significant difference in average maximum von-misses stress by both bridge structure type (F=92706, p < 0.05), by material type (F=5231.8, p<0.05) and by interaction (F=417.5)*

Source of Variation	SS	df	MS	F	P-value	F crit
Bridge Type	0.03457	2	0.01728	92706.3	7.65277E-37	3.55456
Material Type	0.00488	5	0.00098	5231.82	8.47E-28	2.77285
Interaction	0.00078	10	7.8E-05	417.5	3.48587E-19	2.4117
Within	3.4E-06	18	1.9E-07			
Total	0.04023	35				

We found a statistically significant difference in average maximum von-misses stress by both bridge structure type (F=92706, p < 0.05), by material type (F=5231.8, p<0.05) and by interaction (F=417.5), though the interaction is not further analyzed in this study. Hence, we reject the null hypotheses, H0 & H1, discussed in the Materials and Methods section and accept the alternative hypotheses, Ha & Hb, which state that there is a difference in the average maximum von Mises stress for any bridge structure type and that there is a difference in the average maximum von Mises stress for any material type, respectively. This shows that there were noticeable differences in both factors. But we had no idea where these differences came from i.e., the specific groups in the factors. Therefore, to further identify where the differences came from, a Tukey's HSD post-hoc test had to be performed to find out which individual groups differed from each other.

Tukey's HSD post-hoc test- Since the two-way ANOVA tests showed that differences exist between the means of both the bridge structure type and material type, a post-hoc test was required to further identify these differences. Hence, we carried out a Tukey HSD test shown in Table 4 & 5 below.

Table 4: *Tukey's Multiple comparisons of means - A significance level of 0.05 showed that significant differences exist between all bridge structure type groups.*

Group 1	Group 2	diff	lower	upper	p adj	sig
Beam	Arch	-0.03489	0.034436	0.035336	1.4E-14	yes
Truss	Arch	0.040938	0.040488	0.041388	1.35E-14	yes
Truss	Beam	0.075823	0.075373	0.076273	1.2E-14	yes

Table 5: *Tukey's multiple comparisons of means - A significance level of 0.05 showed that significant differences exist between all material type groups.*

Group 1	Group 2	diff	lower	upper	p adj	sig
Concrete	Aluminium	0.020359	0.019567	0.021151	1.87E-14	yes
Copper	Aluminium	0.015751	0.014958	0.016543	1.87E-14	yes
Iron	Aluminium	0.028221	0.027429	0.029014	1.83E-14	yes
Steel	Aluminium	0.035242	0.03445	0.036035	1.8E-14	yes
Wood	Aluminium	0.009253	0.00846	0.010045	1.87E-14	yes
Copper	Concrete	-0.00461	0.005816	0.005401	5.3E-12	yes
Iron	Concrete	0.007862	0.00707	0.008655	1.95E-14	yes
Steel	Concrete	0.014883	0.014091	0.015676	1.87E-14	yes
Wood	Concrete	-0.01111	0.010314	0.011899	1.87E-14	yes
Iron	Copper	0.012471	0.011678	0.013263	1.87E-14	yes
Steel	Copper	0.019492	0.018699	0.020284	1.87E-14	yes
Wood	Copper	-0.0065	0.005706	0.007291	3.22E-14	yes
Steel	Iron	0.007021	0.006229	0.007813	2.28E-14	yes
Wood	Iron	-0.01897	0.018176	0.019761	1.87E-14	yes
Wood	Steel	-0.02599	0.025197	0.026782	1.85E-14	yes

In Table 4, a Tukey's HSD test at a significance level of 0.05 showed that significant differences exist between all bridge structure type groups. Also, in Table 5, a Tukey's HSD test at a significance level of 0.05 showed that significant differences exist between material type groups. The post-hoc test revealed from the significant pairwise differences in bridge structure type that truss bridge had the highest mean maximum von Mises stress than all the other bridge structure type i.e., beam and arch. Additionally, the post-hoc test revealed from the significant pairwise differences in material type that steel bridge had the higher mean maximum von Mises stress than all the other bridge material types i.e., wood, concrete, aluminum, iron, and copper.

Group-wise comparison- From the two-way ANOVA test, we know that both bridge structure type and material type are significant variables, hence, we need to show which of the combinations of bridge structure type and material type that are statistically different from one another. A groupwise comparison bar graph, shown in Figure 4, to find out which group means are statistically different, showed the highest maximum von Mises stress for truss bridges and steel bridges. This suggests that bridges of structure type truss and bridges of material type steel would make the strongest bridge under experimental conditions similar to ours. The small standard error bars further confirm that that data obtained from the replication performed on both laptop computers is consistent.

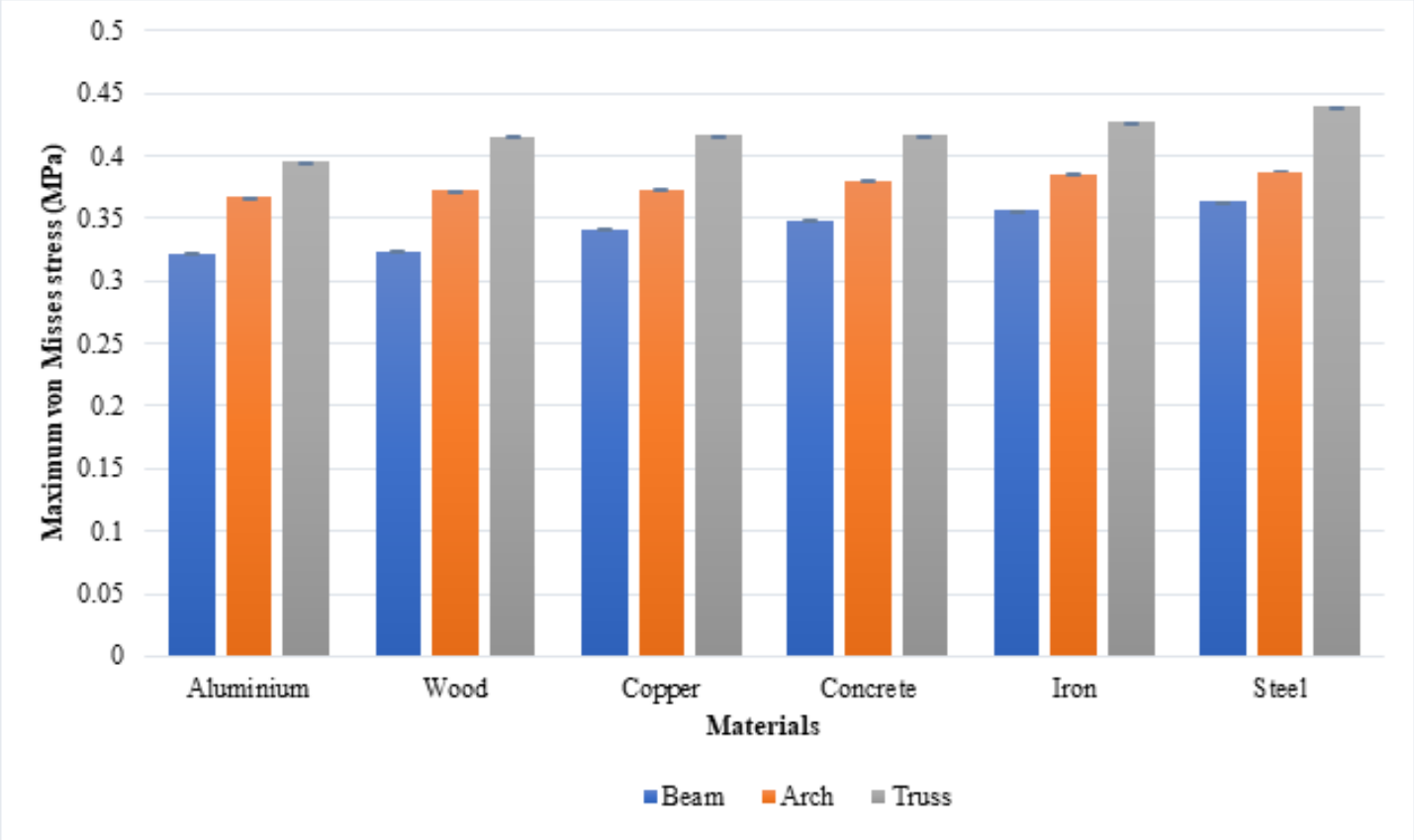

Figure 4: *A group-wise comparison bar-chart. Each bar shows the average maximum von Mises stress on a bridge made of the corresponding material. Error bars indicate standard error.*

4. CONCLUSION

Both material type and bridge structure type simulated in combination affect the maximum von-misses stress hence the strength of the bridge. The highest von mises stress of a truss bridge and steel bridge suggests that under static stress simulation conditions like ours, this bridge structure and material types, respectively, would make the strongest bridges. Truss outperformed other bridge structures as shown by its greater and higher mean difference in the Tukey's HSD post-hoc test. Steel outperformed other materials, as shown by its high mean in the group-wise comparison. Also, arch bridges are stronger than beam bridges. Iron and concrete are also preferable material choices for bridge design. Though it was beyond the scope of our study, the existence of an interaction effect between bridge structure type and material type shows that material type affects the strength of a specific bridge structure type, though at a force of magnitude greater than the one we used in our simulation, this might not necessarily be the case. A more concrete recommendation can be drawn if the interaction between the two factors is considered. That is an improvement that can be made in a future research study.

ACKNOWLEDGEMENT

Much appreciation and thanks go to Elena Rosca (Ph.D.), our Statistics for Engineers and Economists lecturer at Ashesi University, for making this project a success.

REFERENCES

[1] Autodesk Knowledge Network, 2020. About Stress Analysis. [online] Knowledge.autodesk.com. Available at: <https://knowledge.autodesk.com/support/inventor/learn-explore/caas/CloudHelp/cloudhelp/2021/ENU/Inventor-Help/files/GUID-61F01A5D-7E54-45A1-9698-7BB11F0AEE94-htm.html> [Accessed 21 December 2020].

[2] Science Buddies Staff, 2020. Avoiding Disaster: The Right Bridge Design. [online] Science Buddies. Available at: <https://www.sciencebuddies.org/science-fair-projects/project-ideas/CE_p024/civil-engineering/avoiding-disaster-the-right-bridge-design> [Accessed 21 December 2020].

[3] Wiss, Janney, Elstner Associates, 2020. I-35W Mississippi River Bridge. [online] wje.com. Available at: <https://www.wje.com/projects/detail/i-35w-mississippi-river-bridge> [Accessed 21 December 2020].

[4] SimScale, 2020. What Is Von Mises Stress?. [online] SimScale. Available at: <https://www.simscale.com/docs/simwiki/fea-finite-element-analysis/what-is-von-mises-stress/#:~:text=Von%20Mises%20stress%20is%20a,material%20will%20yield%20or%20fracture.&text=The%20von%20Mises%20yield%20criterion,then%20the%20material%20will%20yield> [Accessed 21 December 2020].

Interview 04

Artificial Intelligence Youth Interview


Kevin Carrington Tichana

I: Sure, no problem.

P: I am Panashe Delawinga. I'm Zimbabwean, at Ashesi. I am currently in my final year studying computer science. I am one of the co-founders of AIY with Kelvin.

I: Thank you. Kelvin, from your initial presentation you said that you didn't perform so well in computer programming so that made you seek more. Was that a major thing that birthed the idea for this project or there was something else?

K: Let's just say that when I acquired some skill in machine learning, I felt that everybody needs to have access to it but unfortunately there's not a lot of schools like Ashesi where you can have access to free courses on Coursera that you'd pay for if not at Ashesi. I thought, what if we started something that gives access to other people that are not within the Ashesi community that are in places where they cannot access things like Coursera then we deliver such content to them then they can learn by doing.

Interview 04

Artificial Intelligence Youth Interview

I: Could you give a brief introduction of yourself?

K: Alright. My name is Kelvin Carrington Tichana. I'm going into my senior year now, studying electrical and electronic engineering. I am also the co-founder of AIY or Artificial Intelligence Youth in full. AIY was founded in 2020, December 2020 and it was founded on the basis of technology such as artificial intelligence, robotics, and even simple things like IoT are not explored in detail in places that are not like chess, for example. Since my freshman year, I think right after my first semester, I did horribly in my programming for engineers class so to revise I just went online to study on my own. I started taking other extra python courses. As a result, it forced me to kind of get an interest in artificial intelligence and the good thing about it is that I'm an Ashesi student and when you're an Ashesi student there are so many opportunities that come your way and one of them was Coursera. Through Coursera for students, I managed to enrol in a total of maybe 11 courses that are artificial intelligence related. And when I took these courses, it pushed me forward to try to develop software products. It was just more of a hobby. When it started I just started developing ideas and building my project. That's how this whole thing started, I guess we'll get more when you ask the questions.

I: That's interesting. I think Panashe is here.

K: Yes, Panashe is here as well but unfortunately he's not feeling too good, he has a headache so I was wondering if maybe he could just be passive. He could just introduce himself but he'll not talk much.


Panashe Delawinga

I: When you came up with the idea how did you and Panashe meet? Did you speak to him?

K: Panashe and I have always been working together on a lot of things so even when I was building my virtual system he would give me ideas on what to do and things that I could include in the virtual assistant. Since then, he has been the go-to person when it comes to these artificial intelligence related stuff so when the idea hit me at first – oh I missed something. The idea that hit me at first was to enroll into the Karen course. I knew that AIY – it wasn't AIY then it was just Mischief, which is the virtual system that I built – needs to have some credibility, needs to have some proper research to understand how people interact with artificial intelligence in different communities even in Ashesi. In my third year first semester, I enrolled into the Karen class and in that class, I was exploring Mischief, the virtual system how we can use it to help developing communities, how we can use it to help people with disadvantages for example we have people that are disabled how can we use artificial intelligence to help? It's more of major computer interactions that I was exploring by using Mischief, the virtual assistant that I built. When I took that class, I did some ethnographic research trying to understand the problem space and see how well-versed people are in artificial intelligence. What I found was that people think it's just in the movies, they think of Tony Stark when they hear artificial intelligence, they think of Ex Machina when they hear artificial intelligence, not knowing that we use and interact with artificial intelligence every day. On our phones, computers, and even televisions but we just don't know it. Even when you go on YouTube, TikTok, or whatever you do, you're interacting with artificial intelligence daily. We were trying to bridge the gap between the myths and realities of artificial intelligence. The myth is that we're far from artificial intelligence. We are actually within the era of artificial intelligence. When I took that course, I did get a passing grade and I didn't think it was enough for me to stop there. That's when I approached Panashe and asked him what he thought about the idea of turning that into a think tank. Then, it wasn't a fully formed idea but we agreed that we would explore it more and towards the end of that semester, we applied for the Ashesi Community Entrepreneurship. We became a team to apply for the entrepreneurship program and we got accepted. That's when we started developing the idea for AIY.

P: On my end, the thing that made me hop on this project was that since my freshman year, I have been following Kelvin like we've been close. For every project that he worked on, I would ask him, even the free courses that he took, what courses he would recommend for me so after he takes a course he recommends it to me. I take them and then I do some projects as well, with his help and recommendations. When he came up with this idea I was like okay we can do it so that's the big thing that we did for me. I just hopped on because I believed we could do it because of the connection that we already have.

I: Teamwork has brought you to where you are.

K: Yes

I: How long has this project been running?

K: From December till now, that's nine months right? Eight months
P: Eight months

I: And this current stage, where have you gotten to? In terms of becoming a fully-fledged business.

K: When we got accepted into the Ashesi Community Entrepreneurship program, there were conditions that we needed to meet. The first pitch we presented wasn't a "ripe" pitch, the business idea was not fully baked so we went through very rigorous training, coaching and community visits when we were at Ashesi last semester. That lasted from January to the end of the semester. Through that, we learned a lot of things from problem scope navigation and how to define our problem better, how to go out there and see how we actually can steer people away from the problem, and how to identify other sectors that are stakeholders affected by the problem at a time. After that, we needed to have a final pitch which we did in April. After that pitch, they would then look into whether you are fit enough to receive implementation funds. Fortunately, we were selected to receive the implementation fund of GHC16,500 but we are still waiting for that fund. We're hoping that sometime this week it will be sent to us. We are now in the implementation phase. We've gone through the testing phase, and now we are in the implementation phase. Here in Zimbabwe, I have only approached two schools and they're very much interested in the idea. They're even adopting our curriculum and having students sign on so we can teach them artificial intelligence and a bit of robotics, electronics, and embedded systems. The only problem that we have right now is that there are some papers that we need because we started this idea in ghana, now we're here in Zimbabwe and we need to go through the proper channels. We would like to have one cohort in Zimbabwe and then when we get to Ghana, we continue with schools in Ghana.

I: Your target audience is Zimbabwe, right?

K: Zimbabwe and Ghana.

Interview 04

Artificial Intelligence Youth Interview

I: Kelvin, you mentioned that you're an electrical engineering major, right?

K: Yes, I am

I: Electrical engineering major and AI, there's little correlation. Will you say that you made a mistake in selecting your major?

K: No. Of course, there was a point where I thought that maybe I should have gone to computer engineering. I think that was just a result of some hard courses but I think I'm okay where I am. I can begin to see how AI can work in drones, it can work in robotics, automation, IoT, embedded systems in embedded machine learning, and it can work in identifying faults in motors using computer vision. I am seeing a link between what I study in class and my passion for artificial intelligence. My job now is to find a way to work with both so I don't think I made a mistake in majoring in electrical and electronic engineering and I don't think I made a mistake in having an interest in artificial intelligence.

Interview 04

Artificial Intelligence Youth Interview

I: Any challenges?

K: The first challenge that we have right now is that we are understaffed – it's just the two of us. It's just the two of us because we don't know who else actually believes in our dream and we don't want to just have people on board and they leave when things get hard. It's going to get hard. Right now we are understaffed but that's not what we are really worried about. The delay in funds is another problem but I know that Ashesi finance will sort that out soon. There's also the issue that because we are young it's like we are not taken seriously. I have approached some schools and they said they'll get back to me. They haven't! It's a problem. I think it is because they think they can do better without us. After all, they have something like a programming class. But I know what it's like to be lied to. The students are only being told simple things, there's a gap between learning programming and what programming can do for you in the real world. That's the gap we are trying to close. Unfortunately, such schools exist. Another challenge is that there are a lot of computing resources that are needed. I believe that once we have the funding some of these challenges will go away.

I: What does a fully established organization look like to you?

K: We have many goals. Our goal is to have senior high schools, college students and students in various places like vocational schools acquire and use skills in artificial intelligence to identify problems within their societies with our help so that they can do it on their own. They'll solve problems, reduce unemployment and at the end of the day have a better community. Also, we have another goal to develop artificial intelligence and robotics even drone software that can be used by farmers and other small businesses in the identification of pests, and plant diseases and also in solution proposals such that we can leverage data insights in ai and improve businesses in Africa. We're not just an educational institution or business we also want to develop software and hardware solutions for small businesses.

I: That's great. What's your target audience?

K: So far for the educational side we have the schools – senior high schools, vocational schools, college. These areas make up our customers. Our beneficiaries, those that cannot afford to pay for the services themselves, are the students. That's why we are approaching schools directly, not just students and saying we can do this for you. we want to work with schools and institutions that have access to students and we give them our curriculum and we train them, give them projects to work on, solve problems together and if possible we can have them on board on some of the other projects we will be working on. Our other target audience is small businesses such as farms. We want to develop artificial intelligence software for plant disease detection so that they can have it on their phones and then when they have a disease the technology will be able to tell them the disease and make suggestions on what to do. We could also use drone technology for delivery. Most of the drones that we have are remotely controlled via radio frequency and sometimes there are range problems. If we have an onboard computer with artificial intelligence, it will self-navigate to the provided destination. we can have recommended systems for online stores too to improve their services and make more money. We can also have Ai in finance for example having a well-predicted business outline or cash flow so that we know and be able to make more informed decisions.

