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CONTEXTUAL REPORT

FOR

**An Artificial Intelligence-based Human Elephant
Conflict Mitigation System**

Student Name: Gunarakulan Gunaretnam

Student ID: 2208408

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1. Introduction

This chapter provides the basic information about the proposed project, it is explaining the project background and the problem that this research is trying to solve, the reasons behind this project's implementation, and explains clearly how this process is manually done with manpower and how this proposed project is implementing that method with artificial intelligence to look for elephants instead of humans sitting and waiting for elephants.

This chapter also went through the project's aim, objective, and sub-objective, clearly defined the aim and ultimate scope of the proposed project and explained the artifact's description and the prototype.

1.1 Project Background

The conflict between humans and elephants is one of the most reported issues and severe conservation concerns in elephant-range countries. Several management strategies have been developed and employed at different scales to reduce conflicts between people and elephants worldwide.

Human-elephant conflict is one the most popular and much-debated topics in Sri Lanka. There were 14,516 total numbers of human-elephant conflict cases reported during 2010–2019. Approximately three hundred elephants were intentionally killed by humans each year; there were 807 total human deaths and 10,532 property damages caused by human-elephant conflicts in Sri Lanka, according to a 2020's research paper.

Moreover, Sri Lanka has endangered subspecies of elephants (*Elephas Maximus*); therefore, protecting these species of elephants is one of the huge responsibilities of the Sri Lankan communities to maintain the natural beauty and tourism sector.

Still, there is no solid solution to this problem. Currently, many innovators and social workers are motivated to build solutions that are all on prototype levels, such as IoT sensor-based systems for detecting elephants. The only implemented system for this problem by the government is an electric fence, which does not even work properly. In contrast, elephants

can break the fence; sometimes, the electric fence methodology does not work efficiently as expected.

However, This AI approach uses a camera and computer vision technology to process video, identify elephants, and block them by providing the buzzing bee sounds and sending an early warning message to the nearest village regarding the elephant intrusion; this will give a glimpse to the village people to be alert, and at the same time, the system plays buzzing bee sounds artificially to block elephants entering the village, normally, this method is done by manpower in some villages there are some humans sit and watch for elephants during night time. If the elephant is found, they forward the message to the nearest village; this research aims to automate this manual to machines with artificial intelligence technology.

In Sri Lanka, many youngsters and innovators are naturally motivated by this problem, especially people from the rural areas of the country; this problem provides many reasons for innovators to be invented a solution for this problem.

This project is aimed to propose a computerized system to provide a solution to the following topic "Human Elephant Conflicts". As a sustainable solution for this problem, this research proposes the following early-warning system to be developed "An Artificial Intelligence-based Human Elephant Conflict Mitigation System."

The idea of the proposed system is a bit complex. But, it is very straightforward to understand that this system is going to perform the following methodology to prevent human-elephant conflicts: At first, this system will process the video(frame by frame) from CCTV / wildlife camera traps devices and try to discover elephants in video frames, and if it is found, then it sends an early warning message to the corresponding villages to alert the village people to take actions to prevent damage. This system uses external methods to block (scare) elephants, such as the artificial sounds of buzzing bees;

1.2 Project Aims and Objectives

1.2.1 Aim

The primary aim of this project is to build an automatic elephant intrusion detection system to send an early-warning message to the nearest villages and try to block elephants using some external artificial sound effects.

1.2.2 Main Objective

- To compare existing elephant detection models.
- To build an AI model for elephant detection in the daytime using deep learning algorithms.
- To build an AI model for detecting elephants at nighttime using deep learning algorithms.
- To develop a web panel to facilitate monitoring.
- To test and evaluate the accuracy

1.2.3 Sub Objectives

- Build an AI model for daytime detection
 - Collect daytime elephant images
 - Label images
 - Cleanup image data
 - Prepare dataset
 - Write a Python script to build the model with TensorFlow
 - Train the model (AI Brain)
- Build an AI model for nighttime detection
 - Collect nighttime elephant images
 - Label images
 - Cleanup image data
 - Prepare dataset
 - Write a Python script to build the model with TensorFlow
 - Train the model (AI Brain)

- Build a monitoring system in Python (Main System)
 - Write a Python script to inference the trained models
 - Implement OpenCV to process the videos (Input)
 - Write logic to break videos into frames
 - Process frames with the trained models to look for elephants from the video input.
 - Write logic to send SMS/Emails as early warning messages to the nearest villages based on the GPS location.
 - Write logic to play artificial sounds of buzzing bees and monkeys to block (scare) the elephants
 - Write a logic to update the database if elephants are found with time/date.
 - Write logic to automatically swap AI models depending on the day/nighttime; during the nighttime, the nighttime AI model (AI Brain) will be working, like that during the daytime, the daytime AI model (AI brain) will be working.
 - Write logic to run all processes in a looping manner.
- Build a web panel (Management System)
 - Design the web panel (UI/UX)
 - Create the web panel with MERN Stack.
 - Connect the monitoring system's (Main System) database with this web panel to view information on elephant discovery.
- Testing the functionalities
 - Test daytime AI model accuracy.
 - Test nighttime AI model accuracy.
 - Test the main system functionalities.
 - Test the web panel functionalities.

1.2.4 Features

- Able to identify elephants in video frames.
- Able to send early warning messages to nearest villages.
- Able to send emails/SMS as warning messages.
- Able to block elephants by playing artificial sounds of buzzing bees and monkeys.
- Able to send GPS location with warning messages.
- Able to view elephant discovery history in the web panel.
- Able to switch AI models (AI brains) automatically depending on the time (daytime/nighttime).

1.3 Description of the artifact

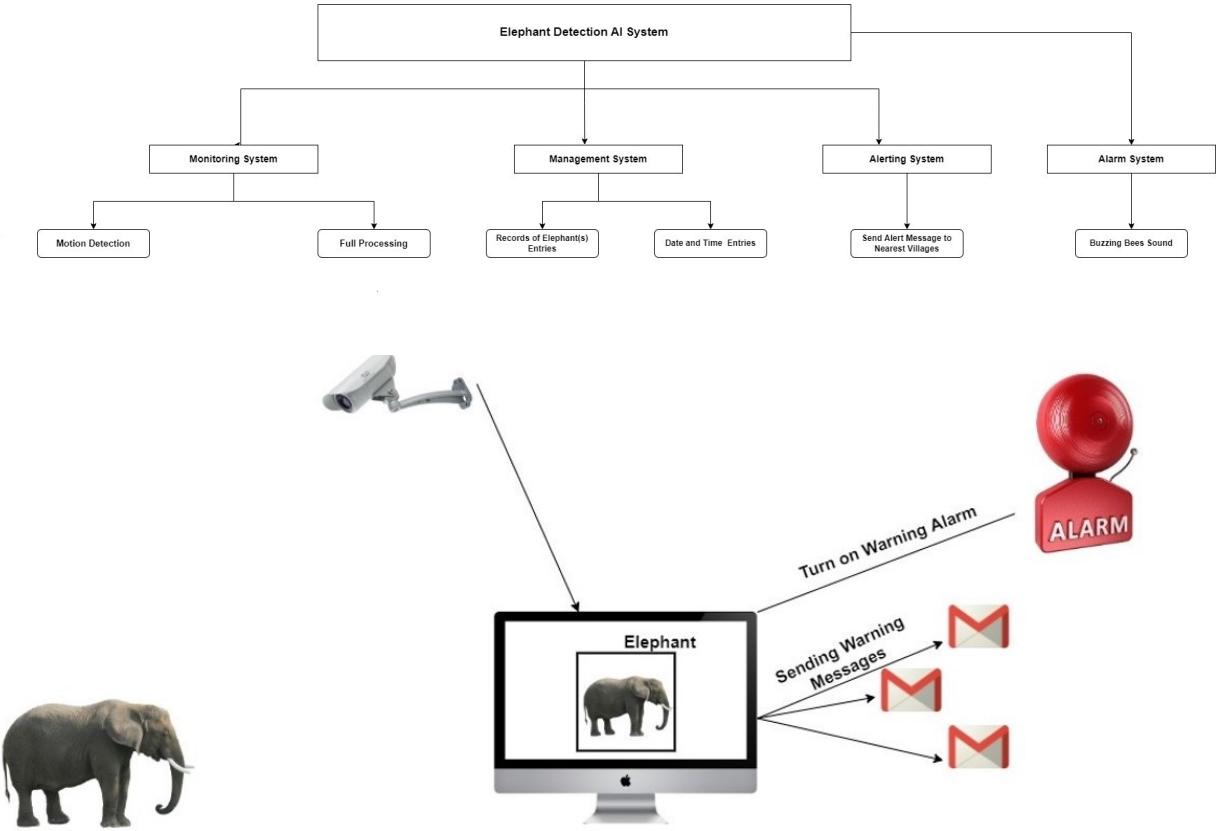


Figure 1: System Diagram

In Sri Lanka, there is no solid solution for this problem; this project tries to implement artificial intelligence technology-based solutions for human-elephant conflicts. There are many similar technological solutions, but none of them are in operation except the electric fence method; in Sri Lanka, many innovators are building IoT-based technologies for this problem; however, this research introduces artificial intelligence technology and tries to automate a manual process by machines.

