2022-07

Automatic Escaped Animal Detection and Monitoring System: A Case study of Volcanoes National Park (VNP) in Rwanda

Zirakwiye, Innocent

ijasre

https://doi.org/10.31695/IJASRE.2022.8.7.1

International Journal of Advances in Scientific Research and Engineering (ijasre)

E-ISSN : 2454-8006

DOI: 10.31695/IJASRE.2022.8.7.1

Volume 8, Issue 7
July - 2022

Automatic Escaped Animal Detection and Monitoring System: A Case study of Volcanoes National Park (VNP) in Rwanda

Innocent Zirakwiye[1], Jema David Ndibwile[2], Kisangiri Michael[3]

Research Scholar[1], Lecturer[2], Proffessor[3]

School of Computational and Communication Sciences and Engineering

Nelson Mandela African Institution of Science and Technology

Arusha-Tanzania

ABSTRACT

The results have been shown that the people especially farmers living at the edge of Volcanoes National Park (VNP) practiced agricultural business due to the fertile soil found in the region. The rising number of agronomies in the zone, number of tourists, and illegal forest users such as poaching, and deforestation cause wild animals to get out of their habitats. Therefore, forest animals present a likely risk to damage crops whenever they get out of the forest. The current systems such as "Buffer Wall also known as wall of stones" was manually operated; electric fence systems resulted in death and pain to wild animals. The primary creation of this paper is to develop an Automatic Escaped Animal Detection and Monitoring System. Due to the development of automatic systems for detecting and monitoring all moving wild animals and intruders, it was stated that using automation at Buffer wall could be helpful for both wild animals and farmers keeping safe. The objectives of developing an Automatic Escaped Animal Detection and Monitoring System were to reduce the probability of crop raids, death and injuries between wild animals and farmers, warning the wild animals using of buzzer, speaker with a recorder voice of lion and block of LEDs to remain in their habitats and the notifications sent to the park officials related to the wild animals getting out of the forest. This system should primarily use sensing devices to detect and monitor their presence. The study reveals that the people especially farmers living at the edge of Volcanoes National Park (VNP) can be protected using this system. The specialty of this technological system developed was to automate manual and improve the current systems by using Arduino NANO Microcontroller to execute system's operations, GPS NEO 6M for locating moving wild animal, Ultrasonic sensor for detecting wildlife and calculating its speed, PIR sensor to detect intruders, GSM SIM900 to notify park rangers, reduction of crop raiding, and finally reducing the death and pain of wild animals caused by the current systems.

Keywords: Automatic Buffer Wall, Ultrasonic Sensor, PIR sensor, Arduino NANO, Buzzer, GPS NEO 6M, GSM SIM900

1. INTRODUCTION

The Republic of Rwanda is recently pacing the development of tourism and conservation such that the "Kwita izina" Gorilla naming ceremony which is known all over the World [1] and welcoming different wild animals for living in different parks for attracting tourists whereby around 1063 mountain gorillas are in VNP [2]. Therefore, wild animals always search to get out of the park for crop raiding. The government used buffer wall, a man-made structure built for securing both farmers and people around the edges of the Volcanoes National Park (VNP). However, farmers reported that despite the efforts of building a wall around the boundaries of the park, wild animals still render their farming products. Apart from crop raiding, death, injuries, compensation for the damages and pain of wildlife caused by electric fence system have been reported to be serious problems to the VNP from the use of traditional and mechanical systems which resulted negative impact to the region.

From 2013 to 2018, Rwanda Development Board (RDB) received 7659 claims with different cases such as crops raided by forest animals; livestock killed death and injured people whereby a total of FRw 580106575 was established to compensate the above claims [3]. The farmers around parks are not happy with insufficient value credited to their properties, as shown by only 16.1% of

the farmers have received financial compensation for their raided crops by wild animals [4]. The goal of developing an Automatic Escaped Animal Detection and Monitoring System was to reduce the likelihood of crop raids, deaths, and injuries between wild animals and farmers by warning wild animals to stay in their habitats through the use of a buzzer, speaker with a recorder voice of a lion, and a block of LEDs, as well as sending notifications to park officials about forest animals getting out of the forest. The technological system developed was to automate manual processes and improve the current systems by combining an Arduino NANO Microcontroller with a GPS NEO 6M for locating moving wild animals, an Ultrasonic sensor for detecting wildlife and calculating its speed, a PIR sensor to detect intruders, and a GSM SIM900 to notify park rangers.

