IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

AUTOMATIC ELEPHANT DETECTION SYSTEM USING MACHINE LEARNING AND IOT TECHNIQUES

Chintada Chandu Sai[1], Ayush Dewangan[2], Korada Puneeth Venkata Sai Aakarsh[3],
Raghavendra Prasad, Assistant Professor*
[1]Amity School of Engineering and Technology, Amity University Chhattisgarh
***Corresponding author**
Raghavendra Prasad
raghav.raghavendra@gmail.com

Abstract:

Due to population growth in the nearby forest areas, there has been increasing in the conflicts between Humans and Elephants. Animals like elephants travel in forest areas in search of food and other available resources. Sometimes they might not get food so there would be a probability to come to living areas. People cannot identify the animal from where it is coming so there will be loss between Human's lives and animals too. There are also several reasons that are happening like destroying agricultural fields, lands, and to the transportation sector. It will be difficult to the forest officers and people to monitor continuously to the specified wild animals in the nearby areas. It will be a difficult task to us. There had been many methods implemented before to track the animals and warning systems. So, in this paper we mention about the elephant identification in the forest areas in the corridor and delivers the signal to the nearby the forest range officers and people who are living nearby. By generating alarms and sending SMS service to the people. We can stop the animal intrusion method by this way so that it's helpful to the people to track the animals initially. Here we used an image dataset containing elephants in different views and developed an approach to distinguish elephants. Machine learning algorithms like Convolutional network to train, test and classify the animals are used and IoT applications like Arduino, GSM modules are used to delivers the signals and to program the code.

Keywords:

Machine Learning, CNN, Image Classification, Arduino, Alarms, GSM Module etc.

Introduction:

From the last few years, the constant capturing of lands for cultivation of agriculture and settlement of livelihoods has forced the large land vertebrates to not to stay in the isolated areas and its national parks. The main purpose of the animals is here to spend different activities like feeding, resting, playing, bathing etc. in the entire whole day. (Vancuylenberg, 1977) It is due to demo graphic pressure of a human, cultivating different cash crops in the forested areas and destruction of habitats leads to the widespread exclusion of elephants. Rural and local areas of the forest areas bear these types of conflicts with huge costs.(Bal et al., 2011) Human-Elephant conflict shows the negative effects on the human social, economic or cultural life and on the environment and conservation of elephant life because of the rapid increase in the interface between humans and elephants because of the wild species.(Yadahalli et al., 2020) These conflicts that can be seen in the localities and rural areas that surround near the forest areas it leads to much cost to them.(Bal et al., 2011)

There are large areas of land, especially with the migratory paths of elephants have been brought under cultivation and constructed into villages. Blocking of these routes causes danger to the animals as well as to the humans that leads to cause conflicts.(Vancuylenberg, 1977) The best method to obtain the most accurate estimates of home range size, spatial use and the behavioural decisions is with the shortest sampling interval over the longest time. Animals that do not have their separate home range and move randomly to the other portions of the forest areas to find out the fixed home ranges demonstrate a long-term, considerable geographical autocorrelation.(Cushman et al., 2005)

Elephants, that are mainly dependent on vegetation and are relatively nonselective and they depend on large, distributed areas. The animals that are dominant in their areas are to be competitive with the other animals for the resources and to reduce the disputes between individuals. The animals which move in larger groups occupy more areas for the resources that are available in the forest that has difficult competition among the animals in the spatial behaviour. (Wittemyer et al., 2007) Failure to understand the movements leads to the Human-animal conflicts. Suppose Elephants are responsible for the crop raiding in the cultivated land borders so the careful understanding of the elephants and their behavioural in the space and time will help us to conserve and elephant management as well as to the adjacent farms.(Bohrer et al., 2014)

Due to the poor rainfall, animals don't get vegetation and because of their hydric stress they search for food instead of drought prone areas for their livelihoods and moving to the cultivated areas in the nearby areas leads to conflict between human-animals conflict. Hence climatic and seasonal conditions are the most important for the survival of the animals.(Foley et al., 2008) The purposive method is the productivity of the resource availability and inversely proportional to their home range size. Males can find mates more easily in productive ecosystems due to less restrictive energetic limitations, while this behaviour is restricted in less productive areas.(P. Fernando et al., 2008) There are various technologies to track the animals like elephants and to process data in real time to systems with using Communications and satellite-based system. It is used in absence of continuous observations, visualization of topographic and ecology contexts.(POVEDA, JIME´ NEZ, 2013)

Increased human settlement in elephant dispersal areas surrounding parks and reserves will lead to increased conflict between elephants and human migratory routes, which will be restricted or entirely barred. A relatively little investment in maintaining critical corridors identified by high-resolution radio tracking would allow elephants to disperse their impact across their possible range.(Douglas-Hamilton et al., 2005) Naturally, wild elephants begin to move into human territory, resulting in human-wildlife conflicts. As a result, tracking their movements becomes critical. These animals are tracked by Unmanned Aerial Vehicles (UAVs) or various techniques like image detection etc.(Suju & Jose, 2017)