This artifact tries to automate the following problem statement in some rural parts of Sri Lanka during the nighttime daytime; a man will be assigned to a task to watch for elephants, especially in the nighttime, that watchman (usually a farmer) needs to watch for elephants if the elephant comes, that watchman needs to report to the nearest villages as an early warning alert.

This research is willing to replace this process with artificial intelligence technology, that this research implements an AI technology that could do the same process with machines without manpower.

The artifact will be a computer-based artificial intelligence software program that can see the elephant with computer vision technology and has the ability to send an early warning message to the nearest villages to be alert. This system will block the elephants from entering the villages by playing the artificial sounds of a buzzing bee since the elephants are afraid of bees' sounds.

Technically, this system has two parts: a **monitoring system** and a **management panel**. The primary tasks of the monitoring system are **looking for elephants** by processing the vision from a camera source and **sending early warning messages** to the corresponding villages.

The primary tasks of the management panel are storing information on elephant detection and having the ability to set settings for the monitoring system example, the password can be changed from the management panel, and the detection parameters can be changed from the management panel; likewise, the detection method could be changed from the management panel.

There are two detection methods used in the monitoring system is using those are with motion detection method and with full processing method; full processing method is computationally expensive since it processes all the frames from the video source, and the second method is motion detection based, which can only process vision that has movement, if any big changes happen in the screen, then it will send the frames for model processing, these settings and parameters can be set from the management panel.

The ultimate **scope** of the project is to explore a solution for the human-elephant conflicts with technology; this research is willing to build a computerized system that can send early warning messages to corresponding villages; this project tries to automate the manual work of watching for elephants without manpower but with machine power.

1.4 Contextual Report Structure

This contextual report contains all the research information and its implementation precisely, and it contains a lot of problems of human-elephant conflicts. This research tries to provide solutions for the problems identified on the ground.

- Introduction
- Literature Review
- Project plan
- Artefact Plan

1.4.1 Introduction

In this section, this report explains the project background and why this research is needed; it covers the motivation behind this research, and it also describes why this problem must be solved; it clearly defines the objectives/aims and the scope of the project by describing the artifact.

1.4.2 Literature Review

The literature review goes from basic information to advanced technological solutions available for this problem; at first, it explains the information about Sri Lankan elephants and how it benefits Sri Lanka. It explains how this problem can be tackled with technology.

1.4.3 Project plan

This section explains the project execution plan, how it will be executed, and how much time this project will take, and it defines the milestone of the research.

1.4.4 Artifact Plan

This section explains the research's final artifact and how this research will produce an artifact that solves the target problem.

2. Literature Review

This literature review contains all information about human-elephant conflicts and explains the previous study material and existing platforms already presented in similar domains; it covers everything from the basic information about elephants to human-elephant conflicts, the literature starts by explaining the basic information about the elephants in Sri Lanka, and it extends to explain how elephant supports Sri Lankan tourism then it detailly goes with the human-elephant conflicts and deaths and properties damages and existing manual solutions and the point of technological solutions, etc.

2.1 Elephants in Sri Lanka

According to a research animal science paper, Sri Lankan elephant types are (*Elephas maximus maximus*) and are native to Sri Lanka. The Asian elephant (*Elephas maximus*) is categorized as Endangered in the IUCN Red List (IUCN, 2007). They have recognized subspecies of the Asian elephant (Campos-Arceiz et al., 2008). Among all the beasts of the world, the elephant is the only one demonstrating God's power and wisdom like no other. (TOPSELL, 2021). The Sri Lankan elephant population is currently mostly restricted to the dry zone within the north, east, and southeast of land. Elephants area unit gift in Udawalawe park, Yala park, Lunugamvehera park, Wilpattu park, and Minneriya park however conjointly live outside protected areas (*Article from <https://www.natureodyssey.com/>*). Sri Lanka holds a crucial position with relation to Asian elephant conservation. spill 100 percent of the world Asian elephant population in but a pair of of elephant vary (Leimgruber et al. 2003). Human–elephant conflict (HEC) is a key environmental issue in several Asian countries, including Sri Lanka. Incidents of HEC have significantly increased in Sri Lanka between 1991 and 2018, with 1734 human deaths reported in this period (281% increase), 4837 elephant deaths (1172% increase), 1053 human injuries (140% increase), and more than 23,000 property damage reports (1406% increase). The elephant is taken into account joined of the celebrities of the kingdom Animalia and may be a distinguished image of life conservation in Sri Lanka. The elephant has compete a central half in Sri Lankan history, culture, faith and mythology (and latterly politics) for over twenty-five centuries (Santiapillai et al., 2010). Tamed elephants

have long been used for numerous forms of add the country as well as moving hardwoods, building and transportation hundreds.

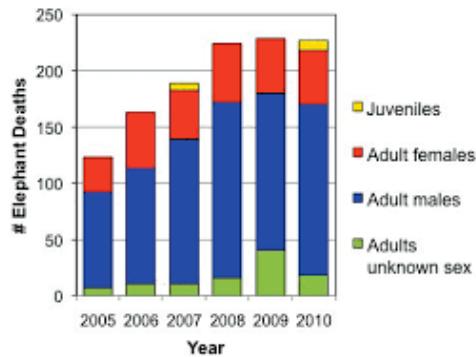


Figure 2: Elephant Deaths in Sri Lanka (elephant-deaths-recorded-2005)

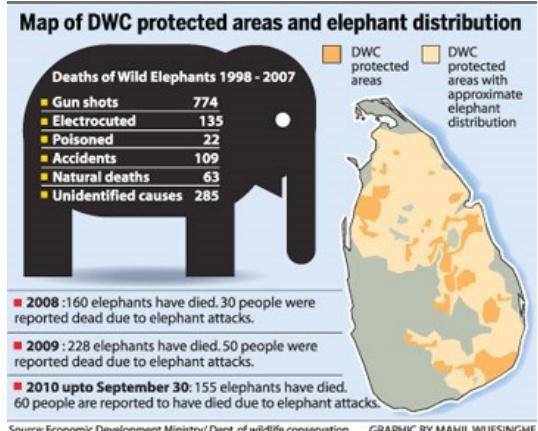


Figure 3: Elephant Deaths in Sri Lanka (1998-2010) (Map of elephants)