I: I think that's a good approach to it. Are you non-profit or for-profit?

K: We are a non-profit. We know that in this business there's not a lot of profit in it. Our main goal is to help people and change lives.

I: Are you open to the idea of collaborating with another company, say another AI-based organization, will you see them as competition or partners?

K: We don't see people who are into AI right now as competition for one reason – it is not fully explored. Anyone willing to have AI within our community is someone who is a potential partner. We believe that we can work together with anyone willing to have ai brought to the African community and we want to catch up with the rest of the world so we don't see competition at all.

Interview 04

Artificial Intelligence Youth Interview

I: AI is a complex concept; how do you intend to make the students understand it? What's the plan?

K: Here's the plan. We know that artificial intelligence and machine learning are very hard especially when you're taking them in college. We are just going to introduce the concept and go straight to Tensorflow. We are trying to abstract a lot of the complex things that are in artificial intelligence by using platforms that have been created say by Google, Facebook, etc that make it easier for anyone who wants to build a neural network. We would use pre-trained models to solve some of the problems. We understand that there's a lot of complexity within the machine learning course so what we're trying to do is to abstract a lot of that complexity using these high-end platforms. What we are doing is trying to build working products that work. Our tutorials focus on the initial programming lessons you need to know, introducing the basics of programming that are necessary for programming an artificial intelligence system with TensorFlow. We knew we were going to work with senior high school students and they may not have taken linear algebra or a bit of multivariable calculus. We knew that we can abstract and if they want to explore that part then they can do it but at least they would have built something that works best in their society.

I: I think a partnership will help because the field is very broad. This brings us to the end of our interview. Do you have any questions or comments?

K: No, I just want to say thank you for giving us this opportunity. We hope that we give you updates soon. We have a lot of work to do. We are applying for other grants to add to the funding that we've currently got so that we can do more and get more people on board.

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Ram vs. Cycle Pump: Designing a Sustainable Water Pump for Use in the Berekuso Township

ABSTRACT

The world's poor rural population (900 million people) lacks access to safe drinking water and sanitation, resulting in enormous human health and economic costs, as well as gender and other societal disparities. Rural water and sanitation assistance is more difficult to provide due to the settlements' location, which is mostly in environmentally sensitive areas: dispersed settlements, an agrarian economy, and complicated infrastructure. Rural populations lack access to appropriate, low-cost, and locally manufactured technologies for water, sanitation, and hygiene. Modern, urban-oriented technologies will not be suitable in a rural setting. Other factors in technology should be considered, such as energy efficiency and the use of dependable and low-cost water transportation systems. In this project, a sustainable water pump is designed and implemented for a local town [Berekuso], in Ghana. Two distinct pump designs are proposed and compared, the ram and bike pump. The ultimate goal of this design project is to scale up the prototype for easy water transportation in a town. The product should be portable and easy to assemble – these will be tested using software simulations [Fusion 360 and SolidWorks] as well as reading physical measurements, using instruments.

Keywords *- Water, Transportation, Pump, Fusion 360, SolidWorks, ThingSpeak*

The world's poor rural population (900 million people) lacks access to safe drinking water and sanitation, resulting in enormous human health and economic costs, as well as gender and other societal disparities.

1. INTRODUCTION

Most villages are situated close to water bodies. However, a huge amount of time is used to transport water to their homes for domestic uses, such as cooking and bathing [1]. Water is fetched with a pail and carried in a bucket to its required destination. A few farmers invest in diesel water pumps, but it is costly and can be stolen. The aim of the research is to find a solution to this timeless problem that has plagued the Berekuso community. The research team aims to develop a portable pump that can move large volumes of water at low pressure, and through a height of at least 5m, when powered. This invention hopes to bring water to the doorstep of the people. This would overall improve their productivity as the time spent fetching water can be used for other activities. With this invention, irrigation-farming can become a norm, thus increasing the crop yield every year. The designed pump must be relatively cheap, portable, and durable. The ideal pump should be able to be powered without the use of electricity. Hence man-powered/ gravity-controlled pumps are acceptable. This is particularly important as parts of a local town (such as Berekuso) lack access to electricity.

2. RESEARCH OBJECTIVES

This project seeks to develop a water pump that can be operated by the Berekuso denizens. Thus, the project should achieve the following objectives:

- Produce a pump capable of moving water through a height of at least 5 meters (2m for prototyping)
- Produce a pump that can move large volumes of water to support a village
- Produce a cheap and durable water pump
- Produce a pump that can be powered without the use of electricity
- Produce a pump that is easy to operate and maintain

To achieve the objectives stated above, other related works were considered. The research on existing water pumps will help the team ideate viable solutions. The list of requirements for the water pump will also serve as a selection criterion for its potential design. The model of the pumps will be generated in CAD (Computer-Aided Design) software, and analyzed to determine areas of interest in the design. The prototype of the pump will be manufactured, and further testing will be done to ensure its safe, and effective operation.

3. LITERATURE REVIEW

The motorcycle-driven water pump is mostly used in the rural community. It is set up where piped tap water is not readily available. In some set-ups, the water pump is used for small-scale (100-1000 m^2). As per the research study that was done by [2], the water pump had a higher efficiency compared to the two other treadle pumps that were on the test. The cheap

water pump gives ample output to people who cannot afford solar and gas pumps. Simple and cheap methods have been used to install stationary treadles and bicycle-pumps. For example, Maya Pedal makes water pumps from discarded bicycle frames. International Development Enterprises (IDE) also installs inexpensive power pumps that are made from bamboo. Although these water pump technologies use inexpensive, they are not portable and require custom construction. [2].

The ram pump technology was invented in the 17th century. It is based on developing a pressure surge when fluid in motion is forced to stop (or change direction) suddenly. The pressure built is then used to lift water to a point higher (supply head) than where the water originally started (deliver head). The main source of energy to hydraulic ram pump technology is the water and gravity [3]. It has low maintenance cost; it works if water is available, and the components are simple with few moving parts which can be produced locally and be maintained by the locals from the community.

3.1. User-focused Technology

One of the most important concepts of appropriate technology (and engineering in general) is the inclusion of users into a project's implementation. These are the people that the device is designed for, so one cannot afford to have a disconnect between the product, and them. As such, these individuals were sought out (these were locals and technicians that live in Berekuso). This is a summary of the insights and points from proposed users.

User 1:

- "Definitely this bike pump would be **great for agricultural** purposes, to pump water to fields."
- "But remember if it's a **motorcycle** pump, it will still need lots of **fuel**."
- "But the idea of a ram pump is interesting. Surely the **bike pump** will require people to be **constantly riding. The ram pump can work autonomously**. I have heard it **wastes water**, but I don't think so. Because it pumps it into the ground. So, it can be re-used later" [4].

User 2:

- "Oh, yes and it's a great idea, most people where I live have to walk **miles** to fetch water from a **stream**."
- "For the bike pump, I like it. But then is there a way to make it such that it spins by itself? because maybe I will be tired after some time."
- "Children in the village would still love to ride it...all the while they will be pumping water for us all."

3.2. The Choice of Water Pump

1) Cycle Water Pump:

Description: When in transport mode, the frame and pump flip up and rest above the back wheel, so the bicycle can be pedaled. When it is time to pump, the bicycle stops and the frame flips down underneath the back wheel, with the **bike's tire resting against the armature of the pump**. Much like a stationary resistance trainer, the rider then pedals in place, **thus spinning the armature and powering the pump** (as seen in Figure 1). Table 1 displays the pros and cons of a ram pump.

Table.1 *– Cycle water pump: Pros and Cons*

Advantages	Disadvantages
Can potentially be interfaced with renewable energy **(solar or wind)**	Parts are more difficult to source and repair (if damaged)
Theoretically the bicycle pump has the ability to increase output revs/min by 10, as humans can ride at 100 revs/ min (max), an E-bike with a 775 motor could run > 1000rpm (accounting for friction)	For the conventional motorcycle water pump, the fuel must still be bought for pumping water. For the bike pump, the riding of a bike to pump water may get tiresome
Most people in Berekuso have access to bicycles	Important parts may be subjected to theft
Easy to understand (most locals would find the concept comprehendible – an important aspect to assure local compatibility)	–
Making your own water turbine can significantly reduce cost	–

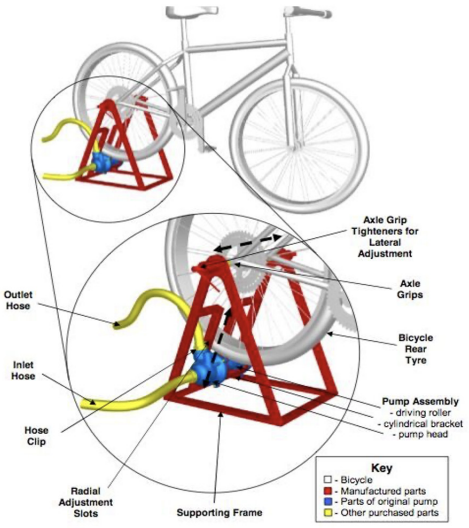


Fig.1 *– Schematic of bike pump mechanism*

2) Water Ram Pump:

Description: Water is pumped from a particular head at a high flow rate and comes out with a higher head but at a lesser flow rate because of the water hammer effect. The system consists of a drive pipe, waste valve, discharge valve, air (pressure) chamber, and delivery pipe. (Figure 2). The only moving parts of the system are the waste valve and the discharge valve which operate from the fluid dynamic actions of the pumping cycle. Table 2 weighs the pros and cons of this ram pump.

Table.2 *– Water ram pump: Pros and Cons*

Advantages	Disadvantages
No moving parts	The water pressure from the source is discontinuous
Cheap (parts can be sourced and replaced easily)	It returns a significant amount of water to the ground through the waste valve. Since water entering the ram is pumped uphill
No electrical energy required	Loss of energy within the pump body – owing to mixing of water from different directions – is a possibility
Very easy to transport	The sudden in-flow of water could potentially wet users
Better for pumping water *vertically*	Does not have the option to be a submersible water pump

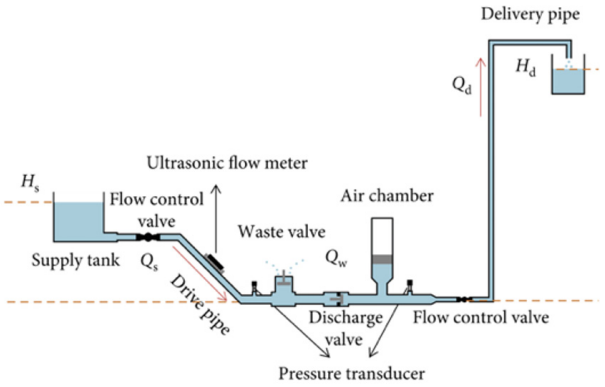


Fig.2 *– Schematic of ram pump mechanism*

4. DESIGN REQUIREMENTS

The choice of the different diameter pipes and components to acquire, was informed by both the type of pump, and the specific calculation.

4.1. Cycle Water Pump

Calculations and Initial Analysis:

1. Assuming the design of a motorcycle water pump. A motorcycle had to be simulated using a motor, this required the purchasing of a large torque motor with low noise. The price range also had to be low (<50ghs). For this scaled down prototype, we calculated for an rpm within an attainable pump output power. Upon further research the identified nominal commercial pump diameters and their corresponding revs per min and water head, were discovered. The nominal small pumps had a diameter of 4 inches, and a head of around 4m. They however had motor rpms of 200rpm. A shaft was also required for the bike pump. Hence, the team reversed engineered a standing fan to procure it cheaply.

Using ratio and proportion:
4m head: 200rpm
For 15m head:

New rpm = 15m x 200rpm / 4m = 750rpm.

An overestimated value was used for the motor rpm: 1000rpm (this would account for any frictional losses that heat and sound energy will subtract from the contact of the bike tires and the motor). The 775-motor selected was rated at 1000rpm to about 2000rpm for 12V batteries. It cost 45ghs (See Table 3).

Table.3 *– Items bought and their respective prices (cycle pump)*

Items needed	Bought or Re-used?
30W Panel	Re-used (200ghs price)
12V, 7Ah battery	70ghs
Charge controller	Re-used
775 motors	45ghs
4” Check valve (x2)	80ghs

Total cost: 195ghs + (200ghs) = 395ghs
Budget: 1,000ghs

4.2. Water Ram Pump

As previously mentioned, this ultra-low-cost water pump is the second alternative design. It was decided that the team would build and compare both pumps.

Calculations and Initial Analysis:

The pump utilizes energy from a supply head, *Hs* with a large quantity of water, *Qs* to a delivery head, *Hd* which is higher than the supply head with a small quantity of water, and *Qd* by rapid closure of the waste valve. The operation is continuous with no other external input and the flow is intermittent [6] – See Figure 2.
The power used to drive the pump is:

$$\text{Pow}_s = \rho g Q_s H_s. \quad (1)$$

The power added to the fluid is:

$$\text{Pow}_d = \rho g Q_d H_d. \quad (2)$$

The efficiency of the pump is defined as

$$Q^* = \text{flow rate ratio} = \frac{Q_d}{Q_s} \approx 1 - \frac{Q_w}{Q_s}. \quad (3)$$

where H* = head ratio = Hd/ Hs and

$$\eta = \frac{\text{Pow}_d}{\text{Pow}_s} = \frac{\rho g Q_d H_d}{\rho g Q_s H_s} = \frac{Q_d}{Q_s} \cdot \frac{H_d}{H_s} = Q^* H^*, \quad (4)$$

From the research conducted by Jurata et. al. [6], they used a 1-inch diameter for their pipes and check valves – which corresponded with the above equations. To utilize these equations, all pipes and check valves were chosen to be 1 inch as well. This was intended to achieve an efficiency > 90% and a delivery head, *Hd* > 1.8m.

• The supply head, *Hs* (distance from the testing water tap to the ram pump) = 150cm (fixed)

• With a volume (quantity of water, *Qs* to a delivery head) = 20L

• The quantity of water that ought to be delivered should be 80% of the supplied water (accounting for water loss). Therefore *Qs* = 80/100 * 16L = 20L
-Using equation 1: Pows = 1.244 x 9.81 x 20 x 1.5m (150cm) = 366.11

-Using equation 2: Powd = 1.244 x 9.81 x 16L x 1.8m = 351.46

-Using equation 3: Efficiency = [(2)/ (1)] *100 = [683.40/ 366.1] *100 = (351.46/366.11) * 100 ≈ 95%.

The efficiency of the pump can potentially be high. But this will be based on:

The initial height of the water supply (if it is low, output water head will be low as well).

The leakages from the ram pump.

The construction of the ram pump needed the following items (1-inch measurements for the prototype and a 20L container to collect the water, were selected):

Table.4 *– Items bought and their respective prices (ram pump)*

Items needed	**Bought or Re-used?**
1” PVC pipes (x9, 15cm each)	Re-used
1” T joints	9ghs
1” Elbow	Re-used
1” Ball valve (x2)	12ghs
1” Male Thread Adapter (x2)	15ghs
1” Female Thread Adapter (x2)	15ghs
Water hose	Re-used
Old Voltaic dispenser bottle (20L)	Re-used

Total cost: 131ghs
Budget: 1,000 ghs

4.3. Research Methodology and Procedure

A. Pump CAD Models

Both pumps were designed in Fusion 360. This helped to specify the measurements needed to fabricate. The engineering process requires continuous re-iteration; hence, the team produced several CAD drawings (See Appendix for orthographic projections).

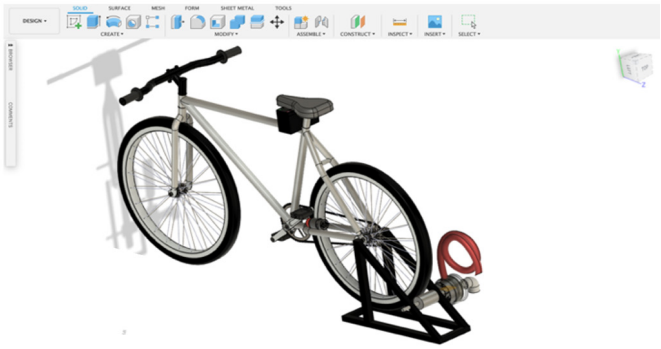


Fig.3 *– Completed E-bike (to simulate a motorcycle) pump with the turbine, shaft frame, and water hose*

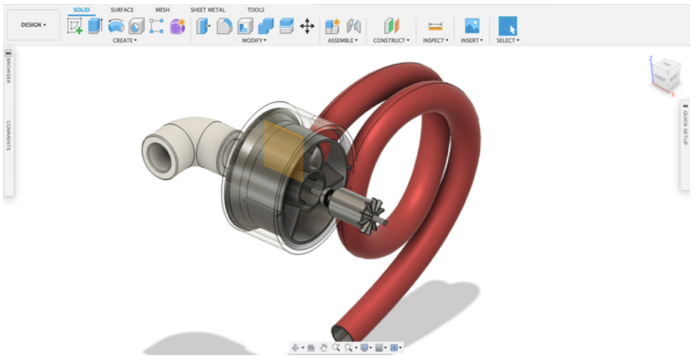


Fig.4 *– Bike water turbine (impeller+ shaft + PVC casing and pipe)*

Please note that the "E-bike" served as an improvise, as we did not have access to a motorcycle. The pump design also works with normal bikes – in this case the paddling of a person will provide the revolutions per minute. In retrospect, a motor can be directly connected to the pump shaft to reduce losses associated with friction on the wheel – but since this product is intended for people with motorcycles/ bikes, that is not an option. When the shaft spins, it turns the impeller, and this draws water inside the pump (from the hose), and outputs this pumped water through the PVC pipe. Figure 3 displays the CAD model of the completed bike pump, and Figure 5 shows that of the water ram pump.

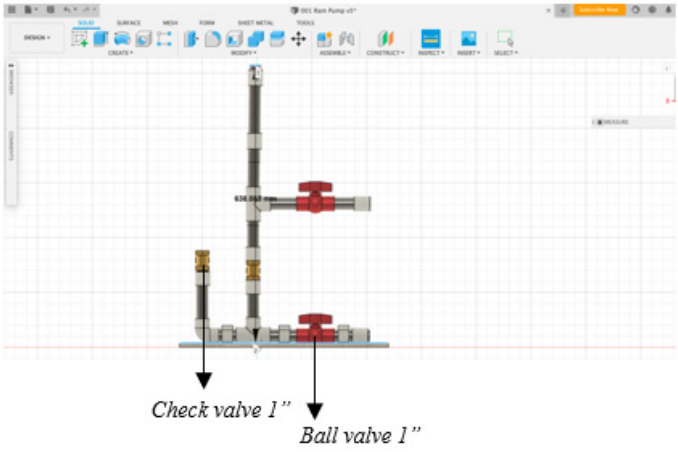


Fig. 5 *– Model of ram pump*

B. Testing and Re-testing

1)Testing (Simulations)

Bicycle structure simulation: This was intended to test if the bicycle stand would be structurally sound. The team decided to use the SolidWorks software. The total weight of the bike and that of the person sitting on the bicycle, needed to be considered. Table 5 displays the results extracted from SolidWorks.

Total force = weight of bicycle(kg) (5)
+weight of human sitting on the bike(kg)

Table.5 *– Material properties of bike stand*

Name:	**1023 Carbon Steel Sheet (SS)**
Model type:	**Linear Elastic Isotropic**
Default failure criterion:	**Max von Mises Stress**
Yield strength:	**282.685 N/mm^2**
Tensile strength:	**425 N/mm^2**
Elastic modulus:	**205000 N/mm^2**
Poisson's ratio:	**0.29**
Mass density:	**7.858 g/cm^3**
Shear modulus:	**80000 N/mm^2**
Thermal expansion coefficient:	**1.2e-05 /Kelvin**

In simulating, four different forces were used. The weight of the bicycle was 10kg, and various weights of people presumed to be sitting on the bicycle, were used. That is: 30kg, 50kg, 70kg, 110kg. Figure 6 shows the simulations as described below.