It is difficult to identify the elephants or the other animals in the forest areas so that in the regular intervals Human – animals conflicts take place. So due to rapid innovation of the technologies and the communication network, wireless sensor networks, Real time Monitoring of the animals plays a crucial role.(POVEDA, JIME´ NEZ, 2013) Global Navigation Satellite System helps us to track the migration of animals with remote sensors with high accuracy and the specific location at a time. Sharing of the information of the animals and its groups with the help of satellite system and its possible movements into human settlement areas or cultivated lands can potentially help wildlife managers and local communities and takes steps to identify the animals before its cause the damage. (POVEDA, JIME´ NEZ, 2013)

The elephant-location framework (elephant identification device) equipment will include specific components such as a Raspberry Pi for preparing detected data and an Arduino UNO board for serial connection. The camera module is used to photograph elephants, while communication via 3G technology is utilised to relay data to field transmission stations. SD card storage space is obtained for the picture database. Power is supplied via solar boards and related components.(Suju & Jose, 2017)

VHF radio telemetry is used in several parts of forests to identify and research of the animals. We should find the elephants in their home ranges that are ranging from 200 to 10,378 Km2.(TCHAMBA et al., 1995) The elephant movements are distributed in the several factors like topography, elevation, soil type, amount of rainfall and human interference. Some are the revenue generators and other are the crop destroyers. The elephant habitat range is declining due to habitat loss resulting from increase in the human population and associated land use. (Ngene et al., 2009) So that elephants migrate from one to another places in search of food, shelter and sometimes destroys crops and lands in the villages nearby forest areas. GPS technology is used for the monitoring the animals and became easier and convenient.(Clark et al., 2006) The use of satellite-linked GPS collars enables for the collection of high-resolution spatiotemporal data, which is critical for understanding elephant ranging habits.(Ngene et al., 2009)

The different scientific knowledge of the animal's migration varies from one another. Monitoring of the animals in the large areas remains challenging and it also with huge cost. Large number of gatherings are migrating more in some situations whereas in some cases with the local understanding by the help of census data of the animals. Artificial water provisioning system helps in increase of the elephant population from <1000 to <45,000 in between 1930 to 2014.With the assess to surface water seasonal movements of large mammals are occurring more. (Tshipa et al., 2017)

Connecting with wires requires huge cost for its installation so wireless networks are useful for the collection of information from GSM Module. It is also need low cost.(Kumar & Kumar, 2013) GPS Technology is used for the migratory of the different animals within or outside the protected areas. (Kim et al., 2010)Large herbivores migrate in the essential corridors for the long-term survival for shelter, food, resources. Due to migration of the large animals, it is very difficult to identify and leads to Human animals' conflicts in the livelihood areas and sometimes leads to the death of the elephants and also to humans.(Galanti et al., 2006)

For some animals that roam in large number of distances it is difficult to identify so various techniques are used such as PAM (Passive acoustic Monitoring) is the autonomous recording device that are fixed throughout the habitats that record the animal vocalization.(Bjorck et al., n.d.) It works through the less bandwidth to transfer the data and it is low in cost. In some cases, we are unable to detect the elephants easier and those are less accurate, and it is very problematic to classify and segmentation.(Pérez-Escudero et al., 2014) Wireless networks also give the unwanted information because of the low bandwidth and signal problems also leads to listen with lesser frequencies of the animals. These are solved by the help of SCG (Stochastic Gradient Descent) to get improvement of the result.(Bjorck et al., n.d.)

Various methods of elephant tracking are fetching radio collars, electric fencing, monitoring using video and audio cameras and using wireless sensors. The main purpose of these methods is to reduce the Human Elephant Conflict without any damage.(Sheebha & Kumar, 2015)

There are many applications that transfer huge amount of data such as Data Centre Switching fabrics have more bandwidth than other networks through the servers.(Curtis & Kim, 2011)

Arduino is open-source and user-friendly. It helps the user to operate in real-time by writing and downloading the code of the software.(Pineño, 2014) We give the input for Arduino with the set of instructions of code with the help of Arduino IDE software and Arduino programming language. So that it reads and executes the results with set of instructions that we have given.(Goud et al., 2020)

VHF transmitters are used before to detect the elephants and their movements. Satellite tracking system helps us to find out the elephants that are available in the forest areas of what they depend upon.(Okaukuejo & Outjo, 1991)

Now a days, rapid development of modern technology for identification of wild animals and its conservation is increased in computational devices, parallel processing, advanced and efficient algorithms, and wireless systems.(Nguyen et al., 2017) Computer Vision is the one technology that can solve the associated problems more

accurately. This includes with working of cameras and image processing software. Cross camera setups will face some issues to identify individual animals.(Ravoor & Sudarshan, 2020)