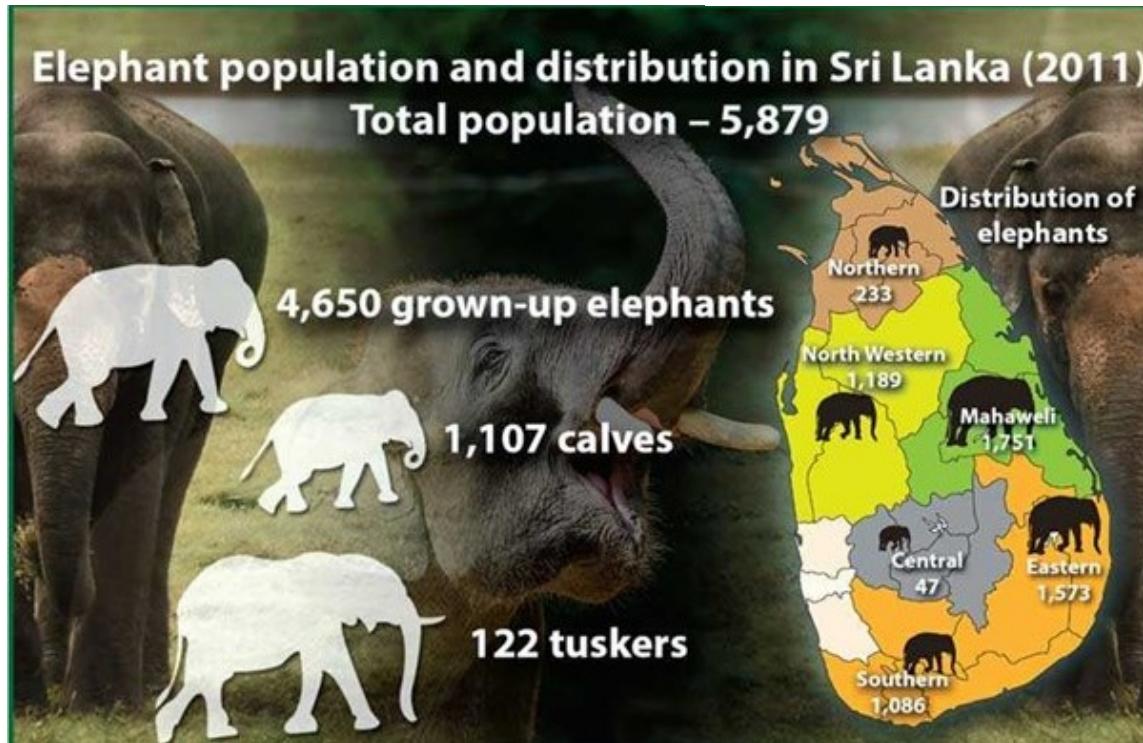


Figure 4: Elephant Population in Sri Lanka.

2.2 Elephants and Tourism in Sri Lanka

The island is famous for its tourism. Some of the favorite places visited by the tourists are Yala, UWNP, Pinnawala Elephant Orphanage, and the Minneriya-Kaudulla national parks (*ft.lk*). Most significantly, the general value of one wild elephant to Sri Lankan commercial enterprise is on the brink of Rs. Four million or \$ twenty one,400 (*lankaenvironmentfund.org Dec 25, 2020*). Elephant-related tourism is worth over Rs. 1 billion or \$ 5.8 million per year to Sri Lanka – over four times as much as tea! (*ft.lk*). According to the statistics, 1,100,435 international guests visited Sri Lanka in 2018, visited Sri Lanka's several life and national parks. Sri Lanka earned Rs. 2,138,450,422.38 in entrance fees alone particularly the elephants were one amongst the favorite picks among them in addition (*ft.lk – 2018 census*)



Figure 5: Sri Lankan Elephant Tourism 1



Figure 6: Sri Lankan Elephant Tourism 2



Figure 7: Sri Lankan Elephant Tourism 3



Figure 8: Sri Lankan Elephant Tourism Image 4

2.3 Human-Elephants Conflicts in Sri Lanka

In conflicts between elephants and humans, crop-raiding, injuries and deaths to humans caused by elephants, and elephants killed by humans for reasons other than ivory are common (*Research Paper: wwf.panda.org and World Wildlife Fund*). However, *human-elephant conflicts also arise; 3,500 elephants require around 17,500 km², or 27 percent of the total land area, while the protected areas in Sri Lanka cover only 12.5 percent of the land area (or 8,200 km²)*. The lack of sufficient land area for the existence of elephants is the foremost reason for human-elephant conflicts (*Ceylon Expeditions*). A total of 112 persons were killed due to elephant attacks in 2020 (*xinhuanet.com*). The conflict threatens community livelihoods and food security and may even cause human fatalities. The ensuing economic stress to marginalized rural communities causes over \$10 million in crop and property injury annually in the state (Sargent, 2021). The institution of protected areas that give feeding, breeding, and residing habitats to the elephants may play a key role in addressing human-elephant conflict in the country. These areas can physically separate humans and elephants. Moreover, effort corridors that connect fragmented habitats can offer additional areas for these mammals to graze. The presence of corridors supports the elephants in their seasonal migration and helps them search out food throughout the year (*Karunananada slycantrust.org*).

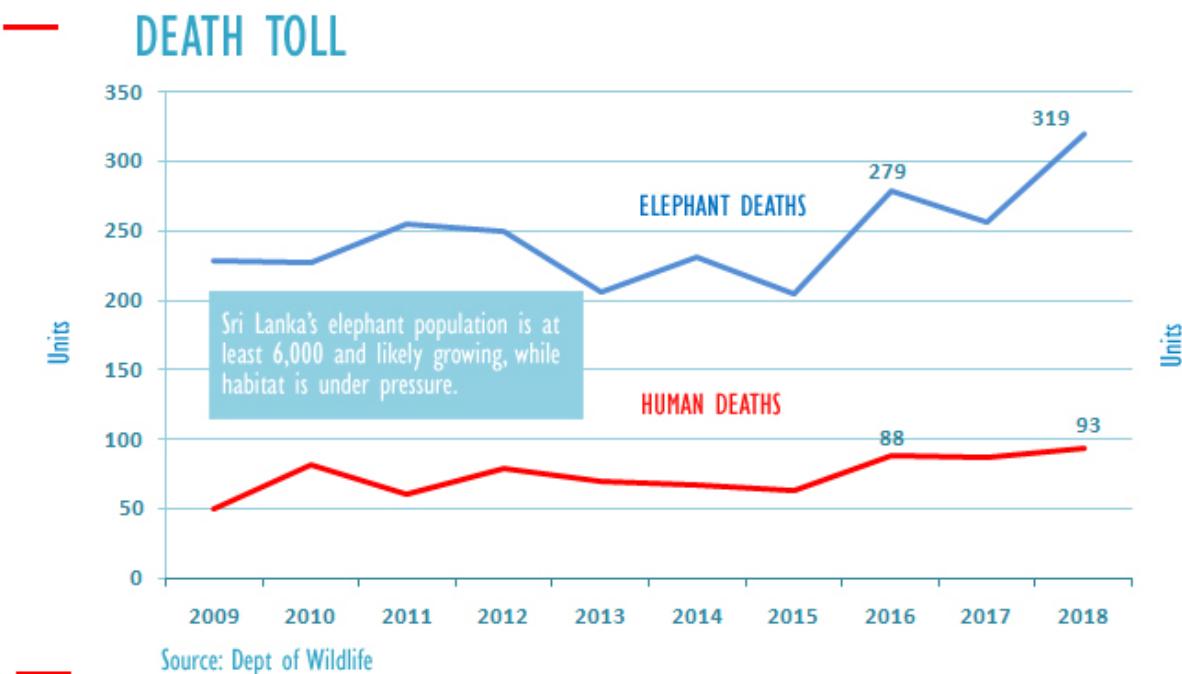


Figure 9: Human-Elephant Conflicts Chart



Figure 10: Human-Elephant Conflict Image 1



Figure 11: Human-Elephant Conflict Image 2



Figure 12: Human-Elephant Conflict Image 3

2.4 Elephants Destroy Farmer's Lives

According to the research, the farmer's earn and their life are affected by human-elephant conflicts: The overwhelming majority (89%) of the farming families seem to earn but Rs. 120,000 (US\$ 1,200) each year. In 100% of cases, the annual financial gain ranges between Rs. 120,000 and Rs. 240,000, whereas only one earns quite Rs. 240,000 (US\$ 2,400). The annual financial gain of the families seems to be sadly inadequate. The poorest forty-fifth earns only Rs. 3,000 (US\$ 30) monthly. Because of the losses area unit involved, twenty-fifth incur associate degree annual loss of but Rs. 5,000 whereas thirty seconds incur between Rs. 5,000 to Rs. 20,000 a year. However, the bulk (43%) suffers associate degree annual loss of over Rs. 20,000 (US\$ 200). Farmers everywhere around the globe do exaggerate their losses; even so, their losses are unit real and, therefore shouldn't be unheeded. (*Rukmali Athurupana October 2010*)