1. Force 1 = 10kg + 30kg = 40kg
2. Force 2 = 10kg + 50kg = 60kg
3. Force 3 = 10kg + 70kg = 80kg
4. Force 4 = 10kg + 120kg = 130kg

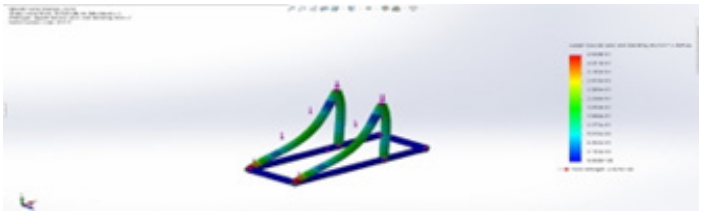


Fig.6- *Simulation results for 40N, 60N 80N and 130N respectively*

The stand was able to withstand all the forces without any deformation due to its high yield strength i.e. the maximum stress that can be applied before it begins to change shape permanently.

2) Re-testing (Physical Measurements)

Now, in order to compare the functionality and output of both pumps, the team ran a series of tests to ensure that both were subjected to similar operating conditions (each pump was tested for 1min 30s, with readings collected 3 times after every 30s). The team then performed weight tests, volume measurements, and flow rate measurements. The testing circuit was built, and it was interfaced with the online ThingSpeak app (see Figure 7). This was helpful in obtaining pump readings.

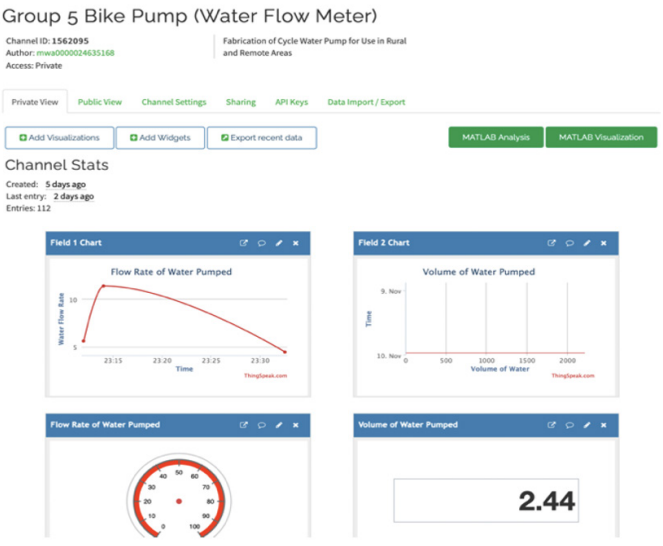


Fig. 7 *– Bike pump online monitor (flow meter)*

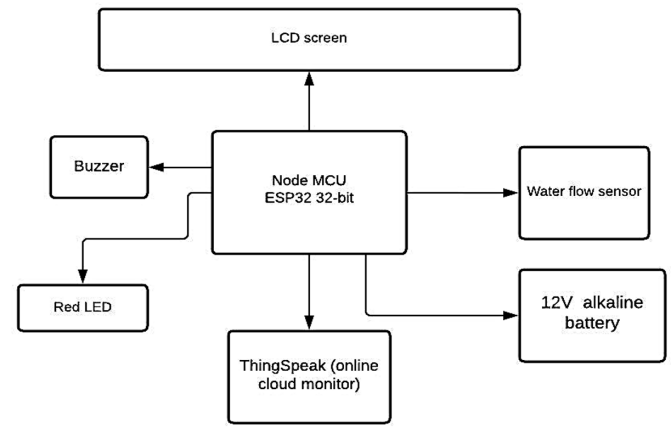


***Fig.8** – Measurement circuit - simplified schematic*

The testing circuit uses a water flow sensor. So, when water flows through the rotor, the rotor rolls, its speed changes with different rates of flow. The hall-effect sensor outputs the corresponding pulse signal. In so doing, the water flow rate coming out of the pump waws obtained. The microcontroller used was the nodemcu that displayed values on an LCD screen. The buzzer and red LED were used to signal users that they must either put off the ram pump or stop riding the bicycle, because the container in which water is being pumped into, is at capacity. **A great addition to prevent wastage of water.**

1) Primary Design: Bicycle Water Pump

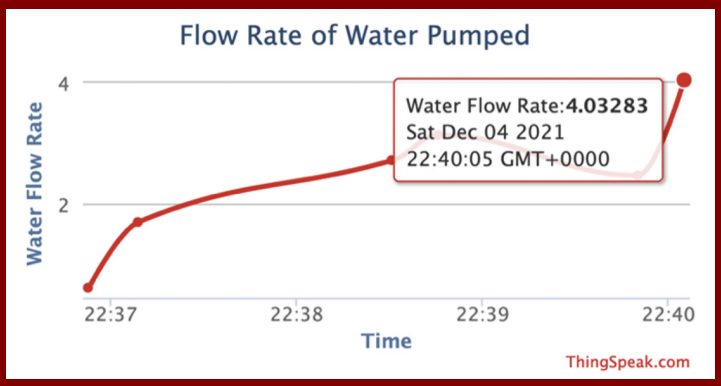


***Fig.9a** – Graph of flow rates from water bike pump*

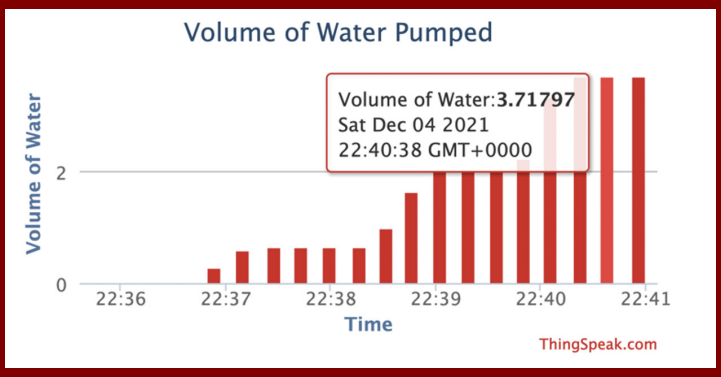


***Fig.9b** – Graph of volume pumped after 30s (for 1min 30s – 3 times)*

At a cycling speed of 60rpm, and a water head of 145cm:

The highest flow rate after 3 tests was recorded:
Highest flow rate = 4.0328 Liters / minute
Volumes collected after 30s: ***0.6464, 1.3542, 2.3658***

Average volume after 30s = 4.3664/3 = 1.4555 L

2) Secondary Design: Ram Water Pump

The derived results of water flow rate and volume collected after a set time, will help in the process of obtaining suitable calculations to scale up this project.

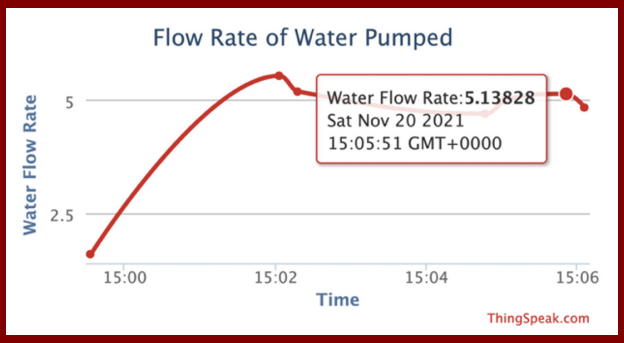


***Fig.10a** – Graph of flow rates from the water ram pump*

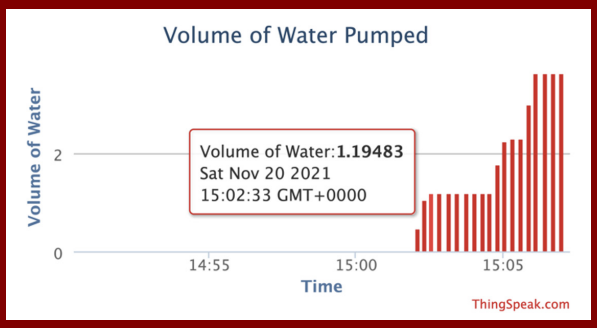


***Fig.10b** – Graph of volume pumped after 30s (for 1min 30s – 3 times)*

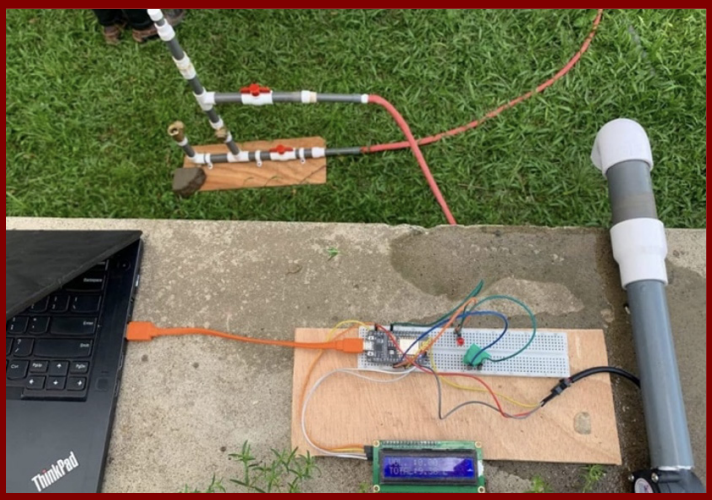


***Fig.10c** – Testing the output water flow rate and volume of the ram pump*

At a testing height of 1.29m:

The highest flow rate after 3 tests (to improve accuracy):
Highest flow rate = 5.2173 Liters / minute
Volumes collected after 30s: 1.1948, 1.1065, 1.3458

Average volume after 30s = *3.64714/3 = 1.2157 L*

C. Fabrication

1) Primary Design: Bicycle Water Pump

The impeller was built after carefully selecting the bike pump diameter, as explained in the Calculation and Analysis section. It was 4 inches in diameter, and all of the PVC pipe parts were 1 inch thick. After several simulations, the bike stand was welded together. This resulted in a rigid stand that could support a variety of weights. The bike parts were assembled and tested. Figure 11 depicts the functioning bike pump; the full video can be found in the Appendix.

Fig.11a *– The shaft connected to the bike wheel*

Fig.11b *– Complete bike water pump*

2) Secondary Design: Ram Water Pump

Each PVC item was 1 inch in size. The first step was to fit the pieces together. Following testing, PVC Epoxy glue was used to join these parts. The pump was then reconfigured with the water hose and dispenser bottle to pump water from a low-pressure tap - see Figure 12.

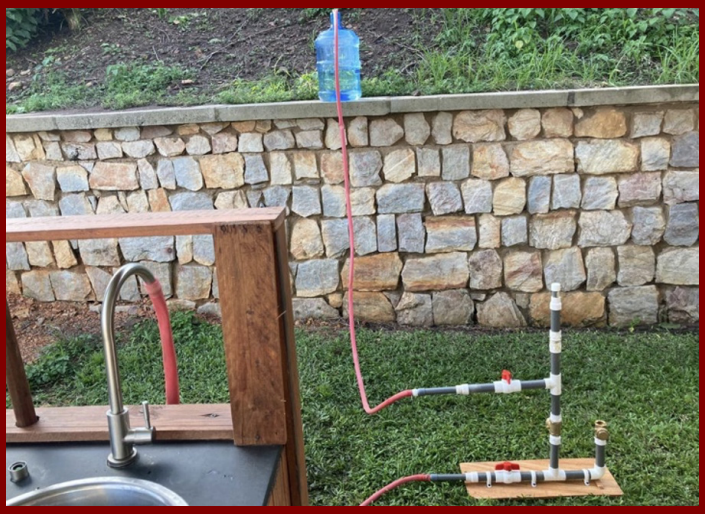


Fig.12 *– Completed ram pump filling dispenser tank*

5. SCALING UP THE BICYCLE WATER PUMP PROJECT

After measuring the bike pump's flow rate, volume, and water head, it will be easier to scale up. An important set of equations were used: Physics Affinity Laws 1 and 2.

The Affinity Laws of centrifugal pumps or fans indicate the influence on volume capacity, head (pressure), and/or power consumption of a pump or fan due to change in speed of wheel – revolutions per minute (rpm).

The volume capacity of a centrifugal pump can be expressed as:

$$\frac{Q1}{Q2} = \frac{N1}{N2} \; x \; \frac{D1}{D2} \qquad (6)$$

where Q = volume flow capacity (m^3/s, gpm, cfm)
N = wheel velocity – revolution per minute - (rpm)
DP = wheel diameter (m, ft) Head or Pressure. The head or pressure of a centrifugal pump can be expressed as:

$$\frac{DP1}{DP2} = \left(\frac{N1}{N2}\right)^2 x \left(\frac{D1}{D2}\right)^2 \qquad (7)$$

where DP = head or pressure (m, ft, Pa, psi) constructed the.

Because we are going to maintain the diameter of the pump. D1=D2, they cancel out, and so the equations are simplified to:

$$\frac{Q1}{Q2} = \frac{N1}{N2} \qquad (8)$$

$$\frac{DP1}{DP2} = \left(\frac{N1}{N2}\right)^2 \qquad (9)$$

-The scaled-down version of the cycle pump delivered water at a height of 145cm (1.45m).
-And the bike rider was paddling at 60 revs per minute.
-In order to increase the water head to 15m (as a scaled-up product), calculations will be made for the rpms necessary to get there – and the volume flow capacity.
*By using equation 4, *DP2* =[N2/N1]^2 x *DP1*, and making a change of subject for N2. We get:

N2=[DP2/DP1]$^{(1/2)}$ x *N1*=[15/1.45] x 60=**620.69 rpms.**

Now to calculate the flow rate from this new rpm:

Q1= 4.0328 Litres / min = (6.721e-5) m^3/s.
N1= 60 rpm.

*By using equation 3, *Q2* =N2/N1 x *Q1*=[620.69/60]x 4.0328 Litres/min= **41.719 Litres/min or 0.000695 m3/s.**

This means that in order to design (with a maintained diameter of 4 inches), a product that pumps water up to 15m and has a high-water flow rate of approximately 42 Litres/min, the device rpm must be 621 and above. This would prompt an increase in the impeller blades quantity and durability. Plastic blades (as we used for prototyping) will be subject to stress and breakage when pumping water through a 620+ rpm shaft.

This indicates that a motorcycle would work well. As they have nominal revs per minute of about 1000rpms. The only downside is the constant need for fueling (as the user mentioned). The designed water pump accommodates bikes, motor bikes or electric bikes, so it has so much potential to suit many different devices.

6. USER FEEDBACK

Following the successful competition of prototype water pumps, the pumps were tested in front of users (those we previously interviewed). Following that, these interviewees completed a product survey form. Please see the appendix for links to the complete customer feedback reports.

7. LIMITATION AND FUTURE WORK

The developed pump designs are scaled-down prototypes. They can meet the needs of less-intensive communities (distances or depths of water about 2m away). These designs, however, would be unsuitable for distances of 15m or greater. A water filter was one of the features that was supposed to be included in the pump design. Despite the fact that one was purchased, it was unable to be included in the final design due to project time constraints. It will be implemented in the future with the goal of filtering the pumped water (from wells or underground). The researchers intend to scale up the project to accommodate the long distances that the water must be pumped.

ACKNOWLEDGMENT

Dr. Kenobi Morris deserves special recognition for the knowledge he shared with us and for his insightful feedback. Mr. Prince Coffie, the class teaching assistant, is also thanked for his expert assistance. Furthermore, numerous gratitude is expressed to Mr. Peter, the workshop coordinator, for making the workshop available and assisting in the planning and construction of the prototype. Finally, many thanks to all the interviewees who took the time and patience to contribute to the project.

APPENDIX

1) Water Pump Orthographic Projections:
https://drive.google.com/drive/folders/1pnlCF-SkObUcQ1idRyr0pJUwDrtCeTrJ?usp=share_link

2) Link to Bicycle Water Pump Video:

- Working shaft and impeller:
https://www.youtube.com/watch?v=2fppw4eVYjs
- Complete bike pump:
https://www.youtube.com/watch?v=CphJ1AYmpII

3) Complete Water Ram Pump Video:
https://youtu.be/KSkPRFTkgMY

4) New Product Evaluation Survey:

- Water Ram Pump:
https://drive.google.com/file/d/1sBej560NyETJz6AFqTkIVU5wWU1-vIz-/view?usp=share_link
- Cycle Water Pump:
https://drive.google.com/file/d/1UHBxyXl40NoHdCaZDHu_z35niujlBeUO/view?usp=share_link

REFERENCES

[1] [UNESCO. (2014, April 10). Rural water development. Retrieved from:
https://en.unesco.org/themes/water-security/hydrology/water-human-settlements/rural-development.

[2] McKay, A. B. (2018). The Water Buffalo: Design of a Portable Bicycle Powered Irrigation Pump for Small-scale African Farmers. University of California, Davis.

[3] R. Ahmad, S. Sarip, K. A. B. Hashim and M. A. Suhot, "Design and development of a hydraulic ram pump for the rural communities," 2020 IEEE 8th R10 Humanitarian Technology Conference (R10-HTC), Kuching, Malaysia, 2020, pp. 1-5, doi: 10.1109/R10-HTC49770.2020.9357006.

7. REFERENCES

[4] Kwao, P. (2021, November 12). Personal interview [Personal interview].

[5] Samuel, O. (2021, November 12). Personal interview [Personal interview].

[6] Jurata, J., Nattapong, T., Yosawatt, L. (2019). Determination of Hydraulic Ram Pump Performance: Experimental Results. Retrieved from: https://www.hindawi.com/journals/ace/2019/9702183/

[7] Royal Academy of Engineering. (2017). The mathematics of Pumping Water AECOM Design Build. Retrieved from: https://www.pumpfundamentals.com/tutorial3.html

Interview 05

Team Deep Breath

Samuel Yawson
Daniel Mainoo
Augustina Osorade
Ernestina Domey
Blessing Asare
Desmond Osarfoh Amoah
Nana Adjoa Owusu-Morgan
Justice Asamoah Aidoo
Enock Baaladoe

Interviewer (I): The first question is, generally, what is the project about?

Team Deep Breath (TBD): Okay Dave. I am Enock Baaladoe and I am part of Team Deep Breath. For the first question, it's an obvious answer. The core priority going into the DSD/BSD/DSB competition was to win because right from the beginning of the course project we were determined to do very well in this project and so we had hopes that we were going to win. Hopefully, we did.

I: So sorry, I think you didn't get the question. I just want a brief overview of what your project is about.

TBD: Oh okay. The project is about creating an automated system which can help predict if a patient has COVID-19 or not from their chest x-ray scans. That's the general idea of the project. That deals with getting test x-ray scans, feeding that into a mobile app and letting the machine learning model which is the automated part of the whole system do the predictions for you. That's a very brief and basic explanation of our project.

I: Now we move to the competition. What was the origin of the competition, how did the competition come about, and what was the whole competition about?

TBD: the competition was a research and design innovations competition where the competitors or those who are involved were required to bring up work that they have done in the direction of research or work that they have done in the direction of design basically to solve medical health-related problems. That's an overview of the competition.

I: Okay, that's very good. Moving on, I think one of your teammates already answered it but before you entered the competition, what was your expectation because as you said, different people were coming for the competition? Did you aim to win, were you scared, were you nervous?

TBD: Sure, we were a little nervous, especially considering the time that was given to us to prepare for the competition and also the project we've come by. We were a little nervous and we didn't know the people we were going to compete with but we had high hopes that we were going to win and of which we did. That was our core priority no matter how nervous we were and thankfully we won.

I: Wow, so during the period of the competition, as you said you were not nervous you met different people, how was it like? First of all is it your first competition of that sort?

TBD: Yes, please it was. I am Ernestina. I am one of the teammates of Team Deep Breath. It was our first competition.

I: And how was the experience?