2. RELATED WORKS

The Automated Wild-animal intrusion Detection and Repellent System in India was designed to come up with the solution of reducing human-wildlife conflicts. Poaching and Hunting have obliged wild animals to leave their environments. The average of one person killed daily, and approximately one thousand three hundred (1300) animals were passed away for the 2010-2020 years. The unlawful solutions of installing electric fencing are unsafe methods on each side. Many people around the zone lost their life and/or their crops. The Automated repellent System which used Artificial Intelligence (AI) and Internet of Things (IoT) and Raspberry pi was used to detect poachers and motion of moving animals and report them without delay. The Faster RCNN that was used as an Object Detection Architecture, it took many times to process, and it showed poor performance. The system used You Look Only Once (YOLO) which has low recall and remembering and localization error and not easy to detect smaller moving objects [5].

Prof. Divya and Prof. Usha Kiran developed the Internet of Thing (IoT) Based Wild Animal Intrusion Detection System inside the buffer zone to monitor continuously wildlife which repeatedly penetrates in the fields for crop raiding. The conflicts among Humans and animals are caused by agricultural encroachment, illegal poaching, and industrial activities all together cause scarcity in the park, and dryness in the forest. The system developed which used PIR HC-SR501 sensor, WebCam, Arduino Uno, Light Emitting and image processing, it was worked when it was positioned on the peak of the tower and the results was always monitored by developers, means the developed system was not automatic [6].

The Animal intrusion Alert System was designed to work together with Wireless Sensor Network (WSN) and image capturing procedure for warning wild animals and notifying landowner and park rangers. The System was used to solve problems found in Agricultural fields in India. Due to deforestation and rapid growth of industrialization in forest zones, forest animals lack food and powerlessness, their habitats and move forward into farmers' fields for crop raiding. The Alert Systems used to warn and block wildlife stopping raiding crops included electric fences in which, Wheatstone bridge was developed. The watershed algorithm is used to capture the image of wildlife and make a barrier between them. The WSN used had limitations such as bandwidth, the charge and prices of nodes, deployment models into the cloud, Hardware and/or software designing limitations [7].

The Crop Prevention and Animal Intrusion Detection System were developed. The Raspberry Pi, Radio Frequency Identification Device (RFID) and fogging machine were used to make Smart Farmland. Forest rangers got notifications holding forests zones in which wildlife are found. The system used RFID injector and LF tag is injected in the animal's kin for better detection. Whenever the wildlife crosses the passing buffer zone, the system detects it and sends messages to the authorized users and uses a fog machine by providing smoke in the area. Solar Electric fence system used to protect crops; it also provided some limitations such as power outage during weather conditions and extreme rainy seasons, loss of life [8].

The uniqueness of the Automatic Escaped Animal Detection and Monitoring System was to increase safety and security in the area by automating manual systems and improving the current systems, reduction of crop raiding, early warning defenceless people for vacating the route, reduction of injury, death and pain of wild animals caused by electric fence systems and finally equipment's would be commanded by the system to turn on or off based on the movements sensed.

3. MATERIALS AND METHODS

3.1 Case Study

To design and to develop this automatic buffer wall system, the Volcanoes National Park (VNP) located in Northern-Western Provinces in Rwanda was taken as the case study. There are many national parks in Rwanda, including Akagera National Park (ANP), Nyungwe National Park, and Volcanoes National Park (VNP). At ANP, electric fence systems were deployed, and they are unethical systems when it comes to wild animals. According to the RDB report, the use of the autonomous system brought an innovative technology closer to the Volcanoes National Park (VNP), where wild animals are abundant [2].

3.2 Description of the System Design

To develop and design the Automatic Escaped Animal Detection and Monitoring System, the Scrum model, the most popular type of agile methodology was used. It helped us to break the project into phases with a fixed period of time and developers could productively and creatively deliver the highest outcomes with higher performance. It was used to maximize customers' needs [9].

DOI: 10.31695/IJASRE.2022.8.7.1

The project design is a framework that consists of procedures and methods that researchers use in order to achieve the desirable project goals. The operations of an automatic buffer wall are understandable through the phase of creation, then the existing practices and availability of tools used for analysis. The validation phase used to test the performance; it involves computation of the design and system refinement processes.