Figure 13: Elephant Destroy Corps 1



Figure 14: Elephant Destroy Corps 2

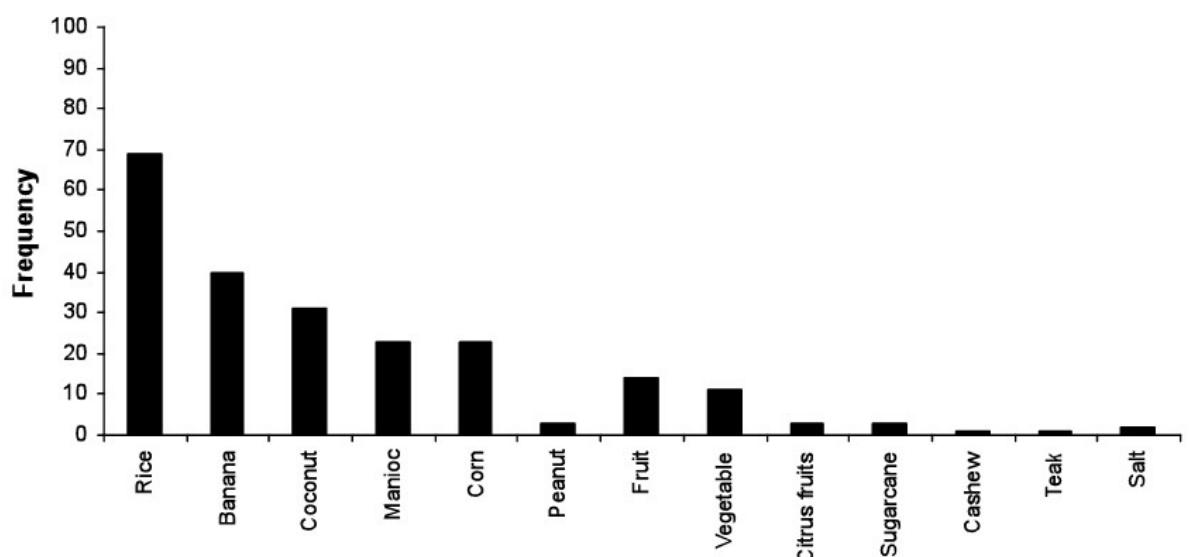


Figure 15: Elephant Preferred Foods

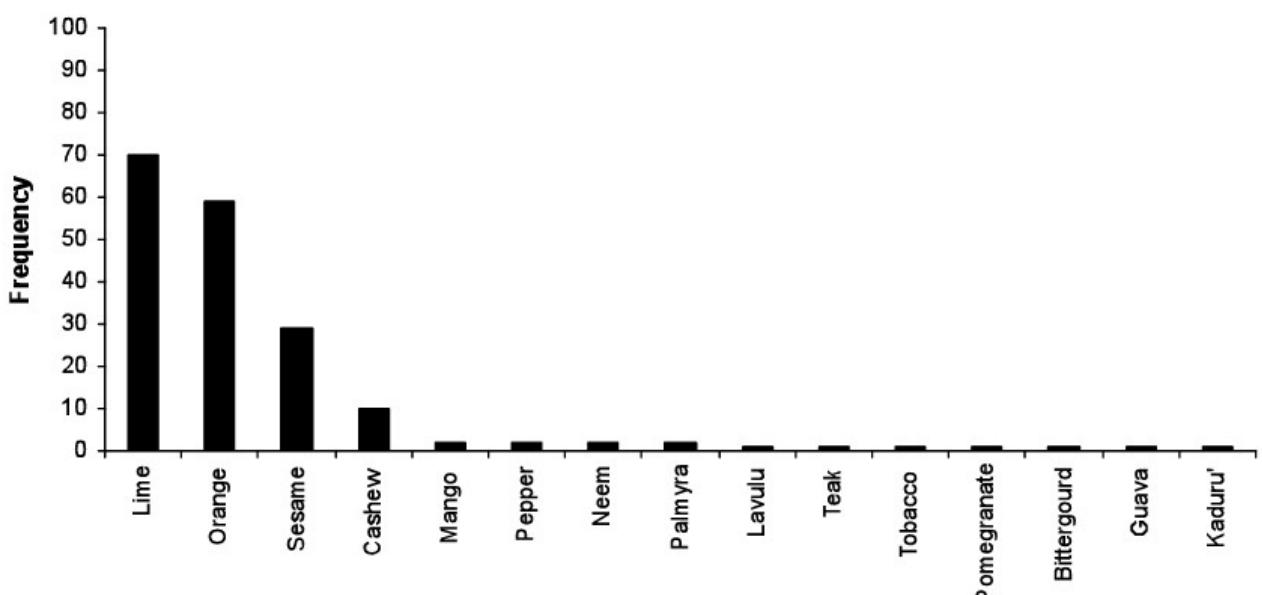


Figure 16: Elephant Avoid Foods

2.5 Existing Solutions for Human Elephant Conflicts

2.5.1 Building Electric Fences

Electric fence area units are the foremost effective human-elephant conflict mitigation measure if they're strategically set and well-enforced. Such fences seem to be the people's favorite answer to the elephant mitigation problem since they physically separate human and elephant territories. The IUCN states that this technique may be economically economical thanks to conserving these valued animals.

The electrical fences don't stop the impact of elephant attacks. Some studies have found that some elephants square measure 'habitual fence breakers' (Peiris & Sooriyabandara, 2014) alternative studies have shown that fences must be compelled to be electrified in most grassland elephant ranges since these square measure places wherever crop raiders are determined and protracted. However, other studies realize that electrification isn't required for the maximum amount in forest elephant ranges wherever elephants seem not to be thus persistent at crop offensive (Peiris & Sooriyabandara, 2014).



Figure 17: Elephant Breaks Electric Fence

2.5.2 Other Existing Natural Solutions

Farmers use external methods to scare the elephants, such as shouting and firecrackers to chase away elephants entering their fields. Building an automatic device to make sound is important because farmers usually stay up the whole night while guarding their cultivation which affects their day-to-day activities (*Karunananda slycantrust.org*); Elephants can be chased away by using bonfires, torches, and flashlights. Solar flashlights, which are sustainable, can be used to make this process more efficient.

Farmers can distribute the lights and place them strategically to cover the entire agricultural area. Light repels systems have demonstrated positive results in preventing elephants from entering cultivated lands, according to the (*Wildlife and Nature Protection Society of Sri Lanka's Annual Report 2019*). To ensure the efficiency of the process, farmers must follow up on maintenance.

Growing unattractive crops: Elephants are fond of crops such as paddy. By growing less attractive crops together with these crops, farmers can reduce the impacts of elephants on their cultivation (*Karunananda slycantrust.org*);

Translocation: Elephants that damage houses, feed on crops, and even kill humans can be tranquilized and transported to another location. After some time, translocated elephants return to their original territories, according to studies. As a result, this is not a long-term solution to the conflict between humans and elephants.

2.6 Technology Based Solutions

Today, the use of machine learning and artificial intelligence is crucial as technology continues to grow. AI can solve most past unsolved circumstances with better implementation. There is a growing interest in artificial intelligence and most tech personnel express their view that AI is the future. In addition to reducing the human-elephant conflict, AI systems were and are developed that send alerts to the villages that enable them to dread elephants before they reach the destination of the system, especially the buzzy bee sound that is widely used to frighten elephants (*BINITA KHANAL Enschede, The Netherlands, June 2022*).

AI system involves small cameras that work remotely, hidden in a tree above the reach of elephants. When the camera's motion sensor is triggered, it uses computer vision to detect elephants in the frame. It transmits those images in near-real time to the cell phones of village guardians (WildEyes AI by NGO RESOLVE and CVEDIA).

The scalable, affordable system, funded partly by One Earth, uses new advances in computing technology to find elephants and transmit alerts to life managers and communities to forestall conflict things before they occur (WildEyes AI).

The Global Positioning System (GPS) collar system used today is another approach towards tracking elephants currently used only to identify migration patterns of elephants (Gamage & Wijesundara, 2014).

These days modern technology enables the ability to monitor elephants' movement with GSM and satellite images. The collected elephant movement data can be analyzed and monitored with the help of artificial intelligence algorithms. These software algorithms issue alert messages and facilitate rapid response if some elephants become unnaturally immobile. STE tracking app uses AI algorithms to visualize and track elephants and investigate their behavior (*Save the Elephants project: <https://www.savetheelephants.org>*)

In Africa, They are leveraging Artificial Intelligence and Machine Learning technologies with drone and camera to stop poaching issues. There is a vision processing platform called (Neurala's AI) that platform is AI-powered and that software can process terabytes of video data in real-time captured by drones, this software uses the deep neural network to track and

predict the movement patterns of elephants and other animals (Neurala's AI: <https://www.neurala.com>).

in Africa, The WildEyes AI is a camera system that uses artificial intelligence technology to monitor African elephants and sends alerts in real time; helping to greatly reduce the risk of human-elephant conflict or enhance research and monitoring efforts; WildEyes AI's journey started in 2014 during the Great Elephant Census, a continent-wide survey of the entire African elephant population conceptualized (by Paul G. Allen).