There are different types of re-identification like feature extraction, it maps in the smaller dimensions than original size and its convert image to a vector.(Pérez-Escudero et al., 2014) There are many ways to identify features with the help of Convolutional Neural Networks (CNNs), Alex net, Inception and ResNet which are trained with the large number of image datasets (Ravoor & Sudarshan, 2020)

We cannot find exact features of animals, and this may result in irrelevant data in the radiographic images. These techniques are especially designed to extract specified, application-development information. Pre-processing techniques are used to select features and to eliminate irrelevant data.(Hall et al., 1971)

Unmanned aircraft systems (UAV) are useful the rapid response operations and to fly under the clouds. Aerial systems are the best ways in some situations to detect the large animals and has some disadvantages with it. (Wilson, 2020)

Biotelemetry had begun in 1960s with the use of very high frequency tracking. Satellite tracking came in 1970s to record, interrogate and location system (IRLS) and NIMBUS 3 satellite was made to monitor geophysical, oceanographic, and meteorological data. GPS technology has begun in 1990s to locate data to identify animals.(A et al., 2011)

Facial Expression Recognition system used to recognize the individual action base on the facial expressions of animals by following steps:(Paradkar & Sharma, 2015)

Acquisition step: It detects and captures the faces of animals.

Extraction step: It extracts the features of the animals the animals.

GSM Module and alert system: If any animal detects in the nearby areas, they are captured by the cameras and after the classification it sends alert to the nearby forest range officials.(Paradkar & Sharma, 2015)

A sensor network is made up of a large number of sensors that work together to respond to changes in the environment detected by sensors in an active and adaptable manner.(Strumberger et al., 2018)

Humans have very poor knowledge of the identification of animals in the largely dense forest areas so that here advance machine learning techniques are helpful to identify with unique patterns and their features, colours, spots etc. It is used for the individual identification and algorithm used and to their features that are to be determined.(Silva et al., 2022)

Methodology:

There are several stages that includes data collection, data processing, machine learning model training and system integration. We collect data with the help of wireless cameras that are fixed in the separate locations to find out the elephants or other animals and later training is done based on the sensor data of what they obtain. We use different libraries like TensorFlow and scikit-learn to process the model .(Vidumina, 2023)

Animals tracking can be carried out with the help of radio tracking system from the air in the gaps between 8-10 days. These systems can detect the elephants in the 1km2 area with collars.(THOULESS, 1995). Convolutional Neural Network (CNNs) is the main algorithm that is used to identification of animals in the forms of object/animal detection and identification of faces. Machine Learning and image processing plays a key role for the image classification and animals' detection. (Premarathna et al., 2020)

We want to develop the system with several cameras and field experiments to evaluate efficiency, an identification using image processing, where an elephant is identified using the SVM classifier utilising video frames.(Dampage et al., 2021)

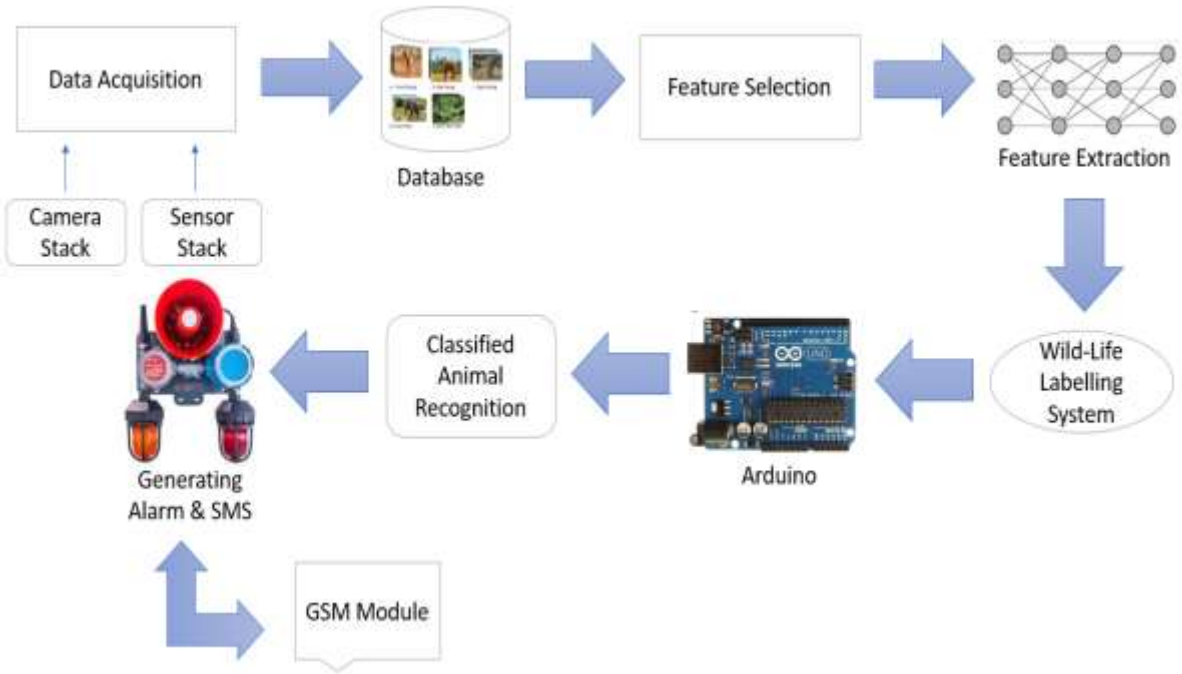
In the recent years, geophones are used to determine the elephants and the main work is when the elephants walking in the specific forest areas, electric signals are generated because of the vibrations created by the elephants and processed within the embedded controller and SMS will be sent to the nearest forest officials. Vibrations are mainly dependent on the weather conditions also.