Figure 1: Agile methodology

3.3 System Descriptions

3.3.1 Hardware Description

a. Arduino NANO: the board shown by Figure 2 (a) facilitates the communication of other Microcontrollers by using UART serial communication available on Digital pin 0 (Rx) and 1 (Tx). It has a simpler design with low cost and requires a low user-friendly programmable system. To program it, we used an analogy and digital pins joined together with logical applications using C programming languages where inputs at sensing part are taken by Ultrasonic and PIR sensors, and produces outputs at actuation part by block of LEDs, LCD display and the buzzer, SIREN and speaker, the GSM SIM900 Module to send messages to all forest officials [10].

Figure 2: (a) Arduino NANO (b) Ultrasonic (c) PIR

b. Figure 2 (b) and (c) show the cheapest and best choice sensors such as Passive Infrared (PIR) sensors which have detection components characterized by a large lens range; they play an important function in current industries over the world for the purpose of movement detection [11]. In this study, PIR sensor was used to detect the moving intruders approaching the buffer wall coming from the community while the Ultrasonic sensor was used to detect the wild animals approaching the buffer wall, the speed, and the distance it used. The sensor measures the time between sending and receiving an ultrasonic pulse to determine the distance to a target (which is wild animal). Both the Ultrasonic sensor and the PIR systems are jointly connected with a microcontroller that is installed in an organized box along the buffer wall lines. The Arduino NANO (microcontroller) generates signal controls found on the detection of the presence of wildlife and notify that there are wild animals attempting to get out of the forest. Sensing, processing, displaying data, and alerting park rangers are all capabilities of the proposed system. The collected

DOI: 10.31695/IJASRE.2022.8.7.1

data is forwarded to the Arduino NANO for processing and displayed on a Liquid Crystal Display (LCD), and the alerting unit includes the alarm that will be generated and messages (SMS) that will be sent.

3.3.2 Software Description

a. Arduino Integrated Development Environment (IDE)

Arduino Integrated Development Environment (IDE) is an official setup launched by arduino.cc mostly used for editing codes, compiling, uploading written codes in the Arduino Sensors. It is open-source software downloaded freely to the internet and all Arduino Modules are friendly with it. It contains a Microcontroller on the board which presents the relationships between sensors and actuators in their environment [12].

The major functions of Arduino IDE:

- ✓ Sketch. It is the unit of codes uploaded to Arduino and run on its board connected to PC via USB
- ✓ Setup and loop. It is a function used to initialize values. When the sketch starts, the setup () function is called. Whereas loop () function runs codes repeatedly until it reaches its conditions.

b. Fritzing. It is massive open-source software used for developers to design prototypes and electronic circuits to solve specific problems such as automatic detection and monitoring of moving wild animals. This tool permits designers to arrange and organize their hardware devices in order to get the intended result by connecting sensing parts with actuation parts together. It is used to document the entire product [13].

c. EasyEda. It is an online dominant schematic tool used to design and simulate online electronic circuits with zero-installation. Easyeda would help the developers to import the designed circuits in either portable document format (pdf) or image. It is a user-friendly tool such that developers should work anywhere at any time on any devices and make online access and sharing of Printed Circuit Board (PCB) [14].