TBD: I'll say it was very exciting but at a point it became stressful. When we started getting good results on the project it was very exciting. We even tried to do more to get excellent results so it was very exciting.

I: Was it a one-day competition?

TBD: Yes please, it was a one-day competition.

I: And as you were saying at a point it gets stressful so what kept you going?

TBD: Okay, first we didn't know it would get us into a competition so what was getting us going was our grade because it was a course project but after we knew we were taking it into the competition we were going in for the prize, so the prize motivated us to do well in this competition.

I: So, imagine if you hadn't won, I mean with all this excitement that you have now as winners of the competition if you didn't win would you have continued? Because as you said earlier, it was a course project initially and you were looking for just grades so would you have continued?

TBD: For your question on whether or not we were going to go ahead and finish the project, supposing we didn't win the competition, the obvious answer is yes. At first, I think what was driving us was just as my colleague said, the A and the grade so our core motivation was to just get an A in the grade but while going on with the project, I think we fell in love with the project and we realized the impact that the project would have in the real world. That was the main focus of our project – the impact, not to win the competition. I think we would have continued to complete the project even despite probably not winning the competition.

I: Okay, is it just your opinion or the opinion of the whole team?

TBD: It's the opinion of the whole team.

I: Now to the impact of your project, how will your project impact the lives of the people?
TBD: This is Adjoa Morgan. The project we did in short was about getting accurate diagnostics for COVID-19 promptly. At its core, the project was just meant to save lives because if COVID is detected early it won't spread and at the end of the day it will save lives. What we also planned to do is that we know COVID is a land disease – it affects the land, so we were thinking that in case – even though we don't want it to happen – in case there was something like another pandemic that affects the land we can optimise the project, we can still make it in such a way that it can be able to be used to detect other pulmonary diseases as well. In the long run, it saves lives, Ghanaian lives by accurately diagnosing COVID-19.

I: It was a semester project, right?
TBD: Yeah, it was a semester project.

I: What was the name of the course?
TBD: Local issues in biomedical engineering

I: Okay so it was not related to AI or Machine Learning?
TBD: No

I: So you guys were the ones who applied the AI and machine learning to it.
TBD: Yes, please

I: That's beautiful. Are all of you biomedical engineering students?
TBD: Yes

I: Then the question I'm coming to ask is obsolete, I think. But then you being biomedical engineering students, how did that help in your project?
TBD: This is Augustina. How did this project help us? Initially, before we started this project most of us didn't know what machine learning was, most of us didn't know what UI/UX was but because of this project we had to go and learn what machine learning was all about so that we can apply it to the project, what UI/UX is all about. At the end of this project, we learnt some new fields which we can add to the skills we're learning as biomedical engineers.

I: So definitely the School of Biomedical Sciences, University of Ghana helped you, right?
TBD: Yes, please

I: Based on that, would you say it was instrumental in coming up with this project?
TBD: I am Asamoah Aidoo Justice. Yes, we will say that the school of biomedical engineering sciences helped us in all courses that we took in our years of biomedical engineering. I would say it helped because initially we were just thinking about the project as being an A course but then we got to know that there are more things that we were supposed to include. Taking it from the biological aspect, it being anatomy and physiology way back to general biology we were able to get to know that we have to target biomarkers and also biosensors that also help in the early detection of COVID-19. Taking it from computational tools, which is also a course that we do under biomedical engineering, we were able to indulge in the project with our programming aspect and we have a course that is called engineering principles we were able to know the steps and processes that we need to follow to achieve better results. Yes, we will say that the School of Engineering, that is the Department of Biomedical Engineering played a huge role in this research.

I: Just a few other questions. You built a model that can detect COVID-19, you went for the competition and you demonstrated it but how close is your project to becoming an actual product? Is the question clear?
TDB: I think the question is more about finding out how close it is to a final product and what are the future steps to get to that point.

I: Yes, that's it

TDB: That's a very good question. At the moment, what we have is the machine learning model together with a user interface that helps the radiologist or even the general medical practitioner to automatically detect COVID-19 from the x-ray scan. One of the key things about biomedical engineering and the medical field at large is that patient data is very important. In a case like this where we're using chest x-ray data, we would have to have some data security as well. That must meet something called paper requirements, that's the protection of the health data of the patient. That's one of the key things we're looking at next. In the case where we're going to scale it up, that's the first thing we'll look at – how to protect the patient's data and how to make sure it's accessible by just one person or a very secure location making sure that no other person can intersect or come into the whole system to access the data. Another thing that we would have to take note of is how to scale it up with other diseases as well. What Google does with Google's DeepMind and all of their products that they're doing is that they can scale up some things that they can do with one disease applying it to other diseases as well. For instance, there's this Alzheimer's project in machine learning that was worked on which was also applied to COVID-19. You can just cough into the app and it detects whether you have COVID-19 or not. That's one of the things we saw in our research. We do not want our project to be limited to just COVID-19 because COVID-19 cases have reduced, we want to scale it up to other diseases as well. Like pulmonary fibrosis. These are things that are possible with machine learning. In the case where we have few radiologists in ghana, it can be very helpful. The last thing I will say is a market survey would be needed to test the beta version of the app when we have it with radiologists so we can improve on it based on their feedback. Finally, we are getting approval from the FDA which is a whole process on its own after which we will have a commercialized product. These are some of the steps we are looking at for the future.

I: That looks like a long time!

TDB: Exactly, yeah. Very long time.

I: There was one question I was going to ask but seems like you've already answered it. The question was don't you think your project will become obsolete since it looks like COVID-19 cases are reducing but you mentioned that it can be extended to detect other diseases. That answers that. Concerning machine learning, is your ML model already deployed?

TDB: ML Model deployed?

I: Have you deployed the model?

TDB: Deployed the model? No, we've not made it open-source yet, we've not deployed it yet. Currently, everything is running locally on the PC we used.

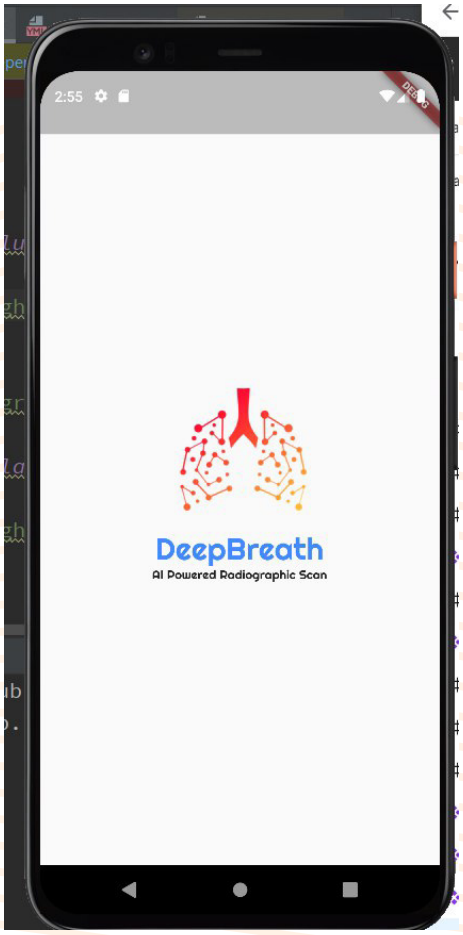
I: Generally, I think it's a very interesting project. What's the future, because normally after the project and everything group members and all that becomes difficult. What's the future, do you look to carry it forward? Are you even thinking of it, maybe business-wise?

TDB: The future, I'll say, is determined by some of the other things that we'll go through in the process. For instance, after a market survey, a real market survey, if you realise that there's not much of a need for a machine learning model to detect pulmonary fibrosis in ghana or some land diseases in ghana then it means that we might have to consider or shift what we are doing to a particular place where it is much needed. That's one thing that we are considering, that even if we are not able to move it up with this same kind of app or software or product, we might use machine learning from a different direction. That's what usually happens in every entrepreneur's life. Mark Zuckerberg began with Facemash. Facemash was just a way for Harvard students to be able to see which person is a good option for a date or not. Then it moved now to Facebook where many people are connecting across the globe. Amazon for instance also began as just an online bookstore, they were just selling books but now they've scaled that up to a whole market on its own. We are not limiting ourselves to just the Deep Breath App but exploring the other options that are there. What is the need that is there? What are people willing to pay for and that is very important? What are people going to benefit from if we produce a final product? These are some of the things that are running through our minds at the moment.

I: That answers part of the question. I wanted to hear about your readiness as in, is the team ready to continue because after some time you know people get occupied in different things. If everything is there, are the people willing, are you guys willing to move on?

TDB: I think I now get the question. Yeah, if everything is available in terms of funding, and grants, we are available to work on this project or any project with the same technique that our model can achieve. What we are doing to prepare ourselves then is that some of us have started taking more specialized courses in machine learning to build up our skills in machine learning. Some of us are also researching more into UI/UX, app development, frontend and backend as well so in the case where we have to scale this up, obviously moving from the course project to a viable commercial product will need a lot of skill to bridge that gap. Yes, the team is willing and ready, we're preparing ourselves with skills for that so that right after we graduate we'll zoom into whether we'll work on this same project or a similar project in the medical field.

I: I think that should be all. Thank you for your time!



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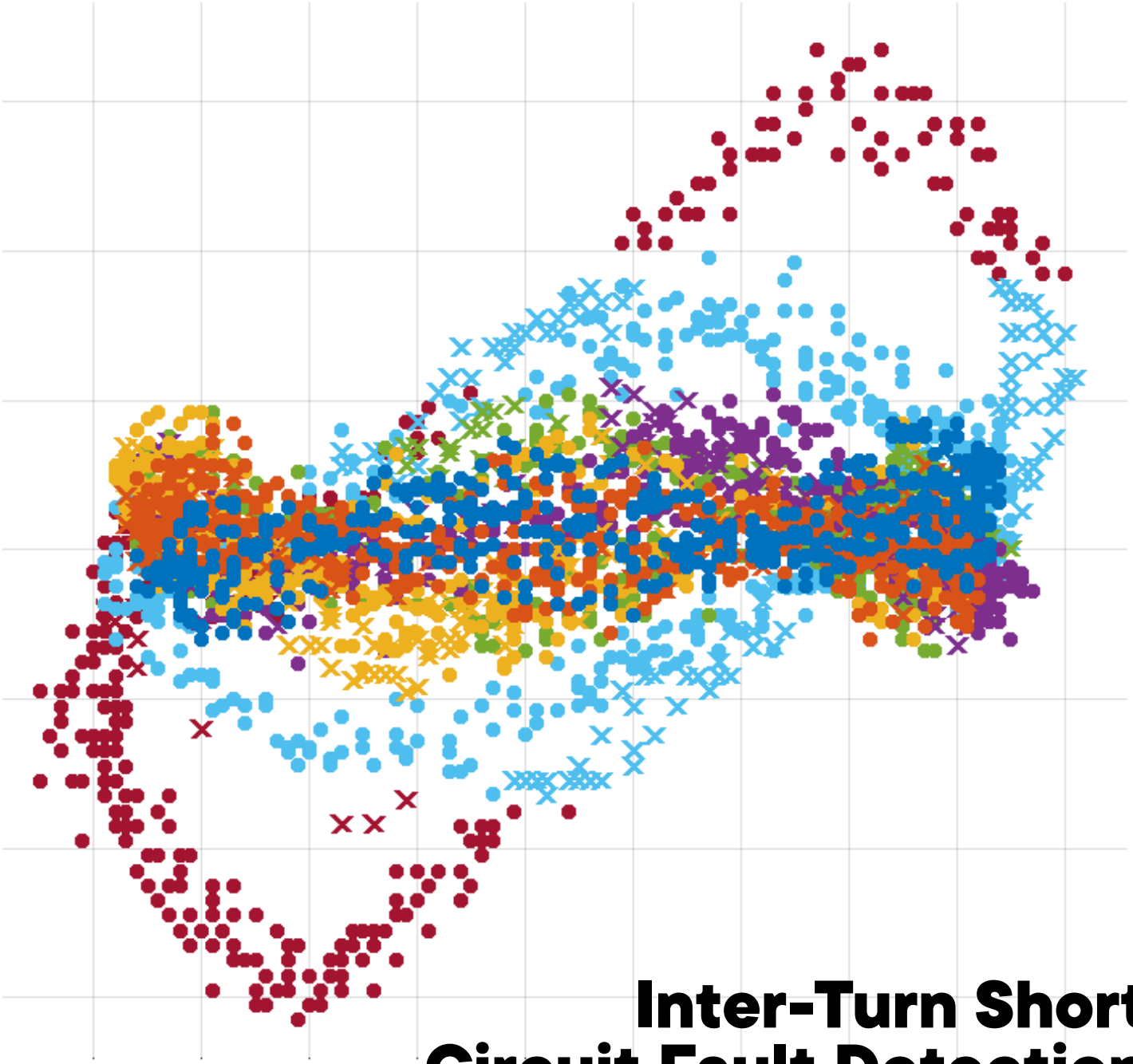


Inter-Turn Short Circuit Fault Detection and Prediction in Induction Motors

ABSTRACT

Induction motors are expensive and the backbone of every industry. There would be no production when induction motors break down. It is also costly to repair them after a sudden shutdown. Industries are gradually adapting to predictive maintenance to prevent unnecessary shutdowns and reduce the cost of maintenance. This paper's objective is to make the predictive maintenance of induction motors more reliable by adding fault detection. This will ensure the reliability of the induction motor, as it will continuously run to increase production quantity and quality while lowering production costs. This project uses secondary stator current data from a three-phase induction motor to detect and predict inter-turn short circuit faults. The stator current data can detect a higher percentage of electrical faults. The predictive maintenance toolbox in MATLAB is used to achieve the fault detection and prediction algorithm. Two classification algorithms, Support Vector Machine (SVM) and K-Nearest Neighbor (KNN) are used to detect and predict the inter-turn short circuit fault. It is found that the selected classifiers of the SVM algorithm gave almost a perfect prediction accuracy as compared to the classifiers of the KNN algorithm. The suggested fault detection and prediction in induction motors work very well, increasing the machine's reliability by decreasing the breakdown time and maintenance cost.

Keywords *- Predictive Maintenance, Inter-turn short circuit, Machine Learning.*

1. INTRODUCTION

Industries have been the driving force of a good economy. Almost all industries rely on induction motors for their functioning, and it consumes more than 50% of the total generation capacity of industrialized nations [1]. Induction motors have high efficiency, performance, and reliability, and their speed can easily be controlled electronically [2], making them the most widely used motors in the industries. These motors are expensive and operating them under faulty conditions can cause deviation in their regular performances, more damage, and reduce the machine's lifespan. They are very expensive to replace or repair when they break down. The cost of repairing a machine after failure is three times the cost of performing predictive maintenance on that same machine [3].

When these machines break down, the economy comes to a standstill, as there would be no production of goods and services, affecting the economy. This makes it crucial for the recent research interest in monitoring the condition of induction motors to detect any fault and failure in advance. Most industries have started implementing predictive maintenance in their equipment to make them reliable. However, the prediction of faults in their machines would not always be accurate. There could be times when the machine will suddenly develop faults without a warning. Hence, this project will focus on combining the detection and prediction of inter-turn short circuit faults in induction motors using the Predictive Maintenance toolbox in MATLAB [4].

2. LITERATURE REVIEW

Condition monitoring is a technique of checking a particular machinery condition while it is in use. These conditions can be pressure, current, voltage, temperature, vibrations, and others. It entails gathering data, analyzing it, comparing it to trends, benchmarks, and sample data from similar healthy machines. These condition monitoring techniques include oil analysis, vibration analysis, Motor Current Signature Analysis (MCSA), Infrared thermography, and many more.

In [5], vibration analysis is used to monitor vibration levels and patterns from an electrical machine to detect abnormalities. Vibration levels rise when mechanical problems like bearing faults occur in high-speed rotating equipment. It is a cost-effective and time-saving method of obtaining condition indicators for machine health management. However, this requires expensive accelerometers and accompanying wiring. This restricts its use in various applications, particularly in tiny machines where cost is a significant consideration when selecting a condition monitoring approach. Moreover, when the diagnosis is based on numerous motors working in tandem with much noise, this constraint becomes even more complicated.

Oil Analysis is another means of performing condition monitoring in induction motors. Much information about the induction motor’s running state can be gathered from its lubricating oil. The induction motor’s wearing state developing trend can be monitored to detect a potential problem in time [3]. However, the analysis intervals are not frequent, which can cause the machine to totally break down.

Motor Current Signature Analysis is also a condition monitoring technique developed by the Oak Ridge National Laboratory [6]. It offers a sensitive, efficient, and cost-effective way to monitor a wide range of industrial machines in real-time. This technique can be implemented using either time-domain or frequency domain, and it is best used for bearing failure and inter-turn short circuit detection. However, it involves a lot of mathematical computations making it error prone.

The dynamic system model is typically used in model-based fault diagnostic techniques. The actual system and model output benefit the industrial system's model-based techniques. The simulation and the real world can be compared, and actual data outputs, and hence, through visualization, the state of a motor can be determined. Physical modelling can be used to create dynamic models. The most important challenge with model-based techniques is its dependent on explicit motor models [7]. The correctness of the model describes how the diagnosis

system behaves.

3. METHODOLOGY

This section focusses on the detailed steps taken to achieve a detection and prediction model.

3.1 Design Theory

Inductance and resistance are the main parameters of the circuit of an Induction motor. Studying the outcome of these parameters' malfunctioning helps identify the parameters and the conditions that can affect their value. These two main parameters are further divided into resistance, self-inductance, and mutual inductance.

3.1.1 The Resistance

The resistance value is given as:

$$R = \frac{\rho l}{A} \quad (1)$$

where R is the resistance measured in ohms (Ω), l is the length of the cable in meters (m), A is the cross-sectional area of the cable measured in meters square (m^2), and the ρ is the resistivity measured in ohm meter (Ω.m).

3.1.2 Self-Inductance

Magnetizing and leakage inductance make up the self-inductance in stator and rotor windings. Because the windings of a healthy machine are identical, the self-inductance of all stator windings will be similar.

$$L_A = L_B = L_C = L_{ms} + L_{os} \quad (2)$$

Magnetizing inductance of the stator is given by:

$$L_{ms} = \frac{\mu_o l r N s^2 \pi}{4g} \quad (3)$$

Where l is the motor's length, r is the radius of the cross section of the motor, g is the radial length of the air gap and N_S represents the effective number of turns of the stator windings.

3.1.3 Mutual Inductance

Mutual inductances can exist from stator-to-stator as shown in equation (4).

$$L_{xsys} = \frac{\mu_o l r N s \pi}{4g} \quad \text{Cos}\theta_{xsys} \quad (4)$$

where θ_{xsys} is the angle between the stator windings x and y, and L_{xsys} is the inductance between any stator winding x and any other stator winding y. By substituting equation (3) into equation (4),

$$L_{xsys} = L_{ms} \text{Cos}\ \theta_{xsys} \quad (5)$$

The normal winding distribution in a healthy induction motor has two stator windings that are displaced 120° apart in one direction and 240° apart in the other direction. Hence Cos θxsys in equation (5) can be rewritten as:

$$\text{Cos}\ \theta_{xsys} = \text{Cos}(\pm 120^\circ) = \text{Cos}(\pm 240^\circ) = -0.5 \quad (6)$$

From equations 2-6, the mutual inductance between two stator windings is: $L_{AB} = L_{BA} = L_{AC} = L_{CA} = L_{CB} = -0.5 L_{ms}$ (7)

where θ_{xsys} is the angle that exist between any stator winding x and y [8].

The above equations show that the inductive flux in the motor's windings decreases when there is an inter-turn short circuit fault in the motor. This is because, when there is a short circuit, the current passes through the windings with the least or no resistance. This decreases the Ns from equation (3) and, in turn, decreases the flux. The reduced flux in one phase winding of the stator exposes the motor to unbalanced currents, which causes a negative sequence current (an indication of the presence of an inter-turn short circuit fault).