In Cambodia, "Wild Earth Allies" is a community-based startup using Camera Traps to protect Asian Elephants. Camera traps are an important conservation tool, as they facilitate remote wildlife monitoring (*Wild Earth Allies 2021*).



Photo by Allison Shelley

Figure 18: Camera Trap in Cambodia (Wild Earth Allies)

They way computer learn, it learns different variations within a species, as well as what an animal might look like in a wide variety of poses and from different perspectives (Arjan Wijnveen CEO of CVEDIA). According to Dinerstein and Wijnveen, this not only makes the AI better-placed to recognize its target, but also prepares the system to recognize it from any angle.

When a camera is deployed in the field, all of this training is stored in a deep neural network on the SD card. This is the same technology that allows a self-driving car to recognize a pedestrian in a crosswalk ahead (*Geib, 2020*).

The camera itself, designed by RESOLVE engineer Steve Gulick, is housed in a thin camouflaged strip that houses a motion detector as well as two sensors for different lighting conditions. It is powered by a battery that lasts at least one and a half years (WildEyes).

Believe the WildEyes can be integrated into existing deterrent systems. Her organization provides farmers with wildlife conflict training and deterrent kits developed by the organization Honeyguide, which use light, noise, and trunk-tickling chili pepper to turn African elephants away from fields humanely (*Silvia Ceppi, a scientific adviser with the NGO Instituto Oikos' East Africa office, Tanzania*).

ForestGuard AI is a platform built by CVEDIA for potential future use, where it could spot logging trucks as they enter forests, to stop illegal timber harvest before it happens (CVEDIA).

The experience has shown that farmers are willing to invest at least half the cost of powerful torches, which are the most expensive asset in the toolkit; farmers are willing to invest in crops-protection technologies that are convincing and proven to work (*Ceppi - Researcher*).

Perhaps, in the future, we can protect elephants while giving farmers more good nights' sleep their farms protected not by human eyes, but by AI (*RESOLVE was a co-founder of Mongabay's WildTech*)

Tracking imperiled elephants with cutting-edge technology, with the warden, we started tracking elephants for security in Meru National Park in 2003. Those were old-fashioned collars; WildTech spoke with Iain Douglas-Hamilton (O'Brien & Palminteri, 2015)

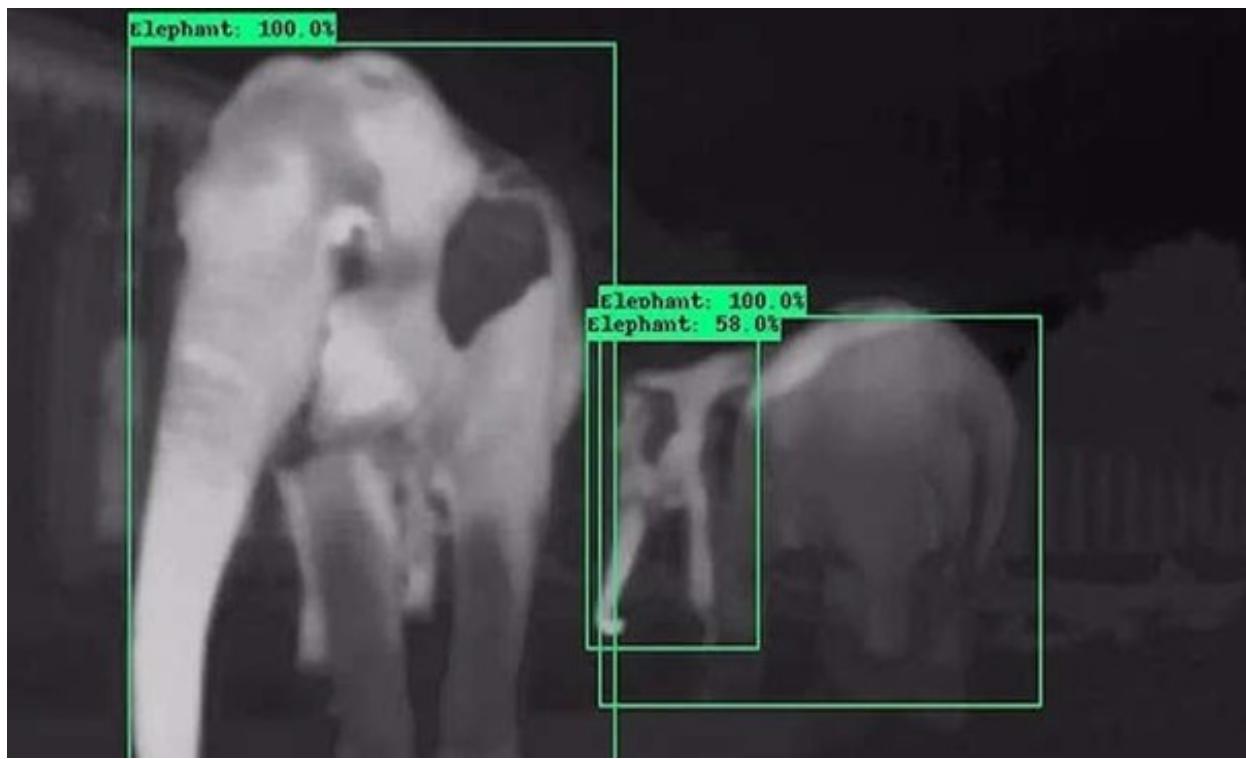


Figure 19: WildEyes Camera Trap Output



Figure 20: WildEyes Camera Trap Output

The Elephants and Bees Project is part of the Human Elephant Coexistence Program at Save the Elephants, which is based in Sagalla, Kenya, near Tsavo National Park. Our award-winning

project investigates the use of Beehive Fences as a natural elephant deterrent, thereby assisting in the protection of farmers and farmland. The concept is based on our innovative research that uses elephants' fear of African honeybees to help reduce crop damage and other human-elephant conflicts (*Elephants and Bees Project*: <https://elephantsandbees.com/>)



Figure 21: Elephants and Bees Project

We spend 80 percent of our time at the Sagalla test site [near Tsavo East National Park], and we've been assisting new partners in Africa and Asia in establishing beehive fence projects [here's one from South Africa]. Of course, these fences will not solve all HEC issues (*Douglas-Hamilton WildTech*) (*O'Brien & Palminteri, 2015*).

2.6.1 Computer Vision Technology

A convolutional neural network (CNN) is an artificial deep neural network used for feed-forward to achieve computer vision-related tasks, for example, classification and identification of images / digital videos; CNN is like conventional neural networks but with deeper strata. This has weights, biases, and a nonlinear efficiency Switch (S, Ramesh, and Divya, 2016).

Computer vision is an interdisciplinary scientific field that deals with how computers can gain a high-level understanding of digital images or videos. From the perspective of engineering, it seeks to understand and automate tasks that the human visual system can *do* (*Zhanyu Ma; Haibin Ling; Yi-Zhe Song; Timothy Hospedales; Wei Jia; Yuxin Peng* 25 June 2018)

We are attempting to do the inverse in computer vision, that is, to describe the world we see in one or more images and reconstruct its properties, such as shape, illumination, and color distributions. Humans and animals can do this so effortlessly, whereas computer vision algorithms are notoriously prone to errors. People who have not worked in the field frequently underestimate the problem's difficulty. This misconception about vision dates back to the early days of Artificial Intelligence when it was thought that intelligence's cognitive (logic proving and planning) components were inherently more difficult than the perceptual components (Boden: Source: Computer Vision: Algorithms and Applications by Richard Szeliski).

Parts of the complexity of the human vision system are being replicated, allowing computers to identify and process objects in images and videos in the same way that humans do. Until recently, computer vision could only perform limited tasks. With advances in artificial intelligence and innovations in deep learning and neural networks, the field has been able to make significant strides in recent years, surpassing humans in some tasks related to object detection and labeling (*Ilija Mihajlovic*)

YOLO (you only look once) is an object detection algorithm that divides images into grids. Each grid cell is in charge of detecting objects within itself. Because of its speed and accuracy, YOLO is one of the most well-known object detection algorithms (Bouchard, 2020)

The field of computer vision is an intellectual frontier. It is exciting and disorganized, as is any frontier, and there is frequently no reliable authority to appeal to. Many useful ideas lack theoretical foundations, and some theories are useless in practice; developed areas are widely dispersed, and one often appears completely inaccessible from the other. Nonetheless, we have attempted to present a fairly orderly picture of the field in this book (*Computer Vision: A Modern Approach* by D. Forsyth, J. Ponce).