3.4 Description of the Developed Automatic Buffer Wall

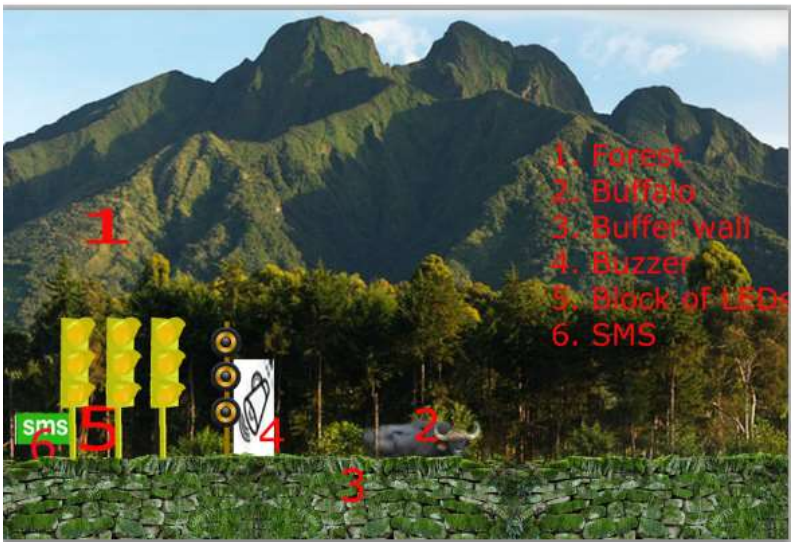

Figure 3: An Automatic Buffer Wall

DOI: 10.31695/IJASRE.2022.8.7.1

3.5 Data Flow Diagram

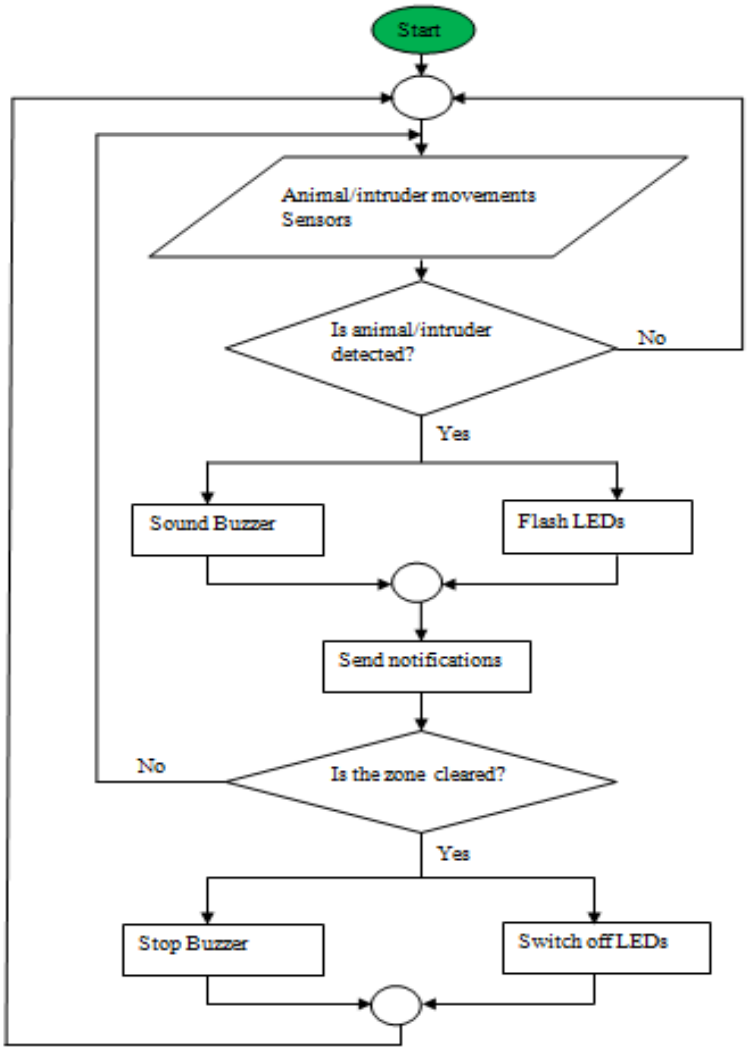

Figure 4: Data Flow Diagram

3.6 Circuit Diagram Design

The following schematic diagram represented the connectivity of all components of the system designed at the control unit.