To identify the elephants, classification of image is done for an intruding elephant in human living areas. Elephants comes mainly to the forest areas in search of food and water for their needs. The cameras that we place above the trees or poles capture the image of an intruding elephant and sent to the base station for further analysis.(Sugumar & Jayaparvathy, 2014) The audio and video recording are taken in the interval of 5 seconds and compared with the database. On an image match, SMS will be sent to the forest officials through GSM transceiver that connects with PC. The setup mainly consists of Wireless cameras, Sensors with signal control modules Module, and power supply.(Sugumar & Jayaparvathy, 2014)

Later, GPS tracking system has come into effect to track and detect the large animals. To record and track the movements of the wild elephants, sensors have been placed all around the field. The drone flight starts when it is detected. The manual flight of the drone is the main emphasis of the suggested solution. The drone has a Raspberry Pi placed on it to fulfil the need for picture processing.
The Raspberry Pi Camera Board, which comes in 2 Megapixel and 8 Megapixel versions, is attached to the Raspberry Pi's CSI connector. Here, an 8MP camera is advised since it produces photographs with high quality and produces processing results that are precise.

The wild elephant can be seen on this camera board. To generate an alarm to the user upon the successful detection of an elephant, image processing and machine learning algorithms—discussed in the following sections—are implemented in the Raspberry Pi as software. The Bolt-IoT module is used to convey the alarm to the user over a server because it has an integrated Wi-Fi/GSM chip and cloud platform. The Raspberry Pi is connected to a servo motor to carry out the servo motion for ejecting the canister of chilli powder from the elephant.

The distinctive features in the image dataset are a key component of CNNs, and weak features will result in a model that performs poorly. Therefore, it is vital to identify the characteristics of an elephant that genuinely enable individual identification.



1.An overview of the project

Result:

Human-Elephant conflicts are increasing every day, and this could rise to property loss, injuries, casualties for people and elephants.

2. Image Dataset of Elephants

Here above images represent the different views of elephants when we want to perform an experiment. In each case we can clarify the elephants depends upon the views.

2. Algorithm Description:

For feature selections, we used different algorithms to identify the animals in different locations.

a) Major axis length: The longest boundary drawn through object containing two far distances in the boundary is called Major axis.

$D = \sqrt{(x2 - x1)\,2 + (y2 - y1)\,2}$

Equiv diameter:

It defines the diameter of a circle with same area as the detected object.

Equiv diameter = $\sqrt{4 \times}$ area of an object(Mangai et al., 2018)

b) The primary goal of the support vector algorithm is to identify a function f(x) that can yield response variables (predicted) with the least amount of divergence from input variables (observed). SVR is thought of as a generalised regression algorithm because it concentrates on generalised error bound minimization. The over-fitting issue is therefore resolved.

The hypothesis space complexity has an impact on the regularisation factor that SVR depends on. The generalisation error bound that SVR minimises to meet the generalisation requirement is represented by this component along with the training error.

Consider a data set of the form $\{(xi, yi), i = 1, 2, \ldots, l, xi \in R^n, yi \in R\}$,

SVR regression function is stated as: $f(x) = \omega.(xi) + b, \omega \in Rn, b \in R$

where (xi) is the transformation function to higher dimensional space, ω and b are control variables that are fine-tuned by risk minimization for the following risk function.