Applications built on animal detection play a vital role in providing solutions to various real-life problems (*S. Sharma and D. J. Shah Jun. 2013.*)

To reduce observation costs, labor, and logistics, ecologists increasingly turn to greater automation to locate, count, and identify organisms in natural environments (*Pimm et al., 2015*).

Automating the Analysis of Camera Trap Images: Prior to the widespread adoption of deep learning systems, computer vision researchers devised several innovative and moderately successful methods for automating the analysis of animals from camera traps using raw pixel data from images (*Schneider et al., 2018*)

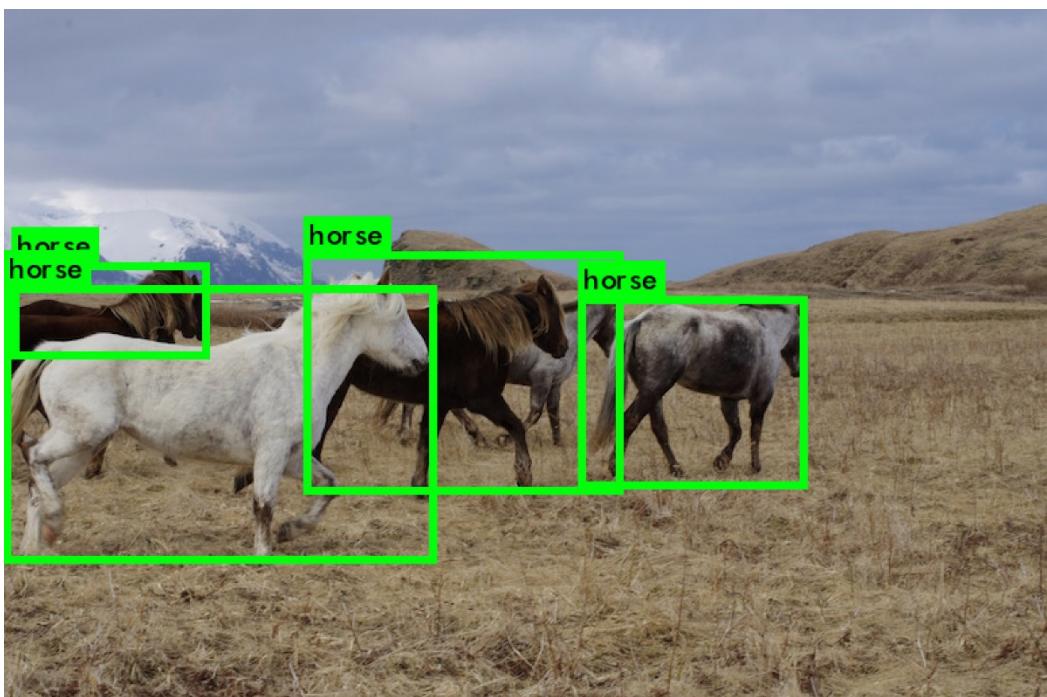


Figure 22: Computer Vision Technology Animal Detection

2.7 Conclusion

Elephas, maximus are the Sri Lankan subspecies of elephants living there, and elephants play a vital role in tourism and Sri Lankan culture, such as traditional religious events like "Kandy Perahera," etc. They are treated as a treasure in some circumstances.

On the other side, there is a serious problem separating humans and elephants, which is human-elephant conflicts. Wild elephants turn into enemies of humans and vice versa.

This problem causes much damage to both sides, such as deaths and property damage, rural areas are people's lives, and Sri Lanka is slowly losing its natural beauty of elephant tourism.

Many techniques are used to avoid human-elephant conflicts in Sri Lanka, such as electric fences and natural methods of scaring elephants. There are many studies related to this problem with technology, such as IoT-based solutions. But, students only do these kinds of research for academic purposes, not as serious research; this causes the local Sri Lankan problems to keep existing in Sri Lanka.

This human-elephant conflict problem exists in many countries; in some countries, they use artificial intelligence; WildTech, ForestGuard AI, WildEyes, and *Wild Earth Allies* are some of the similar startups that are using technology and artificial intelligence for this problem.

WildEyes is a popular community-based startup that solves this human-elephant conflict issue with technology and artificial intelligence in Africa. *Wild Earth Allies* is another similar startup in Cambodia for this problem; ForestGuard AI and WildTech are community-based organizations that work for wild animals and the environment with technology.

There is a project called elephants and bees (Beehive Fences) they are growing bees to avoid elephants because elephants are afraid of buzzing bees sounds.

Computer vision and image processing play the biggest role in this solution.

3. Project Plan

This chapter contains information regarding the project plan, such as task titles, task completion status, start date, end date, etc. To do this project successfully, all tasks must be divided into small parts; the planning work is done with MS Excel program, and every future task is documented properly to take this project in a nice way.