DOI: 10.31695/IJASRE.2022.8.7.1

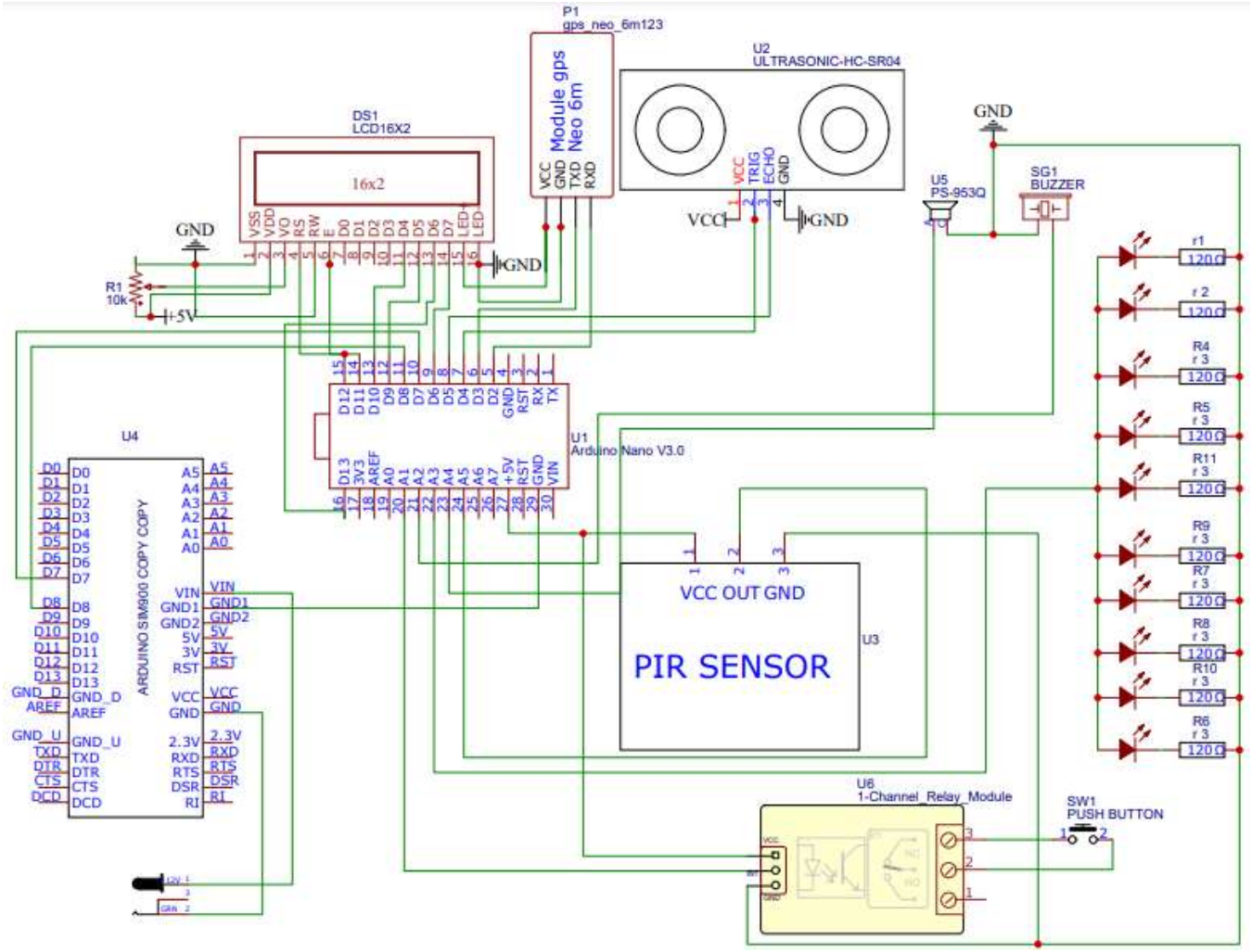

Figure 5: The Schematic Diagram for the Automatic Buffer System

4. RESULTS AND DISCUSSIONS

4.1 Results

The designed system would be used to support park rangers to detect and monitor wild animals or intruders approaching buffer wall and after, the system will automatically be turned on in order to warn wildlife or intruder approaching the buffer wall. Ultrasonic sensor for motion detection at the buffer wall protection system and control, and PIR sensor connected to Arduino NANO were used for wild animal or intruder detection in order to activate and deactivate the buffer wall system.

In this prototype, the designed Automatic Buffer Wall Detection and Monitoring System was developed based on the technical design, standards, and security requirements in order to protect the wild animal from passing buffer zone for crop raiding, death and injury and also infrastructures destructions. The technology used for wild animal detection and monitoring must satisfy the benefits of all park users and people around it. The developed system would warn wild animals approaching the buffer wall and automatically notify the park officials, farmers and people living near the edges of the park. The movements of both wild animal and intruder approaching buffer zone would be detected by Ultrasonic sensor and PIR sensor respectively, the system, automatically sends notifications to park rangers; it would also warn wildlife and trespasses with the facilitation of LED lights, Buzzer, SIREN, and Speaker. The GPS NEO 6M and GSM SIM900 Module start running using commands and codes given to the Microcontroller. The buffer wall system would remain active whenever there are wild animals or intruders being detected in the zone.

The tests carried out showed that moving wild animals and intruders can be automatically sensed; detected, controlled, calculate the distance and speed of wild animals and the information can be immediately shared to the park rangers (Figure 7). Figure 8 shows the setup of the developed system. The system was tested in front of HOBUKA Ltd, a company interested in bringing conservation solutions, and they strongly approved and were interested in the system's operation. It was also tested in Musanze District, Nyange Sector (Figure 8), where wild animals get out for the forest day and night by crop raiding, killing people around the edges of VNP and the participants stated that if the prototype is converted into a finished product and deployed, the people and crops around Volcanoes National Park (VNP) will be safe and secured.