R(f) = C 1 l l i=1 L

(yi,fi) + 1 2||ω||,

$L_E(yi,fi) = 0$,if $|yi - fi| \leq E$

$|yi - fi| - E$, otherwise (Hassanien et al., 2018)

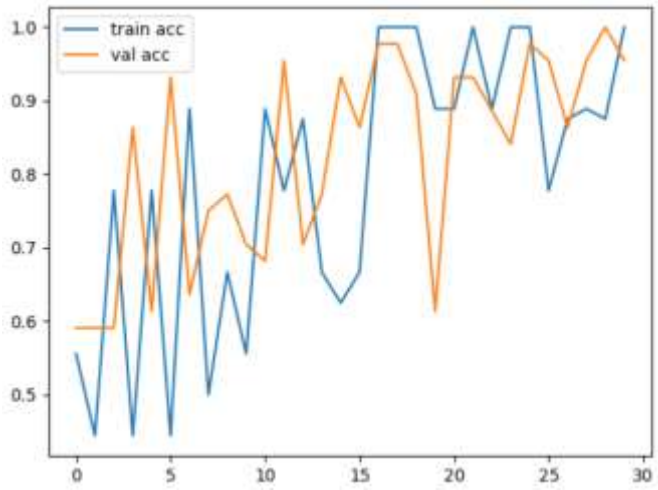
c) K-Means Clustering Algorithm. Clustering is a process of grouping the similar objects from a given data set. The most popular and reliable clustering algorithm is the K means clustering algorithm that classifies the input data points into multiple classes based on their inherent distance from each other. Let $S = \{Si, i = 1, 2, \ldots, N\}$ be the n-dimensional data points to be clustered into a set of K-clusters, $C = \{C1, C2, C3,..., CK\}$ [18] from the given elephant data set $X = \{x1,..., xN\}$, $xn \in Ed$. The M-clustering problem aims at partitioning the elephant data set into M disjoint subsets (clusters) $C1,..., CM$. The most widely used clustering criterion is the Euclidean distance. Based on this criterion, the clustering of elephant images is grouped depending on the cluster centres $m1,..., mM$ as given below

$$E\ (m1,...,mM) = M \sum i{=}1\ M \sum k{=}1\ I\ (xi \in Ck)\ ||xi - mk\ ||^2$$

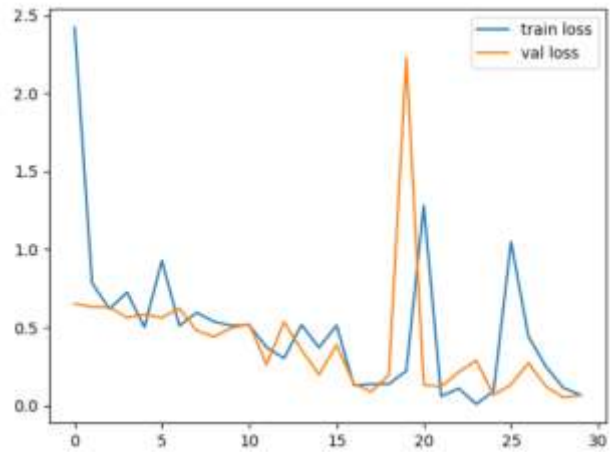
where $I(X) = 1$ if X is true and 0 otherwise.(Sugumar & Jayaparvathy, 2014)

Below are the graphs from the training of the model it defines about the trained accuracy and validation of accuracy that has shown in Figure 1.

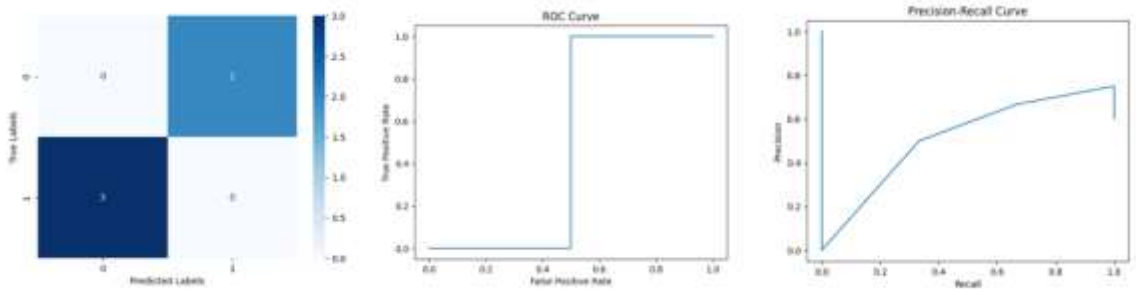
And the Next graph indicates that trained loss and validation loss of our model.



3. The above image defines about the training and validation accuracy of each image dataset. The accuracy of each image gradually increases.



4. The above image defines about the training and validation loss of each image dataset. The accuracy of each image gradually decreases.



5. This picture represents about the Confusion matrix, ROC curve, Precision-recall curve.

Module Description:

A module description often refers to the explanation of a particular module within a hardware system or framework. A module is a self-contained component that carries out a specified set of tasks or offers a certain feature when it comes to the development of software. The function, main functions, and characteristics of the module are described in the description.