3.2 Experimental Set-up

Secondary data for this project was obtained from an online data source of an induction motor [9]. The secondary data is obtained from a test bench consisting of a 4-pole and 3-phase induction motor with a rated amperage and voltage of 3A and 220V, respectively. The testbench is a 1hp motor that operates at a frequency of 50Hz. The data has time labeled as 'TIME,' and current values from the four poles of the motor labelled as CH1, CH2, CH3, and CH4. The stator circuit was re-wound, allowing access to the winding's ramifications to introduce inter-turn short circuits. Different short-circuit levels were emulated, ranging from less severe to most severe.

3.2.1 Fault Detection and Prediction Approach

This project focuses on using MATLAB Predictive Maintenance Toolbox to detect and predict inter-turn short circuit faults of an induction motor. The Predictive Maintenance Toolbox includes functions and interactive apps like the Diagnostics Feature Designer and Classification Learner App that help extract and rank the four current values (CH1, CH2, CH3, and CH4) by the importance of the data and models, including statistical and time-series analysis. Figure 3.1 shows the block diagram for the detection and prediction algorithm.

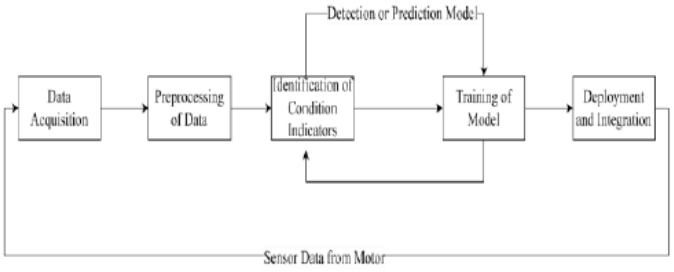


Figure 3.1: *Detection and prediction algorithm*

3.2.2 Data Acquisition

Secondary data consisting of the current values of the motor was used for this project. The secondary dataset was already grouped into seven (7), from 0 to 6. Data under the 0 group was the data for a healthy motor with no faults. Those under group 1 were slightly faulty, and they were in the initial stages of developing inter-turn short circuit fault. The severity of the fault increased as the group number of the motor increased from 0 to 6 [9]. Figure 3.2 (a) shows a picture of the sample current data of a healthy under no-load motor data, and hence, belonging to the group 0. Figure 3.2 (b) also shows a sample current data of a faulty motor under no-load condition, and hence belonging to group 6. The full dataset was imported into MATLAB for the model training. The current rating of the motor used for the experiment was 3A. Looking at the current values, namely, CH1, CH2, CH3, and CH4, Figure 3.2 (a) has values far below the 3A current rating of the motor used to get this secondary data.

On the other hand, Figure 3.2 (b) has current values either very close to or beyond the rated current value of 3A. The CH1, CH2, CH3, and CH4 current values follow the same trend for motor groups (1-5). The current values get close to or go beyond the rated current value of 3A, making the current values important features for machine learning model training.

	TIME	CH1	CH2	CH3	CH4	CONDITION
2	1:58:25 AM	1.584	1.32	2.1	0.9	0
3	1:58:26 AM	1.592	1.32	2.1	0.92	0
4	1:58:27 AM	1.624	1.36	2.12	0.92	0
5	1:58:28 AM	1.608	1.38	2.14	0.9	0
6	1:58:29 AM	1.592	1.4	2.14	0.92	0
7	1:58:30 AM	1.592	1.44	2.16	0.92	0
8	1:58:31 AM	1.608	1.46	2.18	0.94	0
9	1:58:32 AM	1.624	1.46	2.22	0.94	0
10	1:58:33 AM	1.664	1.5	2.22	0.94	0
11	1:58:34 AM	1.672	1.52	2.24	0.96	0
12	1:58:35 AM	1.64	1.54	2.26	0.96	0
13	1:58:36 AM	1.624	1.56	2.28	0.94	0
14	1:58:37 AM	1.704	1.58	2.28	0.98	0
15	1:58:38 AM	1.688	1.6	2.3	0.98	0
16	1:58:39 AM	1.624	1.64	2.3	1	0
17	1:58:40 AM	1.656	1.64	2.34	0.98	0
18	1:58:41 AM	1.752	1.68	2.34	1	0
19	1:58:42 AM	1.768	1.72	2.34	1.04	0
20	1:58:43 AM	1.688	1.72	2.36	1.02	0

(a)

TIME	CH1	CH2	CH3	CH4	CONDITION
2:05:00	2.58	2.75	2.17	3.6	6
2:05:01	2.57	2.75	2.15	3.6	6
2:05:02	2.58	2.75	2.15	3.47	6
2:05:03	2.6	2.7	2.15	3.47	6
2:05:04	2.63	2.78	2.15	3.4	6
2:05:05	2.65	2.78	2.15	3.4	6
2:05:06	2.68	2.75	2.15	3.4	6
2:05:07	2.68	2.75	2.15	3.38	6
2:05:08	2.67	2.7	2.18	3.35	6
2:05:09	2.65	2.7	2.15	3.37	6
2:05:10	2.65	2.68	2.15	3.35	6
2:05:11	2.65	2.67	2.17	3.3	6
2:05:12	2.65	2.65	2.17	3.28	6
2:05:13	2.63	2.65	2.15	3.28	6
2:05:14	2.65	2.63	2.15	3.23	6
2:05:15	2.65	2.6	2.17	3.23	6
2:05:16	2.65	2.57	2.17	3.2	6
2:05:17	2.63	2.57	2.17	3.18	6
2:05:18	2.63	2.55	2.17	3.17	6
2:05:19	2.65	2.53	2.2	3.13	6

(b)

Figure 3.2: *(a) healthy no load. (b) Faulty no-load motor data.*

3.2.3 Pre-processing of Data

The pre-processing of data involved analyzing the current signals and time series of the secondary motor data and preparing the signals for the next step. Pre-processing the data entailed converting unstructured or raw data into a usable format. Data pre-processing required tracing signals into several domains to extract condition indicators from them and generate data ensembles for effective handling of data. The random features discovered using signal processing techniques and feature extraction were the current signals of the motor [10]. Time-domain analysis was the main feature extraction technique used in the data pre-processing stage. In analyzing the signals, operations like filtering, smoothing, and labelling were performed on the signals.

3.2.4 Identification of Condition Indicators

The Diagnostic Feature Designer App in MATLAB analyzed and extracted the most important current values from the dataset. The current values were sorted and selected based on one-way ANOVA statistical tool for further processing. The identification of condition indicators from the one-way ANOVA helped rank the current values for effective training of the model in the Classification Learner App in MATLAB. The current values were ranked to select the most important ones as condition indicators from the raw data. The current values selected as the most important were the current values from CH1, CH2, CH3, and CH4 of the original dataset. Ranking and selecting the most important set of current values with one-way ANOVA ensured that the model's accuracy improved.

3.2.5 Training of Model

The most important current values selected and ranked in the Diagnostic Feature Designer App were exported into Classification Learner App in MATLAB. For this model, all the current values (CH1, CH2, CH3, and CH4) were selected by the Diagnostic Feature Designer App. The model was classified and trained using Machine Learning algorithms deployed in the Classification Learner App in MATLAB. The Classification Learning App separated the data imported into MATLAB into three sets to increase the accuracy of the Machine Learning Models. 70% of the data was reserved for the training, 15% was used for validation, and 15% was used for testing. The classification of the different stages of inter-turn short circuit fault depended on the conditions indicator (rated current value of 3A), which distinguished a healthy motor from a faulty one. The Classification Learner app was used to monitor the induction motor's present conditions and detect and diagnose faults. It determined the machine's health if it was failing and what was failing. The selected condition indicator trained a model using different machine learning algorithms to detect and predict inter-turn short circuit fault in the induction motor. The machine learning algorithm for model training focused on Support Vector Machines (SVM) and the K-Nearest Neighbor (KNN) algorithms. These algorithms were chosen because they have a high-performance ability to accurately predict even with limited data.

3.3 Detection of Inter-Turn Short Circuit Fault

In a short-circuit fault for a given phase, the number of turns of the winding will reduce, causing the resistance to increase, as shown in equation (1). As shown in equation (2), the inductive leakage flux also decreases. The inter-turn short circuit was introduced for the testbench used by taking out insulations from sections of the coil of a phase and connecting it to a conductive material. The severity of the inter-turn short (the percentage of short turns) depended on the particular turn of the coil on which the

conductive material is connected [9]. Detecting the inter-turn short-circuit fault was done in three ways: threshold comparison, the negative current sequence, and the machine-learning algorithm.

3.3.1 Negative Sequence Current

The current sequence of the healthy motor is the positive sequence current. When the inter-turn short circuit fault occurs, two of the windings of the current signals are swapped. Based on that, an inter-turn short circuit can be detected.

3.3.2 Threshold Comparison

Comparing the threshold of healthy motor data signals to a faulty one was one of the methods used to detect the inter-turn short circuit fault. The rating of the induction motor whose current values were used for this project was 3A. Hence, when the signals of these current values went beyond this threshold, it indicated that the induction motor was faulty.

3.3.3 Machine Learning Algorithm

The machine learning algorithm detects inter-turn short circuits of the stator windings when the algorithm predicts that the test data is classified under group 6. For group 6 motors, they have no remaining useful life. The motor has completely developed the inter-turn short circuit fault.

3.3.4 Prediction of Inter-turn Short Circuit Fault in Stator Windings

Prediction of the inter-turn short circuit fault in the stator windings of the induction motor was based on the results of the machine learning algorithms deployed. The algorithm forecasts the inter-turn short circuit fault level by returning a number from 0 to 6. Number 0 meant there was no inter-turn short circuit fault in the stator of the induction motor. As the number increased from 0 to 6, the severity of the inter-turn short circuit fault increased, making group 6 the faulty motor with a complete inter-turn short circuit fault.

4. RESULTS AND DISCUSSION

This section focuses on the results from the implementation of both the detection and predictive algorithm deployed in chapter three. Statistical analysis is performed to select the best algorithm.

4.1 Fault Detection Results

The inter-turn short circuit fault was detected in three main ways: threshold comparison, negative sequence current and machine learning algorithms. However, the machine learning was able to detect and at the same time predicts the inter-turn short circuit.

4.1.1 Threshold Comparison

Inter-turn short circuit fault was detected by comparing the amplitude of any motor current signal to the threshold of the current signals of a healthy motor. The online testbench motor had a rated current of 3.0 A, so the inter-turn short circuit fault was detected whenever the signal went above the threshold of 3.0A, as seen in Figure 4.1. However, this method was inefficient because other faults could make the current signals go beyond the threshold. It was also unable to detect the level of inter-turn short circuit.

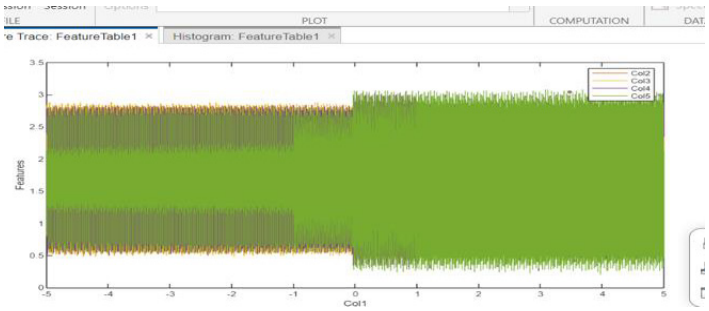
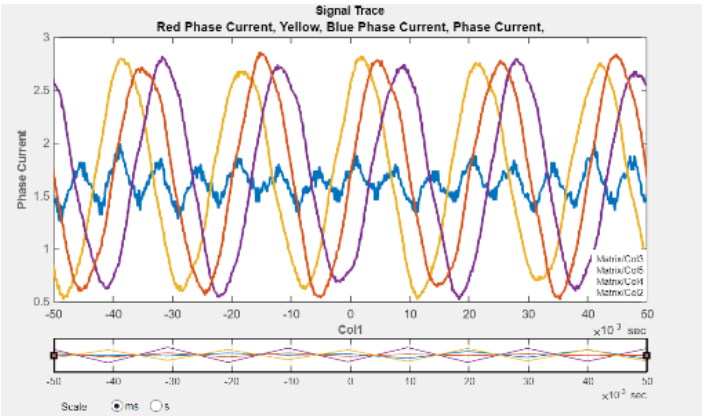


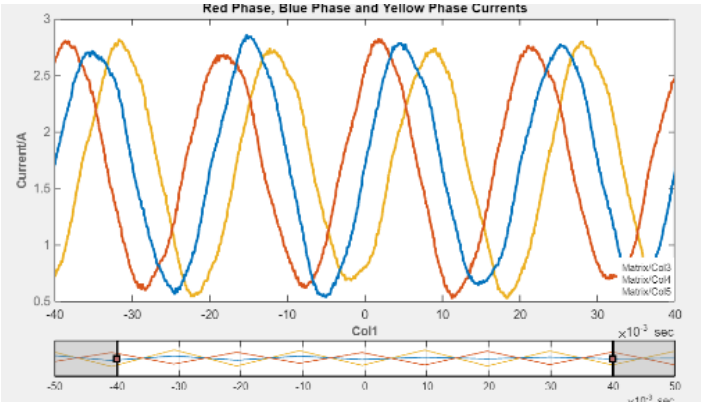
Figure 4.1: *Threshold comparison of current signals*

4.1.2 Negative Sequence Current

A balanced set of three-phase currents has positive sequence currents only as shown in Figure 4.2 (a). Figure 4.2 (a) has unfiltered signals. A negative sequence current is a clear indication of abnormality in the system. During the negative sequence, the direction of two of the current signal switches is seen in Figure 4.2 (b). This fault detection method was, however, not effective. This is because other asymmetry factors could cause the induction of negative sequence current into the system.



(a)



(b)

Figure 4 2: *(a) Positive sequence current graph. (b) Negative sequence current*

4.1.3 Machine Learning Algorithm

The group six (6) motor data had fully developed inter-turn short circuit fault. So, when the machine learning algorithm predicted a motor under group 6, it meant an inter-turn short circuit was detected. The machine learning algorithm is fully explained in next sections.

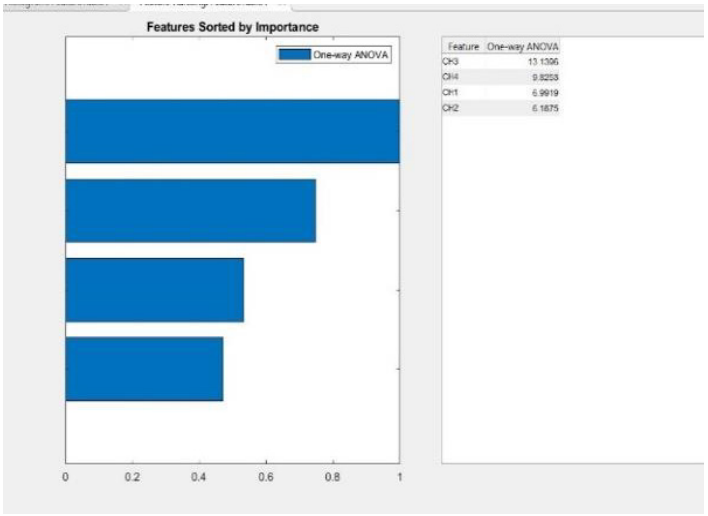
4.1.4 Fault Detection and Prediction Algorithm

Two machine learning algorithms, Support Vector Machine (SVM) and K-Nearest Neighbor (KNN) were used to detect and predict the inter-turn short circuit fault. The fault was detected when the machine learning algorithm classified the data under group six motor data. It meant the inter-turn short circuit had already occurred, and there are 0 weeks of remaining useful life of the motor. Under this section is the results from the procedures in training the SVM and KNN models.

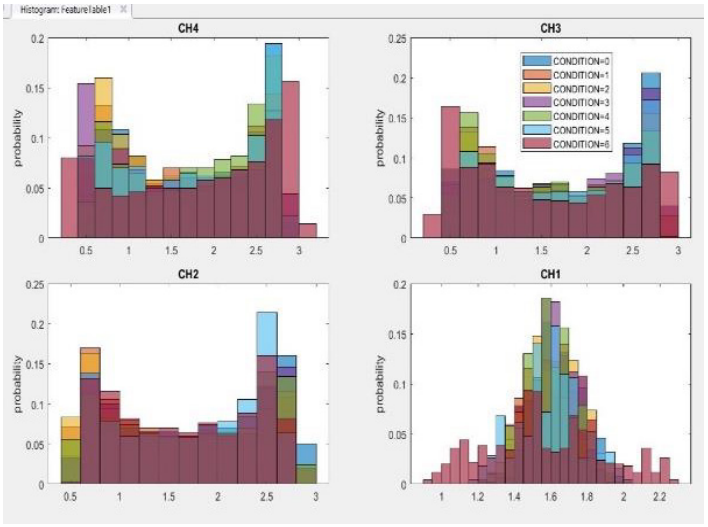
4.1.5 Feature Extraction and Ranking

The current values (CH1, CH2, CH3, and CH4) were extracted from the three sets (no-load, half load, and full load) of healthy and faulty data. Figure 4.3 (a) shows the lists of the ranked current values (CH3 first) extracted in the MATLAB Diagnostic Feature Designer App. Histogram plots from Figure 4.3 (b) also help investigate how the important current values in the different classes of motor separated across a bin. The best feature histogram is the one with the motor group appearing in different bins ranges in a particular histogram. Figure 4.3 (a) shows that CH3 was the set of current values ranked as the most important.

Figure 4.3 (b) explains it well as there are a lot of different motor groups across the CH3 bin in the histogram. The scatter plot from Figure 4.3 (c) further analyses the extracted features by investigating their relationship. For example, from Figure 4.3 (c), there is a high probability that when the current value from CH1 and CH3 are both 1A and belong to group 6, it will predict correctly.



(a)



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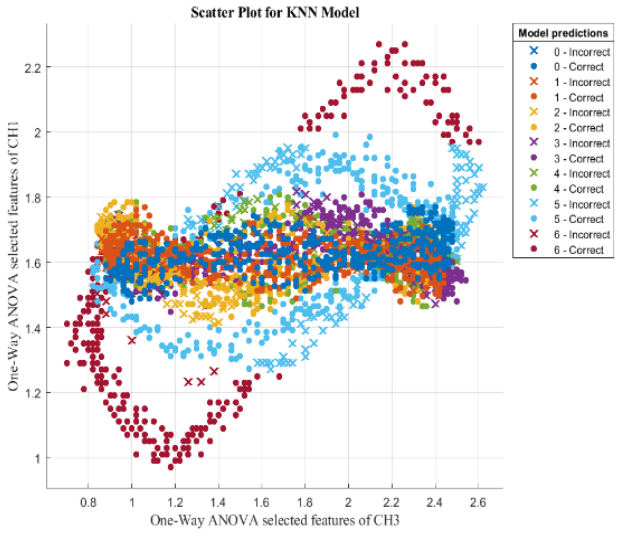


(c)

Figure 4.3: *(a) Current signal sorting. (b) Current in histogram. (c) Scatter plot of current*

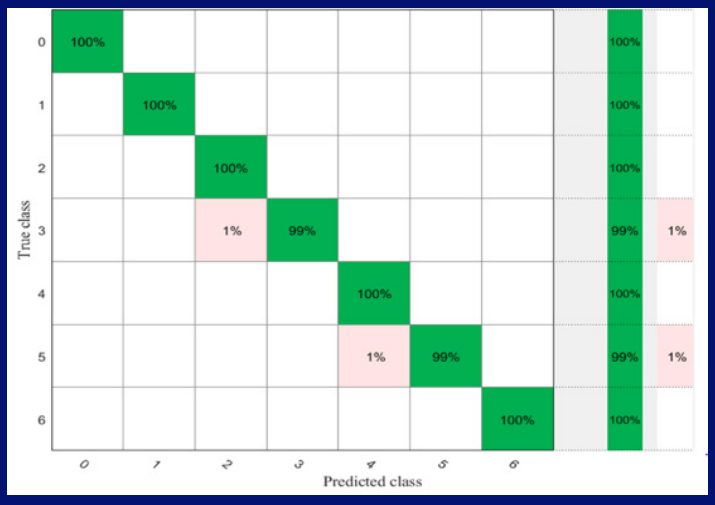
4.1.6 Results from Classification Algorithm for No-Load, Half Load and Full Load Induction Motors

After the feature extraction, the Support Vector Machine (SVM) and K-Nearest Neighbor (KNN) models were used to train the model. All SVM classifiers, namely linear, quadratic, and fine Gaussian SVM, had a classification accuracy of 99.8% for both no-load and half-load motors and 99.9% accuracy for the full load motor, as shown in Table 4.1. Figure 4.4 (a) shows the confusion matrix, which is the same for the no-load and half-load states of the motor. All classifiers of the SVM model under no load and half load state of the motor had a prediction accuracy of 99.8%. The model correctly predicted all the seven different groups of the motor fault (0-6) of the induction motor, except motors belonging to groups 3 and 5. The algorithm correctly predicted only 99.8% of the groups 3 and 5 motor, and wrongly classified 2% of them as belonging to group 2 and 4 respectively.