DOI: 10.31695/IJASRE.2022.8.7.1

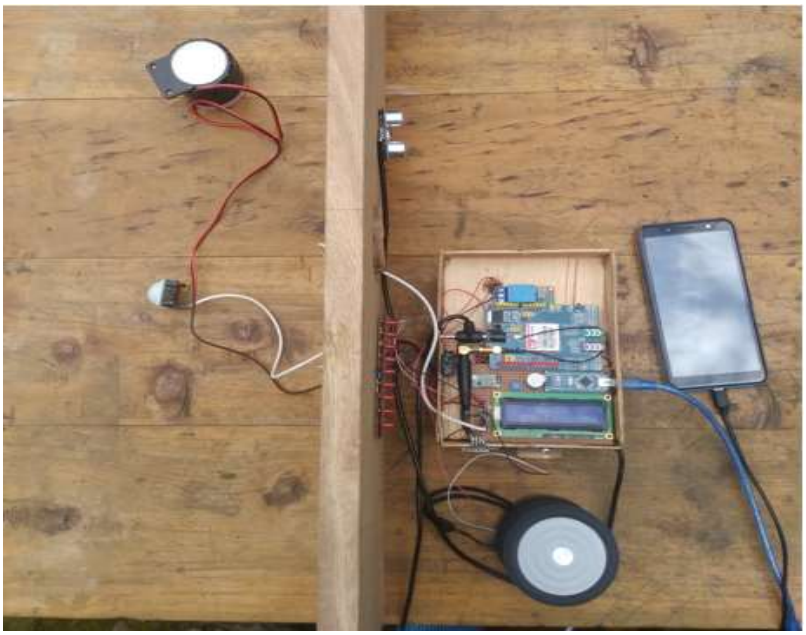

Figure 6: The developed prototype for the automatic buffer wall

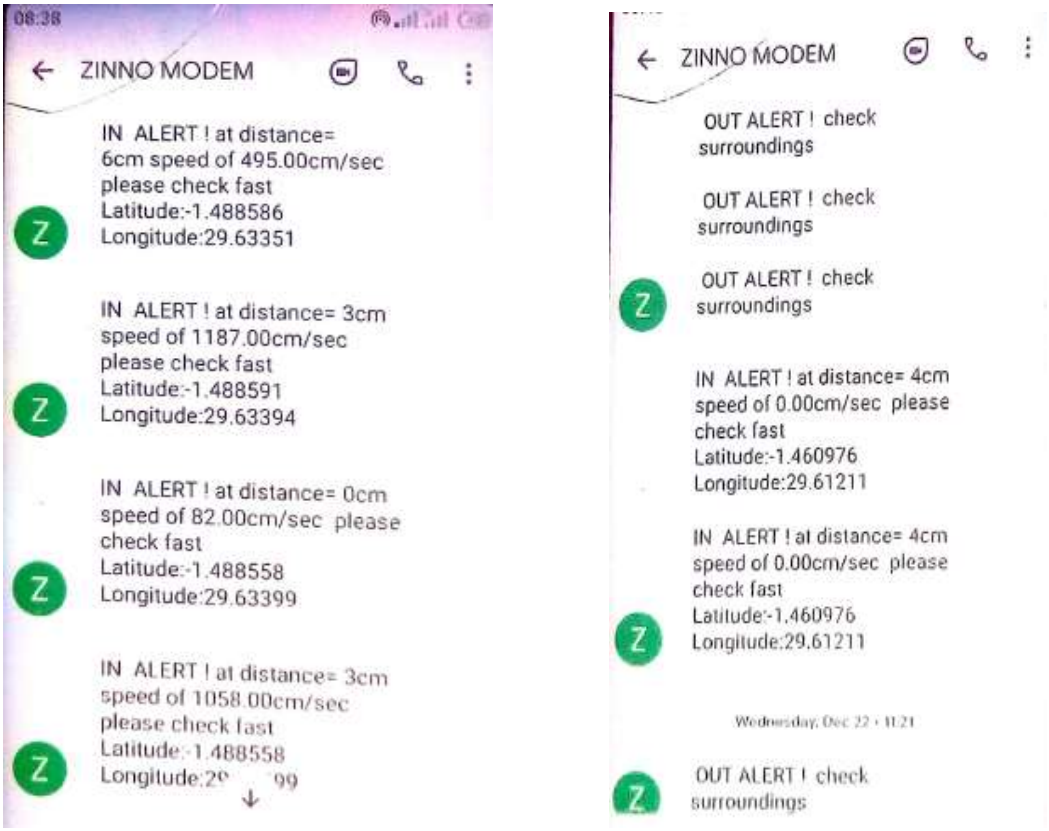

Figure 7: Notifications sent to Park Rangers

DOI: 10.31695/IJASRE.2022.8.7.1

Figure 8: Automatic Buffer Wall Setup

4.2 Discussions

The tests carried out during the design and development of this system confirmed that both wild animals and intruders approaching the buffer wall could be automatically detected and monitored and the reduction of their effects on the farmers. The distance, the speed and coordinates of wild animals were monitored with the help of Ultrasonic sensor which determines the distance to a target by measuring time lapses between the sending and receiving of the ultrasonic pulse together with the GPS NEO 6M; an intruder approaching the buffer wall was also monitored by using PIR Sensor. The IN ALERT! And OUT ALERT! Messages were sent to park officials to notify them of a hazard situation. Figure 6 proves texts messages sent to them. In each case such as IN ALERT and OUT ALERT, Park rangers of VNP, safety could be granted with no delay. The alarm alerts produced by the buzzer, SIREN and speaker showed to be very quickly the way of alerting the people around the edges of the park of the danger. Consequently, the defenceless people can be alerted before a wild animal is getting out of the park and vacate the route towards their home to save their lives. The tests done showed the reduction of wildlife's pain.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Wild animal's accidents are extremely hard to handle during crop raiding and affect not only farmers but also all people living close to the Volcanoes National Park. The buffer wall without active warning components such as automatic barriers, flashing lights, and sound the alarm present risks to both sides such as farmers and wild animals.

The prototype developed showed the improvement at buffer wall solutions through wild animal and intruder motion detection using PIR sensor Ultrasonic sensor. All hardware requirements and software requirements work correctly as they were expected.

The developed system confirmed that the information collected on the movements of wildlife and intruder could be made available automatically; therefore, based on the outputs from the functionality of the developed system, it confirmed that the effects of wild animal's accidents could be diminished through an automatic system. From the traditional system to the automation systems, there would be saving time, there is no dependent source of power, by means the system has chargeable batteries installed on each node. The system minimized the cost of equipments as well as the energy used by park rangers while making patrols.