Cameras are gadgets that record the light that enters through a lens to produce visual images or films. They are frequently used for many different things, such as video conferencing, surveillance, and photography. A standard camera has a lens, an image sensor, a shutter mechanism, a viewfinder, or LCD screen, and controls the focus, shutter and exposure speed of the light. When you push the shutter button, the camera's shutter mechanism quickly opens, allowing light to enter the image sensor and capture an image. Light is transformed into an electrical signal by the image sensor, which is then processed to produce a digital image or video.

Cameras come in a variety of shapes and sizes to meet a range of requirements. Digital cameras: These cameras often store their photos and films on memory cards in digital format. Mirrorless Cameras: These are compact cameras that are like DSLRs but lack the mirror and optical viewfinder. They frequently feature interchangeable lenses and a similar level of image quality. Action Cameras: Designed to record adventures, these cameras are small, tough, and frequently have features that includes water proofing and stabilisation.

Mobile device cameras that are built into smartphones are becoming more and more powerful and well-liked for regular photography.

A piezoelectric sensor is a device that uses the piezoelectric effect to measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge.

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write, and upload computer code to the physical board.

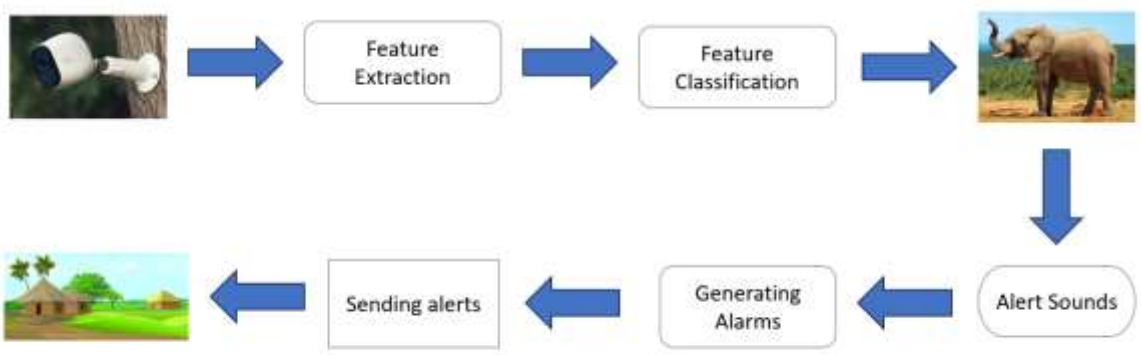
Alarm: It is a sound detecting device that might be mechanical, electromechanical or physio electric. It is useful for giving alert to the people in the forest areas whenever any animal detects.

Discussion:

The conflicts between human and elephants are increased in the recent years. So, this study shows that how the animals are migrating from one location to another and sometimes resulted in the conflicts between humans and mankind.

Due to rise in human population and industrialisation causes habitat fragmentation for many species. Some animals which are highly connected to the local environment search for food results in conflict between human and animals.(Duporge et al., 2020)

In our project we place the cameras in the elephant corridors and the real time tracking is done. Each frame of the image and video sequence is converted to (200 x 200) to improve the processing speed. Raspberry Pi detects the pre-processed video. The microcontroller calculates the input sequence and checks the frame for any signs of an elephant. It generates the sound if identified by an external speaker and alerts the people in the nearby forest areas without causing any interactions between Human and Elephants.(Madheswaran et al., 2019)



6. Working Process of the project

Machine Learning develops most accurate results than the mathematical results that struggle with exponential growth of network. Internet of Things(IoT),cloud computing also plays a vital role in classifying.(Nougnanke, 2021)

IP surveillance is a system that allows the user to monitor activity through an IP-based network such as a LAN or the internet. In this case, we're employing an IP camera to confirm the intrusion.(Sahoo & Pati, 2018)

People track different animal species of their location but not their postures or orientation. Later, Classification algorithms are used on the sensor's data to identify behaviour and postures.(Pons et al., 2015)

We create an image dataset of the labelled photos using the supervised learning in classifying the elephants. Training and testing are done on the sets are created from the dataset to identify the photographs of the specific animals whether it is elephant or not. CNN model is used here for training and testing to get the accurate information.