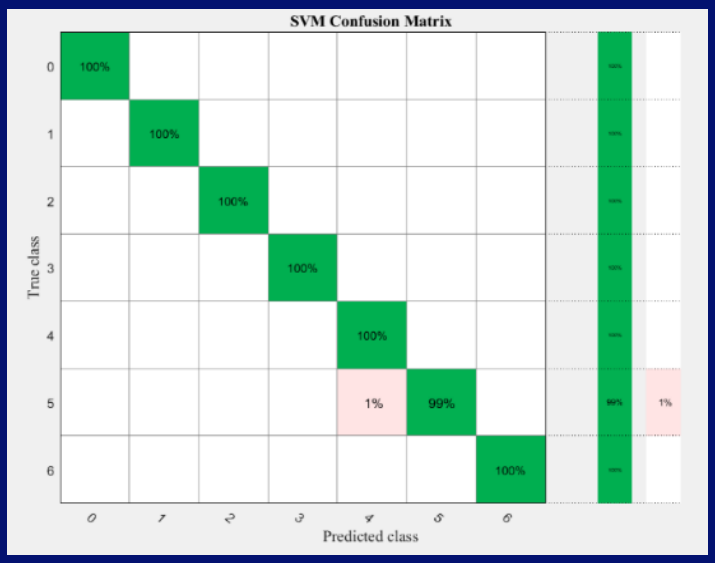
Similarly, Figure 4.4 (b) shows the confusion matrix for the different SVM classifiers under the motor's full load state. The algorithm correctly predicted 99.9% of the groups the motor data belonged. Only 1% of the full load motor data was misrepresented as belonging to group 4, when it actually belonged to group 5.

Table 4.1: *Accuracies for SVM classifiers under different motor loads*

Load State of Motor	SVM Classifier	Accuracy
No Load	Linear	99.8%
	Quadratic	99.8%
	Fine Gaussian	99.8%
Half load	Linear	99.8%
	Quadratic	99.8%
	Fine Gaussian	99.8%
Full Load	Linear	99.9%
	Quadratic	99.9%
	Fine Gaussian	99.9%



(a)



(b)

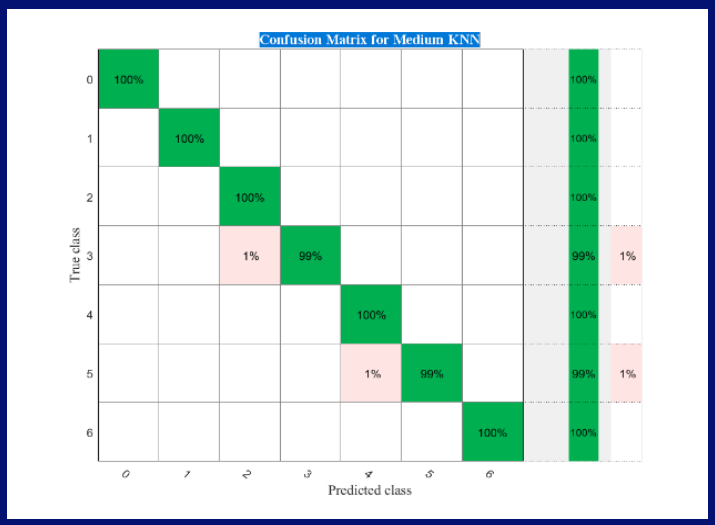
Figure 4.4: *(a) SVM no and half load confusion matrix. (b) SVM full load confusion matrix.*

For the KNN classifiers, namely medium, coarse, and cubic KNN, the confusion matrix accuracy of the trained models was 96.1% for all the classifiers under the motor's no-load and half load state, as seen in Figure 4.5 (c). For the motor's full load, the confusion matrix accuracy for the medium, cosine, and cubic were 99.8%, 73.5%, and 99.7%, respectively, as shown in Table 4.2.

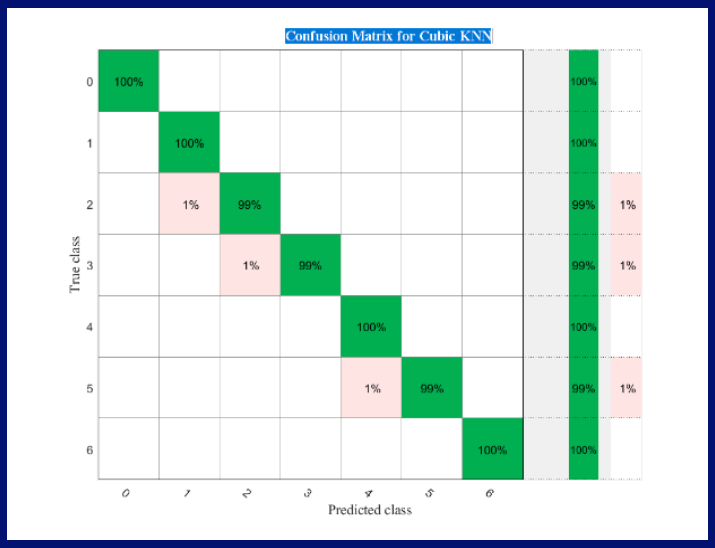
Table 4.2: *Accuracies for KNN classifiers under different motor loads*

Load State of Motor	KNN Classifier	Accuracy
No Load	Medium	96.1%
	Coarse	96.1%
	Cubic	96.1%
Half load	Medium	96.1%
	Coarse	96.1%
	Cubic	96.1%
Full Load	Medium	99.8%
	Cosine	73.5%
	Cubic	99.7%

Comparing the accuracies of the classifiers for both the SVM and KNN algorithms showed that the SVM algorithm was the best. The SVM algorithm had 99.8% for no-load and half load, and 99.9% for full load state of the motor. Therefore, the SVM algorithm was chosen for statistical analysis to see if there is a significant difference between the three different types of motor load states (no-load, half-load, and full load).



(a)



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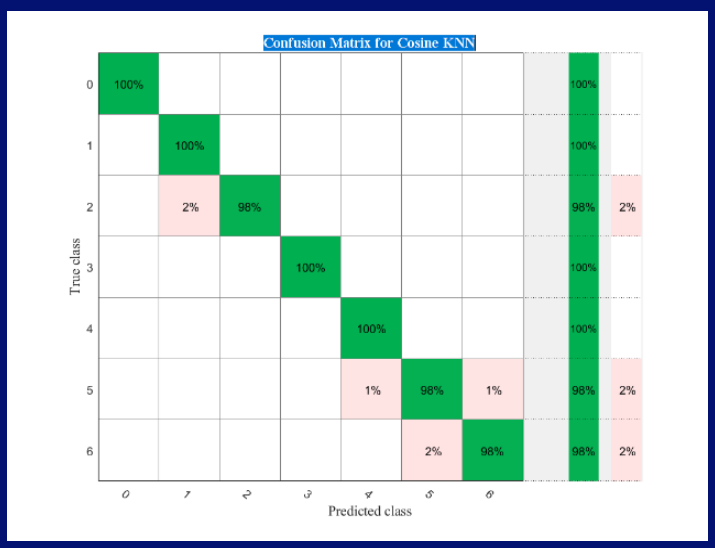

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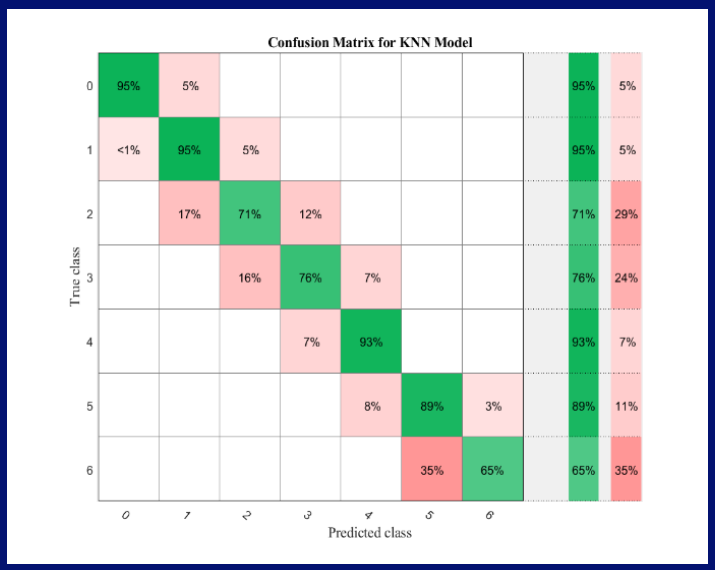
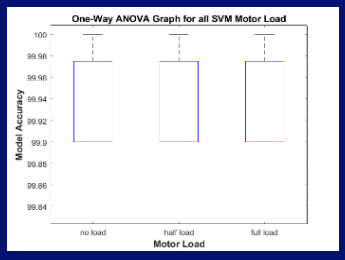


(d)

Figure 4.4: *Confusion Matrices for the KNN models*

4.2. Results from Statistical Analysis

The accuracy of the different classifiers of the SVM model under the different load states (no-load, half-load, and full load) was investigated to see if there was variation among them. Therefore, a one-way ANOVA test was performed on the SVM no load, half load, and full load accuracy values, as shown in Figure 4.6 (a). From Table 4.1, the accuracy for the different motor loads was almost the same, with no significant differences. The one-way ANOVA was performed to either reject or accept this null hypothesis. After the test, the p-value of 1, as shown in Figure 4.6 (b), was greater than the critical p-value of 0.05. Hence, the hypothesis that the accuracies for the SVM model are statistically insignificantly different was not rejected.



(a)

Source	SS	df	MS	F	Prob>F
Columns	0	2	0	0	1
Error	0.02	6	0.00333		
Total	0.02	8			

(b)

Figure 4.6: *(a) One-Way ANOVA graph. (b) p-value for ANOVA*

5. CONCLUSION

Induction motor predictive maintenance, also known as fault detection and prediction, is useful for monitoring equipment health. Predictive maintenance is a unique technique for diagnosing and prognosing faults in industrial machines. The accuracy of the inter-turn short circuit fault detection and prediction depends on getting accurate and enough data from the machine.

The data is then pre-processed to identify condition indicators from them. A model is then trained with the condition indicators to get the relationship between the source of mistakes and projected damage [11]. Making an accurate prediction of machine fault is essential to avoid its breakdown, affecting production. Also, detecting and predicting faults in induction motor lowers maintenance costs and improve reliability and productivity.

REFERENCES

[1] P. V. Patil and S. A. Naveed, "Implementation of VFD Application for Speed Control of Induction_Motor," 2020 International_Conference_on_Smart Innovations_in_Design,_Environment, Management, Planning and Computing (ICSIDEMPC), 2020, pp. 168 170, doi:10.1109/ICSIDEMPC49020.2020.9299636.

[2] [2] N. P. Sakhalkar and P. Korde, "Fault detection in induction motors based on motor current signature analysis and accelerometer," 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), 2017, pp. 363-367, doi:10.1109/ICECDS.2017.8390117.

[3] M. Markiewicz, M. Wielgosz, M. Bocheński, W. Tabaczyński, T. Konieczny and L. Kowalczyk, "Predictive Maintenance of Induction Motors Using Ultra-Low Power Wireless Sensors and Compressed Recurrent Neural Networks," in IEEE Access, vol. 7, pp. 178891-178902,_2019,_doi: 10.1109/ACCESS.2019.2953019.

[4] Z. L. Zheng and C. Tak Son, "A new approach to analysis of inter-turns faults of three_phase induction motors," 1997 Fourth International Conference on Advances in Power System Control, Operation and Management, APSCOM-97. (Conf. Publ. No.450), 1997, pp. 723-728 vol.2, doi: 10.1049/cp:19971923.

[5] S. Balters and M. Steinert, "Decision-making in engineering - a call for affective engineering dimensions in applied engineering design and design sciences," Proceedings of the 2014 International Conference on Innovative Design and Manufacturing (ICIDM), 2014, pp. 11-15, doi: 10.1109/IDAM.2014.6912663.

[6] P. Pillay and Z. Xu, "Motor Current Signature Analysis", Industry Applications Conference, vol. 1, pp. 587-594, Oct. 1996.

[7] F. Q. Yuan, "Critical issues of applying machine learning to condition monitoring for failure diagnosis," 2016 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), 2016, pp. 1903-1907,_doi: 10.1109/IEEM.2016.7798209.

[8] S. Liling, L. Heming and X. Boqiang, "Analysis on the transient of stator-rotor-hybrid fault in squirrel cage induction motors," 2005 International Conference on Electrical Machines and Systems, 2005, pp.1939-1944_Vol._3,_doi:10.1109/ICEMS.2005.202899.

[9] R._Cunha,_"Inter-turn_Short-Circuit_In Induction_Motor,"_Available:https://www.kaggle.com/datasets/rebecacunha/mit-short-circuit-flux-and-current_signals. [Accessed 22-Apr-2022].

[10] E. Byvatov, U. Fechner, J. Sadowski, and G. Schneider, "Comparison of Support Vector_Machine and Artificial Neural Network Systems for Drug/Nondrug Classification," Journal of Chemical Information and Computer Sciences, vol. 43, pp. 1882–1889, Sept. 2003

[11] S. M. Tayyab, E. Asghar, P. Pennacchi, and S. Chatterton, "Intelligent fault diagnosis of rotating machine elements using machine learning through optimal features extractionand selection: Procedia Manufacturing," ISSN 2351-9789, pp. 266-273, doi:10.1016/j.promfg.2020.10.038.

Interview 06

Yonkopa Pork

Mary Domfeh - Founder, Yonkopa Pork

Q: Looking at all the meat that is commonly eaten in Ghana, why was pork your focus? Did other meat not fit your project scope?

A: That is a nice question – according to research pork contains less cholesterol than other fatty meat like beef, mutton, chicken etc. With the aim of providing low cholesterol protein to customers pork was chosen. Also, it was because of the breeding span of pigs – one pig can give birth to at least 16 piglets in a year – imagine 10 pigs giving birth to at least 16 each a year thus 160 piglets. Pig farming seems very lucrative.

Q: What do you plan to do with this business in the future?

A: We hope to be the best and leading pork producer in Ghana and Africa as a whole – with aim to supply fresh lean pork to businesses. Expanding the business and employing more people to reduce the rate of unemployment.

Q: What advice would you give to any engineers who are looking to becoming entrepreneurs as well?

A: I would say, becoming an entrepreneur requires a lot of dedication, commitment, and devotion, having a nice idea is not enough. We all know the study of engineering can be stressful, and requires a lot of dedication too, but there is something about successful entrepreneurs- sticking to the vision of the company and believing in yourself and the vision of the company. Because there are times when you want to give up and passion will not be enough but perseverance, commitment, dedication, business coaching, mentorship, and finally involving God in everything you do. If your main aim is to make money, during the time of crisis you may give up – one thing that keeps me going is the vision of Yonkopa - To become the leading pork producer and provide jobs for the youth. There is a sense of fulfillment that comes with fulfilling that vision- Yonkopa currently has 3 part-time employees.

Q: According to your background, you are a computer engineer. How did you manage to find a working balance between engineering and becoming an entrepreneur?

A: Good question – although I am a computer engineer by profession, I love agriculture. Thanks to the Ashesi entrepreneurship center (AEC) initiative-I gained most of the entrepreneurial skills through their business coaching and mentorship. I am glad to say although I came to Ashesi to study engineering, I left as an AgricPreneur and Computer engineer. Managing business while studying full time was not easy at all, but passion, dedication, having the right people around, AEC initiative made it cool.

Q: How did you start your business and what are some of the challenges you faced when doing so?

A: A friend of mine in UPSA and I decided to venture into Agriculture, so we decided to venture into pig farming due to its lucrativeness. Yonkopa Pork was founded in the second year of my undergraduate program. That was during the peak of the COVID crisis, you can imagine starting a business around that time.

We have been able to secure grant funding from AEC and Ashesi Ford Foundation nevertheless, access to funding is a major challenge.

Also, the inflated cost of pig feeds, building materials are a major challenge.

Q: Would you give any credit to Ashesi for helping you enter this tech-business?

A: Yes- big thanks to the AEC and the entire team for the business mentorship, coaching, funding etc.
Special thanks to Ms Jewel Thompson, Mr Jude Acquah, Mrs Anna Okyere, Angelina Addo. And our mentor Mr Samuel Darko

Q: Do you fear you might not be able to compete with bigger competitors?

A: I will say the fear of expanding the business due to inflation.

Q: Are you open to the idea of collaborating with another company?

A: Yes definitely – Pork feed producers, biogas companies , logistics companies, companies that process pork to sausages, etc. to customers, restaurants, hotels, meat vendors just to mention a few. We are open to investment opportunities as well.

Q: What does a fully established Yonkopa Pork look like to you?

A: When Yonkopa Pork can supply almost 10 -50 pigs on a weekly basis to its target market and employed at least 10-50 full-time and part-time employees.

Interview 07

Trestle Academy

Interviewer (I): Before we begin, tell us about yourself and how Trestle academy came about.

Robert (R): I read BSc. Computer Science from the University of Ghana, Legon. I graduated in 2019. Before I even came to the University of Ghana, I was part of the robotics club in my school. I attended Bishop Herman College. Robotics was something that I've been interested in. I wanted to read Medicine but I failed the interview at Legon so I was given Computer Science as my second choice; I had a robotics background so I think it was cool. I currently have a BSc. degree in Computer Science, I did my national service as a teaching assistant – I assisted three lecturers, two senior lecturers with their research and other things. I have taken a couple of professional courses, I'm taking some courses from Harvard business school - executive education online program – as well. I am currently into robotics process automation. I do a bit of data science and AI too. I'm an ambitious person, I also intend to expose students to global opportunities and let them be able to bridge the gap between academics and what is happening in the real world. That's what started the Trestle Academy. We didn't start as Trestle Academy, I started it as a club. It was Artificial Intelligence Club. I started with a friend from KNUST, he was doing his masters in actuarial science by then and he was also championing a club called Ethical AI. He was more concerned about the ethical issues of how data is used in artificial intelligence technology. He was trying to champion the integrity that must be given to people's data in terms of privacy. He had a couple of chapters on the KNUST campus and UCC so I wanted to start this club at the University of Ghana so that I could collaborate with him. He was my first speaker for our first session in 2018. We transitioned into Trestle when I met some Swiss people, they were executives of Trestle Groups Foundation. It is based in Zurich, Switzerland. They came to Ghana in 2019. They were looking for opportunities to harness talent in the tech ecosystem in Ghana but they needed a base, an existing community to stand on and use as an incubator to work on their reason for being in the country. We met and had that conversation. I told them we've already started something like that at the University of Ghana and they said they will like to be our main sponsors for our events. Through that, we decided – since they already had the brand and were a big corporation – to use their Trestle as our name. we started using Trestle Academy in 2019 as a club until last year when we registered it as a company limited by guarantee, a foundation, and a non-profit. I am the co-founder and director. The current head of Computer Science at the University of Ghana, Dr Jamal is the co-founder and board chairman. We are now an organization, our mission is simply to provide the right environment for young people to discover their talents, nurture those talents and innovate to build sustainable solutions. Our anchor is on industry 4.0 which is emerging technology in areas like robotics, artificial intelligence, data analytics and the internet of things. These are the major technologies we intend to provide the right environment for people to test their skills in this.