3.1 Gantt Chart

3.1.1 Page 1

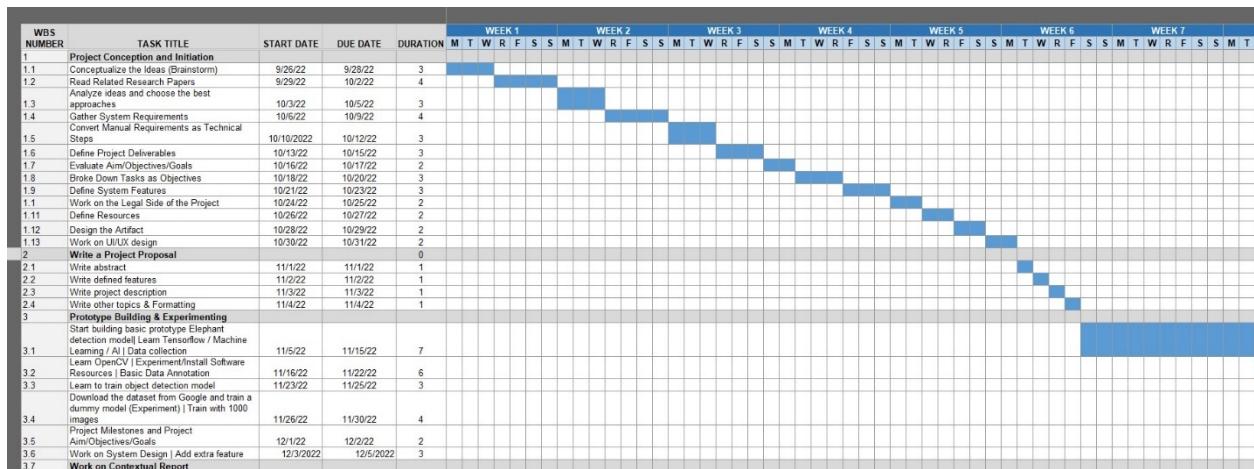


Figure 23: Gantt Chart Page 1

3.1.2 Page 2

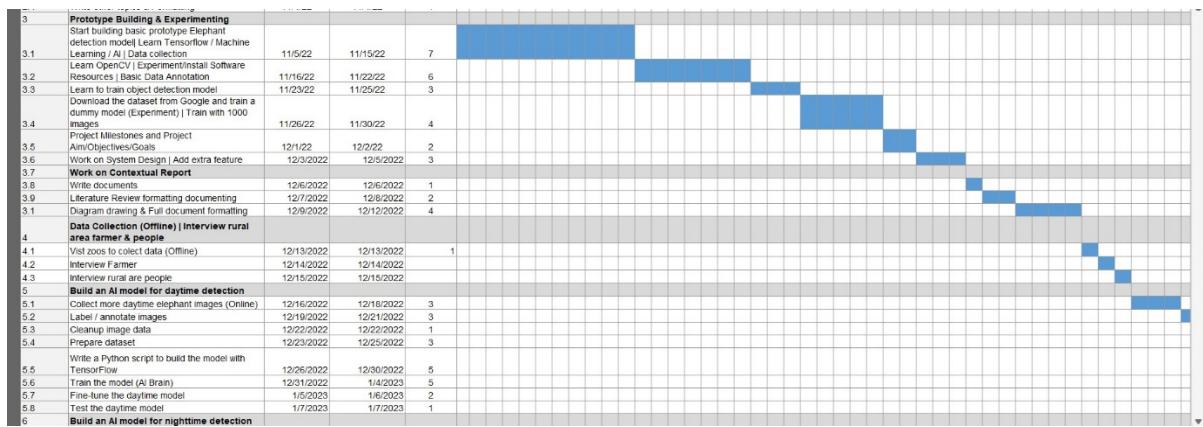


Figure 24: Gantt Chart Page 2

3.1.3 Page 3

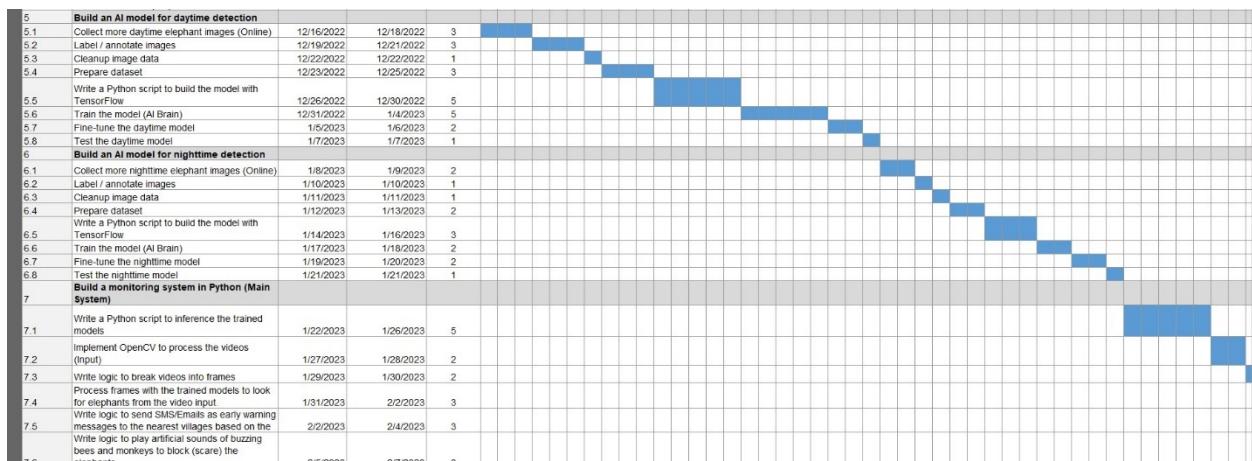


Figure 25: Gantt Chart Page 3

3.1.4 Page 4

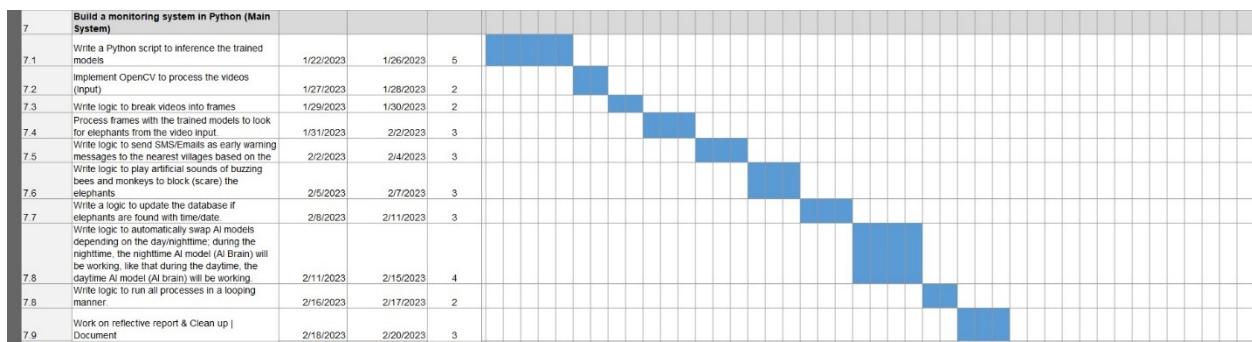


Figure 26: Gantt Chart Page 4

3.1.5 Page 5

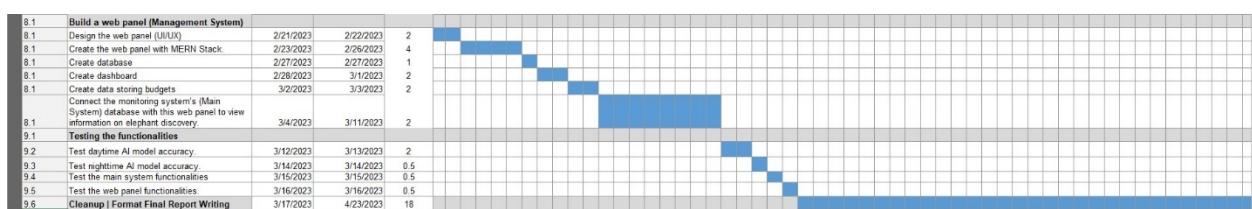


Figure 27: Gantt Chart Page 5

3.1.6 Project Milestones

- **Milestone 01:** (01-07-2023): Daytime Elephant Detection Model Prototype.
- **Milestone 02:** (01-25-2023): Nighttime Elephant Detection Model Prototype.
- **Milestone 03:** (02-19-2023): Fully functional Elephant Monitoring with daytime/nighttime models and early warning SMS sending feature (Without backend panel).
- **Milestone 04:** (03-04-2023): Fully working system with all features (Without bug fixing & Testing).
- **Milestone 05:** (04-23-2023): Final Submission with all documents, manuals and fully working system.

3.2 WBS Diagram

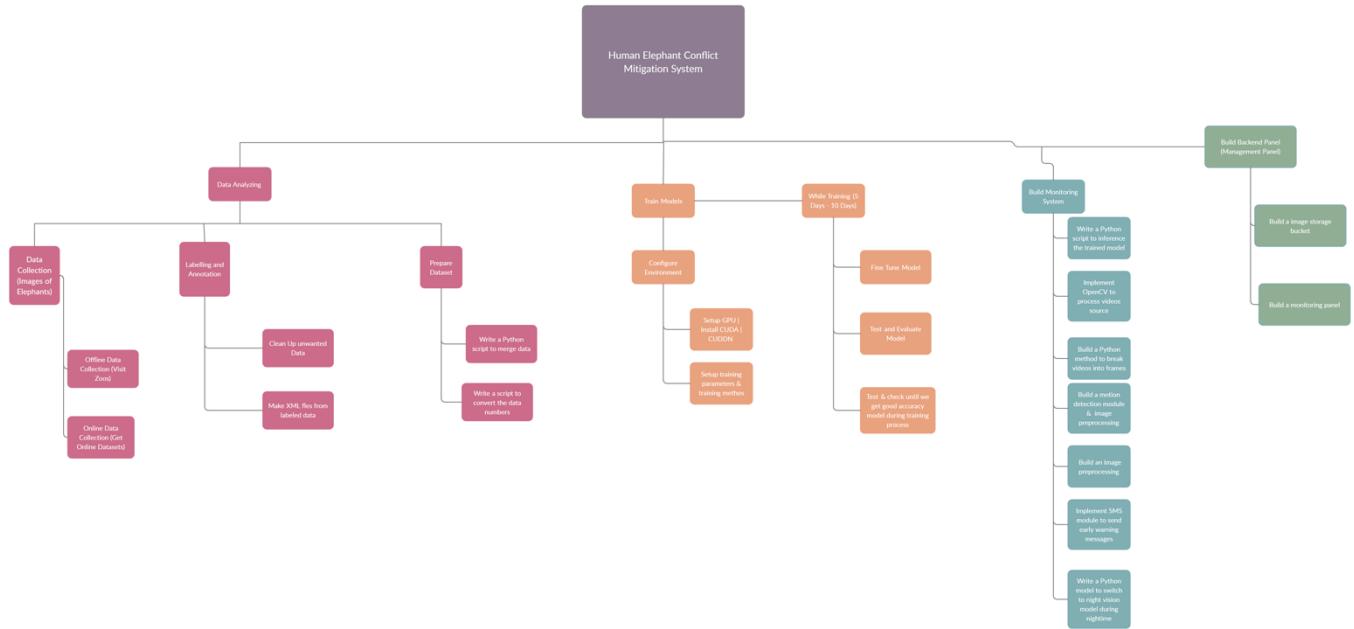


Figure 28: WBS Diagram

4. Artifact Planning

This chapter describes all the information regarding the artifact and its planning; it investigates the project methodology and evaluates how this project will be executed, and it explains why that chosen methodology is suitable for this project.