Image processing is the main method for the image and video sequence for the detection of the target animals. Feature selection is the strongest method extract the exact information derived from the target image to locate the entire containing the other images in a dense forest area.(Premarathna et al., 2020)

The transfer of input data into a set of features to classify images is called feature extraction. Feature set extracts the suitable knowledge from the input data to the output data to perform the identification task instead of using input data. Features are extracted from each available database that we create.(Vinod et al., 2014)

Elephant recognition uses the input images to the system with different user inputs to develop the process related to the monitoring mechanism. The system will hold the records and data and their locations of each individual elephant. The behavioural of each elephant will be recorded with the database that are important for the elephant habitat protection and for the human elephant conflicts.(Dabarera & Rodrigo, 2010)

Present machine learning frameworks have considerably reduced the model training process, making the development of clinical algorithms increasingly commoditized. To fully achieve the potential of these algorithms in increasing animal detection, we must move our attention to implementation and the practical challenges of actionability, safety, and value.(Seneviratne et al., 2020)

Image vision algorithm is performed after the feature extraction. They have proposed a system where an elephant is identified as an object using image processing. The system recognizes the elephants because of lightning and background conditions. Digital Signal Processing is the signal processing algorithm used to generate the signals with the seismic data. The IoT network includes a GSM module of type sim800l model which was connected to the Arduino board for internet access. (P. P. S. Fernando et al., 2020)

SVM (Support Vector Machine) techniques are useful in the bioinformatics fields to get high accuracy, sensitivity, and clarity about the tracking of animal interactions.(Fukunaga et al., 2015)SVM is a kernel method, it maps feature vectors into higher dimensional space using some kernel functions and to build the trained data.(Kouda et al., 2011)

The elephant image classification model can be used to analyse fresh photographs and identify whether they contain elephants after it has been trained and validated. To accomplish this, the image is sent into the trained model to produce a probability score or a binary classification (elephant or not).

Many of these initiatives are centred on the interface between sensors and internet-based communications technologies, which, when associated with cloud-based data storage, allow for unprecedented real-time tracking and visualisation. In addition, Smart Earth efforts usually combine well-established methodologies, such as remote sensing and long-term ecological monitoring, with modern technologies.(Bakker & Ritts, 2018)

The sensor detects animal movement, and the camera captures the image. Using image processing techniques, the obtained image is categorised via a microcontroller, and the GSM module sends an alarm notification SMS to the forest department or the landowner. (KHWOPA ENGINEERING COLLEGE ANIMAL INTRUSION DETECTION AND)

Real Time analysis is used for the to enable the prompt and precise identification of elephants and image classification system is processed for photos in real- time. It will be working in the strong computational model with the hardware.

Gaussian mixture is also used for multiple animal tracking systems that tracks accurately to there animals under severe occlusion.(Fukunaga et al., 2015)GSM module helps us to generate alarms, flashlights, and turning an in-built radio in response to a warning message from an authorized entity via SMS or SOS.(Jayasinghe et al., 2006) The system can help forest range officials, wildlife conservation groups, and residents collaborate and coordinate. Sharing the alarm signals allows for the gathering of important data and insights, which improves management of elephant habitats and protection initiatives.(Wang et al., 2016)

The Mobile Station in the GSM module is like a security module and Base Transceiver Station is the part of network and it sends data from one another. Network capability is more important for sending SMS service to the officials.(Karri & Lim, 2005)

Ranging patterns have major implications for the management of elephants and mitigation of human– elephant conflict.

IoT technology is used to create the alerts and warnings for the conflicts between humans and elephants. They are used with the sensor networks with these IoT devices that are scaling to the animals with the thermal sensors, wireless cameras, and motion detectors. Early warning systems are helpful in the preventive actions like warning to the police, taking measures to lessen the disputes between both humans and elephants.

Many of the animals were assigned names of everyone for taking photos and videos which are taken manually by researchers on the site. These images were stores in the dataset. Elephants can visible clearly when it comes to

closer for the identification. There are also the animals which are quite different from the front view rather than side view.(Korschens & Denzler, 2019)

When the primary focus is on behaviour and interaction with the immediate surroundings rather than absolute position or movement over the environment (as in wildlife tracking), body position or amount of movement is seen.(Lahoz-Monfort & Magrath, 2021)

CNNs are excellent tools for extracting information from photos, but they perform best when trained on a large volume of images, most of which contain classes that can be distinguished visually. This distinction can be attributed to the enormous quantity of samples present in these datasets, which have been gathered and annotated by a wider group of people.

After going through the CNN, an image is abstracted into characteristics or factors that are arranged hierarchically, with higher level factors or more abstract notions (e.g., an item or a landscape) learning from lower level or more basic layers (e.g., circles, square edges). Based on this notion, the CNN architecture extracts and transforms features from images using a cascade of many layers.(González-Rivero et al., 2020)

SIFT is a widely used technique for object detection and picture comparison that efficiently finds and specifies distinctive and scale invariant key points inside images, providing a significant advance over earlier techniques.(Wäldchen & Mäder, 2018)

There are different techniques for image feature selection and its extraction such as Scale Invariant feature transform (SIFT), Bag of Words (BoW) and Spatial Histograms. For classifier we use the Navies Bayes Nearest Neighbour (NBNN) algorithm.(Harish et al., 2019)

There are various types of methods in the animal detection used with the image and video processing. These applications are very much important in the real life to prevent the collision on roads, preventing dangerous animal intrusion in the residential areas and understanding the motion of the targeted animals and many more.(Sharma & D.J, 2013)