I: And the tertiary students, do you go for people with a background in AI or any background at all doesn't matter?

R: When we started, we went for any background at all. It was a club and it was open to anybody. The basic requirement was to have a laptop and a desire to learn something new. But now, some of our boot camps are tailored so we may require say basic programming skills based on the chosen boot camp. As for becoming part of the Trestle community, we don't have any requirements for that.

I: That's very interesting. You said your aim is for people to harness robotics, AI, internet of things, that's your main focus area. Are you targeting only tertiary students or students of any age?

R: Yes, currently our focus is on tertiary students.

I: Your introduction somehow answered a lot of the questions I wanted to ask but what's your motivation for trestle academy?

R: I am a very curious person. Before I came to the university I started researching some of the things that were happening at MIT, Harvard, Stanford and others. I watch Stanford business school, I watch their tutorial sessions and some of their executive programs. I was following what was happening in MIT's media lab – I think it was built for innovation so students can collaborate with faculty to work on projects. The same thing at the Harvard iLab was designed purposefully for innovation. I saw these things and upon my coming to the University of Ghana, my expectations were not met. I had high expectations from the department. I got there and realised that things weren't the same there. It has then been my plan from level 100 to make a change. From level 100, I started working on becoming president of the Computer Science Students' Association. Right from the day I went to do my registration, I decided that I had to get into a leadership position and see what I can do differently. I got the contacts of all the computer science executives at that time and began chatting up some of them. I was also regular at the department helping out with the registration process because they were in their final year and most of them were not readily available to help with the L100 registration. Through that, I had a clear chance of taking the presidential position. I started going to programs at Movenpick, and professors from the Hult International Business School came there to have presentations. One thing that got me excited and puzzled at the same time was that a professor who teaches business was presenting on artificial intelligence. It was something I had never seen before so I was deeply puzzled and that opened my eyes to the fact that things could be better in my department. In the second semester of my third year, interested students were to file nominations for executive positions. I filed for president. My colleagues knew what I had done in the department right from my first year. Nobody even contested with me. I was then elected the president of the computer science student association and right from there I started organizing workshops. I had my first workshop with Edem Kumodji, I don't know if you know him. He used to be one of the best software engineers in ghana. He now works with Microsoft as a product manager. Edem was the first professional I brought as well as some other software engineers from Hubtel, the organisers of the workshop. The department had never seen such workshops organised by the student association before, the place was full up. There were people from Ashesi too, I remember. There were people from IMPC, Accra technical university, GTUC, and all over. It was an exciting session. Next, I collaborated with Figma Africa. I hope you know Figma.

I: Yes, I do.

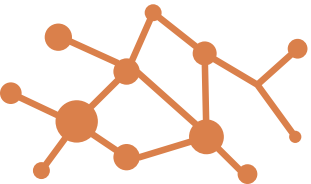
R: Yes, at that time, none of my colleagues or any other students in the department knew about Figma.

I: That was level 300

R: First semester of L400 because I started work first semester of L400. So none of my colleagues knew of Figma. Some knew of Adobe XD but not Figma. I was the first person that brought Figma to the department and it was really exciting. We had some interesting, interactive sessions. The people were surprised that you could build an entire user interface from such a simple software and prototype it quickly. We run it for a couple of days. We had a hackathon session as well where the people were to prototype some ideas and present them. Through that, the department entered a partnership with Figma. One of my friends, James Baddoh, is the co-founder of ADP List, a mentorship platform. He co-founded it with a guy from Singapore. Then, he was leading the Figma chapter here in Ghana so the department entered into a partnership with him. There was this course called Human-Computer Interaction, normally taken in level 400. Figma was integrated into the curriculum and we used Figma for our UI/UX designs. Because it was now part of the curriculum, students took an interest in it and the department currently has many UI/UX designers as a result. I also held a workshop with a certain networking company. The department has a full CISCO Lab for networking but barely anyone was using it because most of the lecturers are not technically inclined. Hence for the networking course, they use a software called CISCO packet tracer for simulation of IPs among other things. The company that came for my workshop gave students a hands-on practical session for networking. The students enjoyed this workshop too. Looking at the momentum the events I put together for the student had gathered, I formed a club to create the space for students to come together and work on projects while learning more.

I: Were there any challenges you faced in forming Trestle Academy?

R: Oh yeah, there were a lot of challenges. The department had been so dull for a while so convincing faculty to even come on board as patrons and advisors was difficult. They were not willing because they thought it won't work, they thought that all students cared about was their academic work hence the scepticism. The head of the department, Dr Jamal, is a visionary so he understood that a change needed to take place in the department. He supported me right from the get-go. Getting students together was the next challenge.



I: In the future, what does a fully established Trestle Academy look like to you?

R: Right now, we started as a club and now we are an organization. What I am looking at is in threefold. We will offer training. We will offer a hub for people to come and innovate and build, we will expose them to our partners outside, to industry experts for them to show our members some of the things that are happening on a global front. We would also want to be able to outsource them, not just be a community of talents but these talents should be outsourced to the industries that need our talents. What I have realized is that Europeans are coming to Africa because the youthful population of sub-Saharan Africa is about 75% under the age of 30 according to the current statistics. Europeans don't have these figures so they see the opportunities for them here. Most of us are taking online courses aside from the school curriculum which is preparing us to meet the needs of the Europeans. It's up to us to position our talents and get them to a point where they can compete on the global stage. We are working on getting a website, an online platform for our training programs and a job site. This is the ultimate goal I have.

I: Do you sometimes have some fears concerning Trestle?

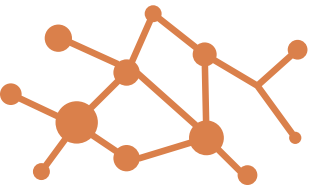
R: Yes, I have some fears. I can place them in 3 parts. The first one is not having the right people on my team. I was working with one of my friends who was my vice president when I was the president of the computer science student association. I made him the lead trainer at a point because the guy from KNUST could not be around every week for our sessions so my vice was to take over the training of students. He became a partner at some point but he had some issues with the foundation so he decided to leave and find full-time employment. He resigned in March of this year. People don't want to volunteer these days so it becomes a challenge to get people on board. Dr Jamal and I are the major runners of the academy right now because we are the only people who understand the vision which expands beyond five years from now. If someone has issues with the foundation now then they don't understand what the vision is about. People do not want to do things for free, they don't want to sacrifice, and they're seeking instant gratification hence, I am not getting people who are committed to the goal of the Trestle foundation/academy. The next one is the limited number of tech companies in Ghana to absorb the talents that we have. I have a number of guys who are qualified to work, are final year students and are ready with the skills to work but there aren't many companies available to give them the space for growth or even test their skills. I have been struggling to secure internships and national service opportunities for them and it is really disturbing. Companies are not looking to nurture young talents and groom them for tech roles rather they want talents who have experience in the industry. Even those willing to take green-eyed talents cannot recruit a lot, just one or two people. The last fear I want to talk about is funding. The more funding we have, the wider our reach will be. I'm trying to get our reach up to 90% nationwide through our campus chapter program within the next 5 years. I want to increase our local partnership too but these plans need a lot of funding to achieve. We would also have to provide some kind of stipend for our campus ambassadors and chapter executives for their services rendered. We currently don't charge for our hackathons, boot camps and other events, they're free. We give them t-shirts, and souvenirs, and feed them for free. For us to keep doing this for free, we would require more funding and that has become a challenge lately.

I: This has been very interesting, knowing about trestle academy how it started and how far it has come. I am impressed. My last question is not necessarily about Trestle. At the beginning when you were talking about yourself you mentioned RPA – robotics processes automation and that's a new field, right?

R: Yes, that's a new field.

I: Can you tell us briefly what it is about because I see that a lot of companies are now interested in it.

R: Robotics process automation is just a way of automating normal business processes. Instead of needing a human to manually interface operations in the office, companies want to automate that task now. Let's say, email processing. I am not in the office but someone has sent an important email. I need to send a response but I am not with my email. I could program a simple automation robot that can send an automatic response to the person. Another scenario is the processing of employees' pay slips. I don't need an accountant or an auditor always working on it, I can automate the whole process so that when the month end, having all employee details and salary details, a robot can be programmed to carry out the payment of salaries with minimal human contact and effort. It's simply running business operations with as little human interaction as possible. It uses bots – chatbots to aid in automation. For example, some websites now have bots for customer service instead of human beings. The bots have been trained with likely customer issues and also fed with the answers to these issues, saving the company money spent on manpower.



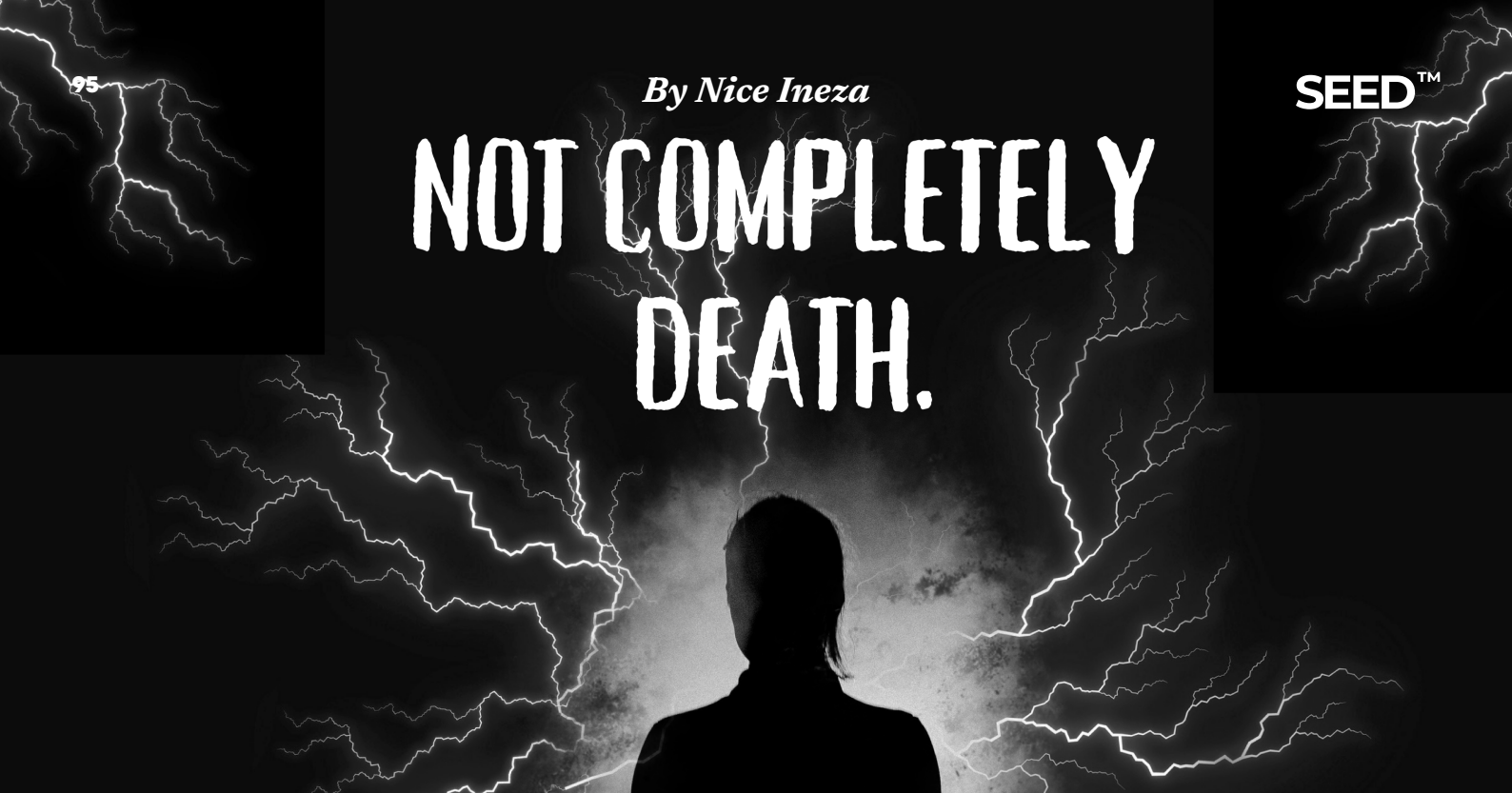
I: It is such an interesting field
R: Yes

I: People entering it can get employment from any sector at all
R: Yes. The health sector, everywhere!

I: Thank you so much for your time. Do you have any questions or comments?
R: I would just like to thank you for what you are doing. The seed journal is a good initiative. Thank you for reaching out.

By Nice Ineza

NOT COMPLETELY DEATH.



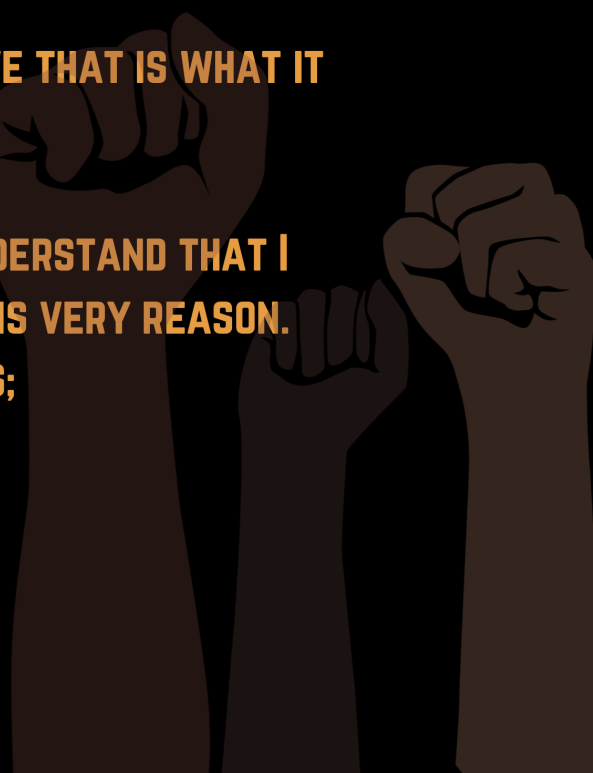
I'M SURE HE WAS SLEEPING, BUT HIS DREAM WAS AS FAST AS LIGHTNING. APPROXIMATELY 3.2 MILLION YEARS AGO, AND FOR THE FIRST TIME, A HUMAN FACED A CIRCUMSTANCE IDENTICAL TO MINE. LUCY WAS HIS NAME. I'M NOT SURE WHAT HE SAW, BUT I AM CERTAIN THAT THE SAME THING HAPPENED TO HIM. IT WAS LIKE BILLIONS OF HUMANS EXPERIENCED THE SAME THING, AND IT WAS CURRENTLY SPREADING LIKE A CONTAGIOUS SICKNESS. EVERYONE WILL EVENTUALLY HAVE IT, OR AS WHAT SCIENTISTS WOULD LIKE TO CALL IT, "THE RECALL OF LIFE." HE WAS IN HIS BED, DREAMING. NOTHING HAPPENED FOR THE PAST 15 MINUTES. THAT'S HOW I REALIZED HE WASN'T SLEEPING. HE WAS DEAD. WHAT WE THOUGHT WAS A DREAM WAS A FLASHBACK TO HIS LIFE. HE HAD PASSED AWAY, BUT HIS BRAIN WAS STILL WORKING. AT AROUND THE TIME OF DEATH, IT SHOWED RHYTHMIC BRAIN WAVE PATTERNS SIMILAR TO THOSE SEEN DURING A DREAM, A MEMORY CALL, OR MEDITATION. IT GAVE HIM A NEAR-DEATH EXPERIENCE. DID HE REALIZE IT? WAS HE ABLE TO SEE WHAT HIS MIND WANTED TO SHOW HIM? WE COULDN'T FIND OUT BECAUSE HE WAS NO LONGER ALIVE.

THE IRREVERSIBLE TERMINATION OF ALL CRITICAL ACTIVITIES, PARTICULARLY THE PERMANENT CESSATION OF THE HEART AND BRAIN ACTIVITY, ALLOWS ONE TO SEE ALL OF EXISTENCE IN TERMS OF SECONDS. THIS IS WHERE WE ENCOUNTER THE UNEXPLAINED END OF LIFE. DEATH IS A NEW BEGINNING, BUT WE IGNORE WHERE IT BEGINS. WE MAY BE IN PREVIOUS INCARNATIONS OR IN THE HEREAFTER, BUT WE WILL NEVER KNOW. HOWEVER, SCIENCE HAS DEMONSTRATED THAT HUMANS ARE NOT TRULY DEAD WHEN OUR HEARTS CEASE BEATING; DEATH IS PRONOUNCED WHEN THE BRAIN DISPLAYS THE LAST FLASH. BUT: WHY DO WE DIE? WE COULD SAY THAT NATURE IS DONE WITH US AFTER A CERTAIN POINT. FROM AN EVOLUTIONARY STANDPOINT, WE SUCCEED IN LIFE WHEN WE PASS ON OUR GENES TO PROGENY. AFTER THAT, NATURE HAS NOTHING TO DO WITH HUMANS. THAT IS ONE OF THE CAUSES. BUT THERE COULD BE MORE. WE WILL ALWAYS CONTINUE TO INVESTIGATE THE ENIGMA OF DEATH.

By Naa Lamiokor Boye

MODERN AFRICANISM

I'M A HYBRID
A CROSS BETWEEN 2 SPECIES, SO ELECTRIC, LIL GAS
I'M COST-EFFICIENT AND A PRIZE MODEL
DRESSED IN A HOODIE AND AFRICAN PRINT SKIRT,
I DON'T MEET MOST CULTURAL STANDARDS
BUT THAT'S WHAT MAKES ME STAND OUT AS ME.
I'M PURE BREED GA
AND FULL-ON MILLENNIAL
I WEAR OLD SCHOOL WITH A NEW STYLE AND GEE, NO TP COULD WIPE UP MY DRIP.
THIS LIFE IS NOT ALL GLITZ AND GLAMOUR
IT'S NOT JUST IPHONES AND TIK TOK
MY FATHER WILL STILL BEAT ME WHEN I FOOL
AND I STILL ASK FOR PERMISSION TO GO OUT, BUT IT'S COOL.
WHAT MAKES ME AFRICAN IS NOT JUST MY MELANIN-INFUSED SKIN
WHAT MAKES ME MODERN IS NOT SIMPLY MY SWEET KICKS
WHAT MAKES ME A MODERN AFRICAN IS MY BELIEF THAT, THAT IS WHO I AM.
AN EAGLE CAN LIVE WITH CHICKENS AND BELIEVE THAT IS WHAT IT IS.
I'M CONFIDENT IN WHO I KNOW MYSELF TO BE
I EMBRACE MY MIX OF CULTURES BECAUSE I UNDERSTAND THAT I WAS BORN IN THIS PLACE, AT THIS TIME, FOR THIS VERY REASON.
I CAN TELL YOU MY NAME BUT ALL I WILL SAY IS;
THEY CALL ME LAMBO.



Interview 08

Sokolata

Interviewer (I): Hi! please, could you start us off by telling us a bit about yourself and how Sokolata came to be?