This chapter also describes the project execution plan, requirement gathering methodologies and collected requirements, the requirement analysis method, and the full design of the project. It clearly defined this project's final implementation and the best testing and evaluation strategies to be used during the development process.

This chapter went through a detailed description of study types and why that study was chosen and the research design behind this project, data gathering techniques data analysis methodologies and, it also explains the project's main concept.

4.1 Methodology

This section is going to explain the methodology that this project is going to be used; this section is divided into two categories those are research methodology and development methodology; it is going to describe both, such as what methodology is going to be used to develop the system and what methodology is going to be used to collect data.

4.1.1 Research Methodology

As a research methodology, this project will use the **quantitative** method since it involves many mathematical operations, countable data, and statistics. Normally, the major scope of this project is to build an artificial intelligence model that can detect elephants in the daytime and nighttime, and it can also send early warning messages to nearest the villages. Therefore, this research involves a lot of data collection and annotation, data parameter switching, etc.

Normally, in machine learning, to build a better performance model, we need to have a lot of data in different shapes of perspectives, and we also need to produce sample data augmentation to generate more data.

In this research, a better AI model must be developed. Developing a better model means more training, testing, evaluating, dataset increasing, data augmentation, parameter tuning, model tuning, and a lot of scripting and mathematical approaches are involved in this study to build a computer vision model; Therefore, a lot of **quantitative** approaches will be used in this study to achieve the right destination.

To train a computer vision model, we need to feed a lot of images of elephants; as this tries to build two different models those are daytime and nighttime model, we need to collect datasets for both models; as a data collection method, this research is going to use the offline and online collection, to collect images of elephant, the researcher will visit the zoo and collect videos of an elephant then it will be converted as frames during the training process, this is the offline method, as online methods, this research will download some publicly available dataset of elephants.

4.1.2 Development Methodology

This project will use the Agile methodology for development purposes since it involves artificial intelligence technology; normally, AI models need to be tested and evaluated frequently to achieve the best accuracy.

Therefore, this research cannot use any single-shot approach like a waterfall; in this development process, there will be more failures to overcome and produce a better model; this research needs to stick with a development method goes until it finds the best result, therefore, this research is going to use the prototyping methodology.

During the model training process, at each stage, there will be a testing and model accuracy evaluation; if the model does not perform well, then another cycle of training with different approaches and parameters or with a different dataset to be used; this cycle will be repeated until the model get the good results in detection.

Most of the time, these three methods of development, planning, and research will be respected to achieve the destination.

Sometimes, if the computer vision detection architecture does not work, this research needs to involve identifying the best architecture; there will be more changes during the development time.

The primary objective is not only about training a better model but also about building the best solution for the human-elephant conflict. To do that successfully, this research has to build an additional software platform, such as a backend panel for elephant details monitoring and a monitoring system that inferences trained the model and send early warning messages if an elephant is found and it plays artificial sounds to block the elephants entering the villages.

4.2 Requirement Gathering and Analysis

The fundamental requirement for this research comes from the problem Sri Lanka and similar countries face in human-elephant conflicts. Therefore, the main requirement is clearly defined.

However, even though the fundamental requirement is the same, and the problem can be easily understood, the implementation requirements will differ. This research tries to help rural area farmers by providing a solution.

In Sri Lanka, many manual methodologies are used by farmers and people in rural areas to avoid human-elephant conflicts, which are already given in the literature review section.

As main requirements, this research is trying to build two AI models that are daytime and nighttime models, and a backend system to monitor elephants' data and a monitoring system to send early warning messages and play artificial sounds to block elephants; these are top-level requirements that this research is going to solve.

4.2.1 Requirements

- Build an AI model for daytime detection
- Build an AI model for nighttime detection
- Build a monitoring system in Python (Main System)
 - Able to send an early warning message (SMS) to the nearest villages.
 - Able to play artificial sounds to block elephants.
 - Update real-time data to the backend panel.
 - Able to switch between nighttime and daytime models automatically depending on the time.
 - Able to send Emails to authorities regarding elephant detection.
 - Update how many elephants were found (Counting).
 - Able to record the video of the elephant and store it in the database to see from the backend panel if elephants are found.
 - Able to take images and upload them to the backend panel.
- Build a web panel (Management System)

- All the camera trap information will be stored in this database
- Able to see from which area that elephant was detected.
- Able to see the videos that are recorded by the monitoring system.
- Able to see photos that are taken by the monitoring system.
- Able to see the elephant detection record
- Able to search camera places by name and ID
- Able to send authority email ID/phone numbers that the monitoring system sends early warning messages and reports.
- Able to create a new camera trap when implementing this system in a new place.
 - Able to set its own value, such as email address/phone numbers

Note: This system can be treated as a distributed system; for example, the monitoring system that uses the AI model to detect elephants and warns is a kind of think client application; it will be installed in hardware and will be placed in a wild area, and it will be updated to the backend panel, in the backend panel there will be a sperate folder for that specific camera, images/videos/authority emails/phone numbers could be set up and maintained from the backend panel. The requirements are simplified in the following 4 steps.

- Daytime AI model: To detect elephants in daytime
- Nighttime AI model: To detect elephants in the nighttime
- Monitoring System: Monitor elephants / send warning messages/play sounds
- Backend Panel: To manage data / to create a new camera.

The entire requirements can be summarized as above; this project may have sub-requirements. To achieve this, this research has to fill the above-mentioned requirements.

Note: As requirement gathering methods, the **brainstorm/farmer interview** and **rural people interview** must be held to understand the problem better.

4.3 Implementation

The way this research will be implemented as a software product will only focus on building a software product for this problem; the implementation will be split into two parts.

The output of this research would be a computerized system, as already mentioned in the requirement section; there will be two major 2 sub-systems in it: the monitoring system and the backend panel.

The backend panel will be hosted on a server since it is a web application, the monitoring system must be installed on a Nano computer like Raspberry PI or Jetson Nano, and that will be placed in the jungle as a camera trap.

Note: This research is not building any hardware like camera traps; the main focus is to build better software, then it will be installed on a Nano computer to be in operation.

4.4 Testing strategy and Evaluation strategy

This research process will have many testing strategies since it is split into four types of modules. To test the AI model, the learning rate, Precision, and Recall methodology will be used to check the model's accuracy.

To test the web platform, Selenium testing cases will be written to test the web platform, and there will be some white-box, and black-box testing will be taken place.

To Evaluate the model, a lot of elephant images will be provided to the machine; since it is a machine learning application, it may also return false positives and false negatives; therefore, there will be some testing with some similar images like an elephant to check whether it predilect false negative.

4.5 Study Type

This research is choosing the **experimental study** type since it involves a lot of experimentation such as coding, building models, data analysis, this research process/analysis, and experiment data collected for this study. Therefore, this research goes under the category of experimental study.

Since this research involves machine learning, it needs to perform/be involved in many kinds of data analysis; experimentation approaches; this research needs to be involved in many experiments and hypotheses, etc.

4.6 Data Gathering and Analysis

This research uses the interview method to collect information from farmers and people in rural areas. This research uses an online and offline methodology to collect digital data on elephants. It uses “**Open Images Dataset V7**” to collect online data from Google and **Kaggle** and other open-source platforms for digital data collection.

Next, to collect digital data on elephants offline, this researcher visits the zoo to take real elephant videos for training; then, those video data will be analyzed and converted as frames, and those frames will be annotated and converted as vectors of numbers.

This research statistically analysis the digital data of elephants; for example, once the images are collected, those images need to convert as number datatype to make the machine understand, then after the analysis of data, these data will be inverted into a vector format, like this, there are lot of data analyzation technique that should be used to build AI models.

The data will be tested before it is converted as a vector because an improper image will make the AI works worse; some data from Google might not be a proper elephant; they could be cartoons/designs. Therefore, good data analysis must be done before proceeding with the vectorization and training process.

4.7 Future Works

In future works, this research will continue to work on the hardware development for the camera traps; at the movement, this research only develops the software products for the problem; as future works, there will be more studies on the hardware side.

Future Prediction: In the future, there will be more system-generated data, such as elephants-detected data with times, dates, and circumstances; with the help of those data, a prediction model will be developed to give an early warning message at this time, at this circumstances that the elephant may come.

Tech WildLife Startup in Sri Lanka: In the future, this study will be extended to monitor all wild animals; it will become a startup to provide service and support communities that works for wildlife and animals, environmental challenges.

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