5.2 Recommendations

This project was developed to help out the government of Rwanda for its present operational system, thereby removing some of the ditches and wall of stones used in the area. Therefore, from the gaps presented in the existing systems, the followings are addressed in this project:

a) Training of the community around the park and campaign awareness would take place frequently to notify farmers and all people about the hazards.

DOI: 10.31695/IJASRE.2022.8.7.1

b) The developed system could be applied in most National Parks in Rwanda because the Automatic Buffer Wall System uses low power, presents full safety from the loss of crops, human life, wildlife and infrastructures.

c) The Republic of Rwanda is advised to do park expansion and planting plants which are not likely by wild animals in the edges of the park.

d) The implementation of having a centralized control room to monitor the working of the system whereby the extended of this project would meet the demands according to the situation.

e) The designed system could be scalable whereby developers could add different sensors and it can be added without affecting the existing systems' operation. This would tolerate the flexibility and simple maintenance of the developed system.

f) The use of PIR sensor and Ultrasonic sensor that sense moving objects in at least 150meters, image detection and sending detected information to the cloud.

ACKNOWLEDGMENT

The developed system was supported by CENIT@EA (Centre of Excellence for ICT in East Africa) through the Nelson Mandela African Institution of Science and Technology (NM-AIST) in Arusha, Tanzania, under the Programme of Master's degree in Embedded and Mobile Systems. Many thanks to HOBUKA Ltd's staff for their encouragements, inputs, their time and guidance in order to accomplish this research.

REFERENCES

[1] Izina, K., Izina, T. K., Sector, K., Province, N., Izina, K., Izina, K., Sector, K., Izina, K., Sector, K., District, N., Sector, N., Province, E., Ali, A., Rashid, B., Nuami, A., Sheikh, G., Rakotoarisa, N. R., Chief, P., Building, C., … International, C. (2018). 2018 Kwita Izina Baby Gorilla Namers revealed. September, 10–11.

[2] Numbers, M. G. (2019). Mountain Gorilla Numbers on the Rise.