Elom (E): Okay so my name is Elom Awo Acolatse and I am Ewe. I am 23 years. I have been an entrepreneur since I was 12. I started out selling chocolates – no toffees – in front of my house when I was about 10 or 12 and now, I am running two businesses. That is food, I do food and we have Sokolata too – my chocolate brand. For Sokolata, before I started, I was looking for something that stood out and something that was rare, not a lot of people are in that industry. I was thinking, I was praying, and there was this one time I saw chocolate, Swiss chocolate, in my brother's room. That was how I knew this was the idea. That's how Sokolata came to be.

Elom Acolatse - Founder, Sokolata

I: That's very interesting, being an entrepreneur since 12 and everything else. What were some of the challenges you faced when starting out this

E: For Sokolata initially I had supply issues, printing issues because I am using boxes and for these things in Ghana it's quite, hm what's the word? It is more expensive to produce some things locally, so most people like to import them into the country. That was my challenge. Getting a supplier a supplier for my chocolate, getting somebody who would make the chocolate to my specification was my other challenge.

I: With the challenges you have mentioned how along or how far have you come in overcoming them or finding alternatives or ways to deal with challenges?

E: Okay. Right now, I think most of it is sorted. I have found reasonable priced printing press and also a reasonable priced chocolate supplier. I even went on break for a while and I came back last month. Things are making sense, you get me?

I: Yeah, that's wonderful. Since coming back from your break what should your customers expect to see from Sokolata in the coming months and years?

E: Okay, they should expect to see a variety of flavours not just a base. So maybe interesting flavors with nuts, products that can be used for baking, chocolate drinks, you know, there will be a variety of products that will be launched along the way.

I: Okay. You are with the Ashesi Venture Incubator right?

E: Yeah

I: How helpful has the Incubator been in growing or just helping you understand your business and what opportunities has it opened for your business as well?

E: Well, I just joined the Incubator so I have not really started my journey with them. So far, we've just done your value proposition, your value fulfilment blueprint, your BMC – Business Model Canvas, and other stuff but I feel like when I start, in September, then I will see the opportunities it will bring for me. Looking at the past students that have been in the incubator, they've gotten grants, they've gotten new mentors that are making them structure their businesses better and understand their businesses better, so I am hoping for that for Sokolata.

I: Okay. Looking back at 12-year-old Elom do you think where you are right now is where she dreamed you'd be?

E: Hm this question. I don't think I was even thinking that far. To be honest everybody felt like they'll become a doctor or become this or that, but I was thinking that I would become a banker. Like I really fancied bankers, but I feel like I am in a better place.

I: Right

E: Yes, like having a hold of your business

I: In light of that, knowing what you know now and what you have accomplished, if you could go back, is there anything you would have done differently?
E: I think I would have explored more in the sense that maybe I would have learnt an instrument or some other stuff like swimming. I would have been more open-minded.

I: Okay, okay
E: Not letting shyness get into my head.

I: Okay. Most people in Ghana right now are looking to start a business or venture into entrepreneurship. What advise would you give to people who want to become entrepreneurs?
E: Hmm, okay. I will first say that it is a difficult path, right?

I: Right!
E: And also, it gets lonely so I feel like I would say that if this is the path you want to go on, you should have a mindset that you might be alone on the journey. People will not support you, even your own household cannot even see the vision that you have for whatever industry that you want to enter. You should have a strong mindset and be focused on your goal. Whatever dream you have that you want to be a multibillionaire, whatever. That should be your focus so whatever distraction is coming your way, whatever negative comment that people are saying to you, you understand your vision. Also, I spoke to this entrepreneur, he also has a chocolate business and he was advising me. I asked him this same question and he told me that, just make sure you're alive. So, I will also add that because it gets tough, you'll give up, there will be times that you'll feel like you should just give up but you understand?

I: Very deep stuff, thanks for sharing. You mentioned friends and family right and I just want to ask, how have friends and family been instrumental in your sokolata journey?
E: Oh, so for me, I feel like my parents and my family have been supportive in the sense that my parents took the same entrepreneurial journey so they've been very supportive, especially my dad. He has been even researching about cocoa more than me, feeding me information. I feel like because he's also a pharmacist, he's looking at it from that angle which a lot of people won't look at. Like the pharmaceutical part of chocolate and the whole scientific process of chocolate making which is giving me a better understanding of the product that I am putting on the market.

I: Oh, that's very nice. You mentioned the health or the scientific side of the chocolate. I was wondering, does Sokolata have options for people with certain conditions for example people who can't take sugar, those with nut allergies? Do you already have products that cater to these needs or you're looking to add that in the future?
E: Yeah, I will say that I am looking to add that because I realized that the older generation is more centered or more focused on dark chocolate and the younger generation is for the flavors I currently have, that is milk chocolate, caramel crunch and the white chocolate. I had discussions with the AVI mentors last week and they opened my mind to that so it's in my head, I'm working on it.

I: We will take it like that. Are you looking to collaborate or partner with any company and if yes, would you be able to disclose said company?

E: Well, if the opportunity comes my way and I feel strongly about it, I will but currently, that hasn't come up.

I: Right. The last question is looking at where you are right now, what does a fully established Sokolata looks like in the coming years.

E: As I said earlier, it will not just be about chocolate bars we'll have a variety of products solving different needs in the community. We'll go international, we'll not just be in Ghana.

I: That's amazing and that's all the questions I have for you for now. Thank you very much for your time.

E: Thank you, you too!

Interview 08

Sokolata

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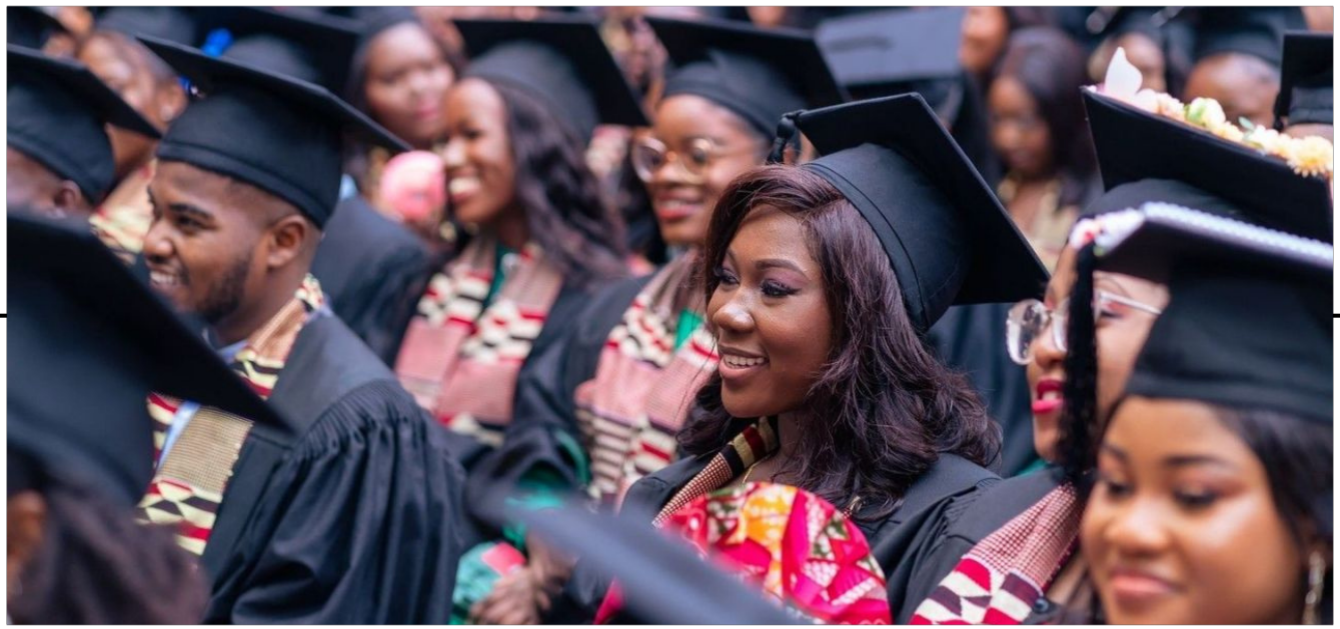

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I AM HAPPY TO ANNOUNCE...

"ALRIGHT, SO TELL US ABOUT YOURSELF. WHO IS ORETHA? WHAT MAKES YOU UNIQUE AND AWESOME, Y'KNOW, AND WHAT MAKES YOU SO WONDERFUL?"

"OKAY, SO UHM...MY NAME IS ORETHA FREEMAN. I AM A 21-YEAR-OLD ENTHUSIASTIC LIBERIAN LIVING IN CALDWELL, DIXVILLE. I'M MAJORING IN INFORMATION TECHNOLOGY AT BLUECREST UNIVERSITY COLLEGE. UHM...I LIKE TO DRAW. BOTH TRADITIONALLY AND DIGITALLY. I LIKE TO ANIMATE AND CREATE VIDEOS WHEN I AM FEELING BORED OR WHEN I PRETTY MUCH DON'T HAVE ANYTHING TO DO. AND THEN, I WOULD JUST SHARE THE VIDEOS ON MY INSTAGRAM STORY OR MY WHATSAPP STATUS. I THINK WHAT MAKES ME UNIQUE IS THAT I CREATE FUNNY CONTENT, AND IN THE END, PEOPLE WOULD COME AND SHARE WITH ME THAT BECAUSE OF MY CONTENT, THEY WOULD EVEN LIKE TO PURCHASE THE PRODUCT TO TRY IT OUT AND SEE."

"OH WOW, THAT'S MAGNIFICENT! I WOULD LOVE TO SEE THAT VIDEO SOMETIME..."

ORETHA CHUCKLED, NODDING TO HER STATEMENT. "YEAH... I RECENTLY WON AN AWARD. I WAS SHORTLISTED AS A WINNER OF THE PIXIE-DUST TEEN AFRICAN-AMERICAN ANIMATION CONTEST."

"OH REALLY? CONGRATS! THAT'S VERY IMPRESSIVE OF YOU."

SHE CHUCKLED AGAIN. "THANK YOU."

"CAN I TAKE A LOOK AT YOUR PORTFOLIO? IF YOU COULD SEND THE LINK TO ME AGAIN, THAT WOULD BE GREAT."

"RIGHT, SURE." SHE QUICKLY OPENED A NEW TAB. SHE STOPPED A BIT. SHE CLOSED HER EYES AND SQUINTED, TRYING TO FIGURE OUT WHAT WEBSITE SHE SAVED THEM ON AGAIN. SHE HURRIEDLY COPIED THE HYPERLINK AND PASTED IT IN THE CHAT BOX OF THE GOOGLE MEETING AS SHE FINALLY REMEMBERED.

"PLEASE, I HAVE SENT IT."

"RIGHT, JUST SEEN IT. THANK YOU."

THEN ANOTHER VOICE POPPED UP AND ASKED, "OKAY, SO ORETHA, IN A WORD, COULD YOU TELL US WHAT ATTRIBUTES YOU POSSESS THAT MAKE YOU FIT FOR THIS INTERNSHIP? OR, IN OTHER WORDS, WHY ARE YOU THE BEST FIT FOR THIS OPPORTUNITY?"

"OKAY, UHM....IN ONE WORD, I WOULD SAY...I AM TOLERANT."

"DO YOU CARE TO SHED MORE LIGHT ON IT?"

"YES, PLEASE UHM...NORMALLY I DON'T LIKE TO IGNORE PEOPLE'S COMMENTS ABOUT MY WORKS. I AM OPEN AND READY TO LIKE...TAKE IN PEOPLE'S COMMENTS AS FEEDBACK. AND THEN I WOULD GO AHEAD AND IMPROVE ON MY NEXT WORK AND TRY TO GET BETTER AND STUFF LIKE THAT. SO, I DON'T JUDGE AT ALL. BECAUSE I BELIEVE EVERYONE IS LEARNING AND WE CAN NEVER STOP LEARNING, SO...YEAH. I HEAR PEOPLE FROM DIFFERENT BACKGROUNDS TELL ME HOW BEAUTIFUL MY DESIGNS ARE, WHICH HELPS ME MAKE MORE DESIGNS LIKE THAT. SO, I WOULD SAY THAT MY TOLERANT BEHAVIOR WOULD HELP...UHM.... CREATE A DIVERSE LEARNING ENVIRONMENT. WHERE EVERYONE IS HAVING FUN AND CREATING SOMETHING UNIQUE....SO YEAH, THAT'S PRETTY MUCH IT."

"WOW, I'VE SEEN THEM. I DO LIKE YOUR ANIMATION. IT IS LOVELY." A DIFFERENT VOICE BLURTED OUT.

"THANK YOU."

I AM HAPPY TO ANNOUNCE...

THEN THE FIRST VOICE CUT IN, "SO HERE IS THE FINAL QUESTION, JUST TO WRAP THINGS UP BECAUSE WE DON'T HAVE THAT MUCH TIME. HOW LONG HAVE YOU WORKED AS A SOCIAL MEDIA CONTENT CREATOR? DO YOU HAVE ANY EXPERIENCE, AND HOW WAS IT WORKING AS ONE?"

"OKAY, SO BASICALLY, I HAVEN'T ACTUALLY HAD ANY EXPERIENCE WORKING AS A CONTENT CREATOR IN ANY FIRM. THIS MIGHT BE MY FIRST TIME WORKING AS ONE IF I GET THE JOB, BUT I HAVE BEEN TO SOME PLACES WHERE I HAVE DONE ANIMATED WORKS FOR THEM, BUT I WOULDN'T SAY I WORKED FOR THEM. THEY JUST HAPPEN TO MAKE ME ANIMATE A SHORT SCENE FOR A GIG OR SOMETHING OF THAT SORT.... YEAH."

"MM. OH, OKAY, I SEE. ALRIGHT, SO THANK YOU SO MUCH, ORETHA, FOR HAVING THIS INTERVIEW WITH US. WE DEEPLY APOLOGIZE FOR THE LATE TIMING. WE HAD TO LET OUR SUPERVISORS KNOW WE HAD TO ATTEND ANOTHER MEETING WITH YOU. WE ALSO APOLOGIZE THAT WE ARE NOT ALLOWED TO SHARE OUR IDENTITIES WITH YOU BECAUSE OF THE RAMPANT CYBERCRIMES IN OUR VICINITY. AND SO, OUR VOICES HAVE TO BE CONCEALED FOR SECURITY REASONS. SORRY IF IT KEPT YOU NERVOUS THROUGHOUT THE CALL. WE WOULD END THIS CALL BY SAYING THAT SESHAY, IS A DIVERSE, RAPIDLY-DEVELOPING FULL-ADMINISTRATION REAL ESTATE FRANCHISE. WE ARE COMMITTED TO GIVING OUR REPRESENTATIVES ASTOUNDING SOCIETY, COACHING, HIGH-LEVEL EFFICIENCY INSTRUMENTS, UNRIVALED PREPARATION, AND LEADS BY 2300. WE SUBSIDE IN ATLANTA, GEORGIA, BUT OUR BRANCHES ARE LOCATED IN DIFFERENT PARTS OF THE GLOBE. RUNNING FROM SWEDEN, SERBIA, POLAND, NORWAY, MEXICO, EGYPT, KENYA, SOUTH AFRICA, AND MANY MORE. WE BELIEVE THAT IN MAKING CITIES AND HUMAN SETTLEMENTS INCLUSIVE, SAFE, RESILIENT, AND SUSTAINABLE, WE NEED TO TACKLE THE PROBLEM OF URBAN PLANNING. IT HAS BEEN A HARD TIME OUT THERE, ESPECIALLY WITH THE BAETA WAR OCCURRING FOR THE PAST 5 YEARS. Y'KNOW...BECAUSE OF HOW INTOXICATING THE BAETA CHEMICAL HAS AFFECTED THE WORLD'S ATMOSPHERE AND PLANTATION, THERE IS A HUGE DISPUTE BETWEEN BANGLADESH AND THE US, SO IT REALLY AFFECTED US ALL. I'M SURE YOU HAVE HEARD ABOUT THE PLATFORM THEY PLAN TO BUILD ON TOP OF THE EARTH. SO, BECAUSE OF THAT, EVERYONE IS SLOWLY RELOCATING TO THAT PLATFORM, MAKING OUR WAY OF LIVING DEVASTATING. THE PRIVILEGED ARE THE ONES LIVING ON IT RIGHT NOW, AND THE IMPOVERISHED ARE LEFT TO LIVE BELOW. AND WE HAVE NO CHOICE BUT TO ADAPT TO THE WORLD'S WAY AS BUSINESS AND JOB CREATION ARE SPIKING UP ON THE PLATFORM. PEOPLE NEED GUIDES ON WHERE TO INVEST. HENCE THEY NEED REAL ESTATE MANAGEMENT COMPANIES, AND WE ARE HERE TO PROVIDE THEM WITH TOP-NOTCH."

FULL STORY AVAILABLE HERE: HTTPS://JOURNAL.ASHESI.EDU.GH/INDEX.PHP/SEED/ARTICLE/VIEW/75

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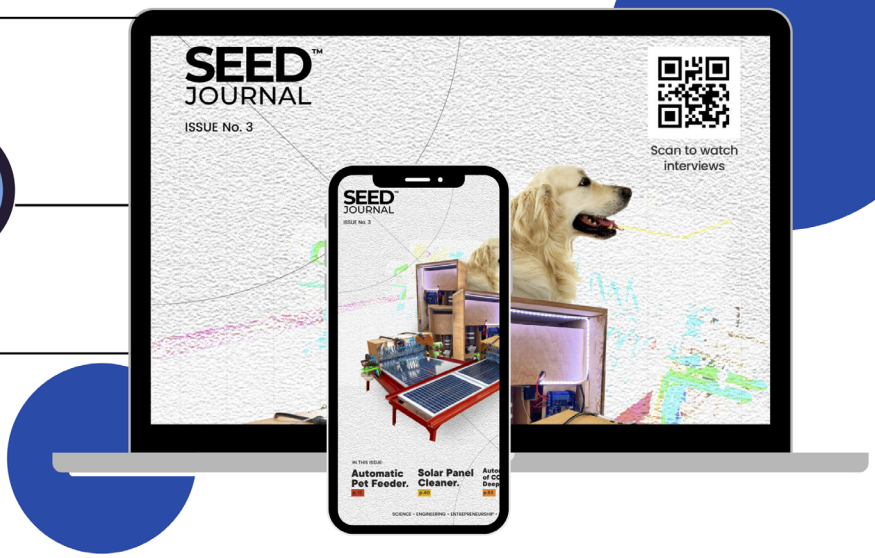

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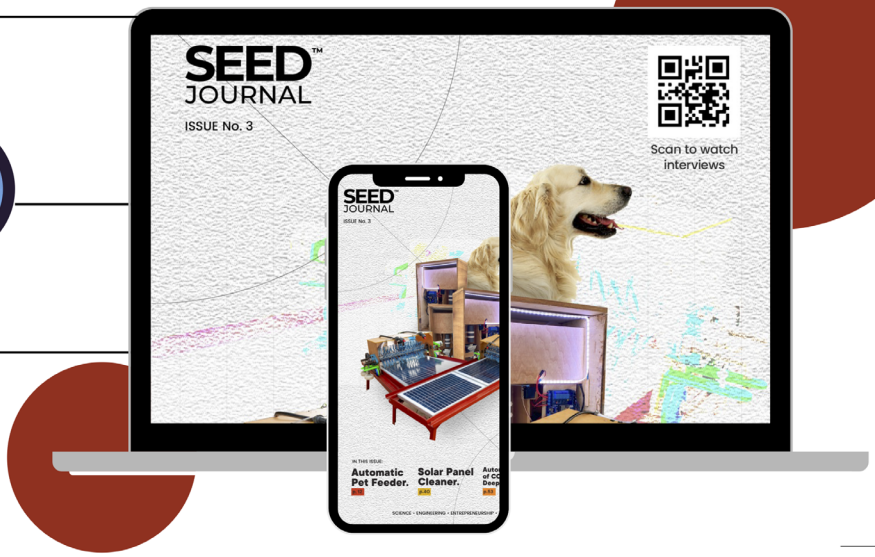

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