[3] Park, A. N., & Oort, J. Van. (2020). *Republic of Rwanda Rwanda 6th National Report to the Convention on Biological Diversity*. *September*.

[4] Park, V. N. (2019). *Quantifying tolerance to crop-raiding near protected areas A case study of Volcanoes National Park , Rwanda Thesis submitted as partial fulfilment for the degree of*. *March*, 0–78.

[5] Patil, H., & Ansari, N. (2021). Automated Wild-Animal Intrusion Detection and Repellent System Using Artificial Intelligence of Things. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3867275

[6] Divya, P., & Usha, P. (2018). *IOT-Based Wild Animal Intrusion Detection System*. *July*, 7–9.

[7] Jeevitha, S., & Kumar, V. (n.d.). *IJERT-A Review of Animal Intrusion Detection System Related papers A Review of Animal Intrusion Detection System*. *Dipet Ii*.

[8] Journal, I., & Priya, S. H. I. (n.d.). *A SMART FARMLAND USING RASPBERRY PI CROP PREVENTION AND ANIMAL INTRUSION DETECTION SYSTEM*.

[9] Sharma, S., Sarkar, D., & Gupta, D. (2012). Agile Processes and Methodologies: A Conceptual Study. *International Journal on Computer Science & Engineering*, *4*(5), 892–898. http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=82397457&site=ehost-live

[10] Uno, A., & Front, R. (n.d.). *Arduino Uno*.

[11] Ada, Lady. (2020). Adafruit Learning System: PIR Motion Sensor. *Adafruit Learning System*, 1–28. https://cdn-learn.adafruit.com/downloads/pdf/pir-passive-infrared-proximity-motion-sensor.pdf?timestamp=1585441256

[12] Fezari, M., & Dahoud, A. Al. (2018). Integrated Development Environment " IDE " For Arduino. *ResearchGate*, *October*, 1–

DOI: 10.31695/IJASRE.2022.8.7.1

12. https://www.researchgate.net/publication/328615543%0AIntegrated

[13] Knörig, A., & Cohen, J. (n.d.). *Fritzing – A tool for advancing electronic prototyping for designers*

[14] Editor, E., Client, E. D., This, R., & Tutorials, E. (2020). *Easy EDA Tutorial Can I use Easy EDA in my company ? I don ' t like others seeing my design . How can I stop What happens if Easy EDA service is offline for some Is Easy EDA safe ? What if Easy EDA cannot become self-sustaining and has to close down ?*

AUTHOR'S PROFILE

Innocent ZIRAKWIYE *born at Nyange-Musanze District, Northern Province of Rwanda. He is an MSc candidate in Embedded and Mobile System, specializing in Embedded System at Nelson Mandela African Institution of Sciences and Technology. He has a background in Computer Science obtained at the National University of Rwanda in Huye Rwanda., Worked at Ministry of Education Rwanda (Ecole Secondaire Saint Joseph Karuganda). His interest lies in ICT for Transportation, Drones for Agriculture and ICT for Health. Email: zirakwiyei@nm-aist.ac.tz*

Prof. Kisangiri Michael *has been working with NM-AIST as lecturer then Senior lecturer since December 2011. Before joining NM-AIST, he worked with Dar-es Salaam Institute of Technology in the position of lecturer for 3 years. He is a PhD holder in the field of Telecommunications, with which he graduated from Wroclaw University of Technology – Poland. Currently he is working as academician and has supervised dozens of MSc and several PhD researches. He possesses good knowledge in Artificial intelligence, Antenna design, and wireless communication systems. He is fluent speaker of three languages: Swahili, English, Polish. Email: kisangiri.michael@nmaist.ac.tz*

Dr. Jema D. Ndibwile is a Computer Scientist and a Lecturer at NM-AIST and the Tanzania *Communication Regulatory Authority (TCRA) representative on cybersecurity issues at NMAIST. Prior to that he was a senior IT System administrator and one the pioneers of the NM-AIST computer systems and networks. He has a doctorate degree in Information Security from Nara Institute of Science and Technology in Japan which he attained in 2019. His general research interests are in the areas of Cybersecurity, Cryptography, Ethical Hacking,*
The Psychology of Cybersecurity and Network Engineering to help resolve complex security challenges. Currently his research work is focused more on predicting cyberattacks through Artificial Intelligence and Human Intelligence. Email: jema.ndibwile@nm-aist.ac.tz

DOI: 10.31695/IJASRE.2022.8.7.1