This paper defines about the development of wireless network to detect and verify the images of the animals by using the Wireless Local Area Network Technology (WLAN). (Lloret et al., 2009) We are creating a WSN with a PIR sensor and a ZigBee network. The system is made up of two components: a sensor node and a central node. PIR sensors are installed in the sensor nodes. When a sensor node senses motion, it wirelessly transmits the details of the intrusion to the central node through ZigBee. When the central node receives the information, it sends a text alert to the user's phone via the GSM module.(Sahoo & Pati, 2018)

Like Human Prediction approach for the animal detection, threshold segmentation approach for detection, Power spectrum and face detection and deep learning approaches are used in the real life to detect the animals in various circumstances.(Lloret et al., 2009)

WSN technology can be used to build virtual walls, monitor focal areas, and/or monitor behaviour. A virtual fence setup consists of several sensors positioned around the protected perimeter of a target area that can instantaneously recognise an intrusion and its location. This should be communicated to network monitoring.(Marvin et al., 2016)

Wireless Sensor Network allows data collection from different locations in the forests. These data are collected by the sensors and also have high security.(Adu-Manu et al., 2022)

Pattern identification aims to classify the data in the collection of methods for supervised or unsupervised learning that depends on prior knowledge.(Deka & Sarma, 2012) The first stage is feature extraction and the second stage is classification. Feature extraction is the measurement of population of entities that will be classified.

Additional advantages of employing IoT technology for animal identification and detection include the following:

Real-time data: IoT devices can gather data in real-time that may be utilised to hastily decide how to manage animals.(Dhillipan* et al., 2020)

Efficiency gain: IoT technology can increase the effectiveness of animal management by automating processes like tracking animal movement and keeping track of its health.

Cost savings: IoT technology can lower the cost of managing animals by removing the need for manual labour and by supplying information that can boost animal output.(Dhillipan* et al., 2020)

There are different approaches for the animal recognition is to use in the machine learning algorithms like support vector machines (SVMs). SVMs are a type of statistical learning algorithm that can be used to classify data into two or more categories.(Pons et al., 2017)

Another approach to animal recognition is to use traditional machine learning algorithms such as support vector machines (SVMs). SVMs are a type of statistical learning algorithm that can be used to classify data into two or more categories. SVMs have been demonstrated to be effective at classifying animals, however they are not as popular as CNNs.

Animal recognition depends upon the several factors that includes size and complexity of the dataset, accuracy, and the available resources. Animal recognition systems have several potential benefits. They can be used to monitor wildlife populations, track animal movements, and identify individual animals. Animal recognition systems can also be used to improve animal welfare by monitoring animal health and behaviour. In addition, animal recognition systems can be used to control pests and protect crops.

There are several challenges in that animal populations can be difficult to track, especially in remote areas. The second challenge is that we can't predict the animal behaviour that makes us difficult to identify individual animals. Thus, animal recognition systems can be expensive to develop and deploy.

Here is some additional information that to be added. The future of animal recognition systems. The future of animal recognition systems is likely to be driven by advances in deep learning. Animal recognition systems can be used to improve our understanding of animal behaviour and ecology. Animal recognition systems have the potential to revolutionize the way we interact with animals.

The main aim of the project is to develop the automatic techniques to establish the foundation for the future directions and monitoring systems for free ranging elephants. Counting the wild animals is difficult task for monitoring and it is also time consuming. Machine Learning helps us by detecting these animals in an image and it can count automatically.(Valletta et al., 2017)

We obtained a detection rate of 91.7% at a false positive rate of just 2.5% for elephants in proximity. Accordingly, most elephants are correctly spotted (only 8.3% are missed), and the incidence of false detections is rather low (only one in every 40 detections is not an elephant). It gets harder to identify objects at greater distances. (Zeppelzauer & Stoeger, 2015)

We can utilise Bayesian occupancy and abundance models in which the central tendency of the prior distributions for the false negative and false positive error rates are obtained via validation of our machine learning models.(Tabak et al., 2020)

The input photos must be segmented considerably more precisely due to the tiny area that the elephants occupy in the image plane. Small patches have fewer distinguishing visual characteristics than bigger segments, which inhibits automated detection and increases detection mistakes for far-off elephants.(Zeppelzauer & Stoeger, 2015)

Identification of animals can be done through deep learning techniques with taking videos of the animals with using R-CNN, flow-guided feature aggregation, action recognition works etc.(Schindler & Steinhage, 2021)

A study made in the region of interest shows that elephants move into human habitation due to many reasons.

(i) Fences and trenches compromised by people who need access to forests.

(ii) Farmlands may funnel them to unprotected adjacent villages.

(iii) Badly planned barriers that do not take elephant behaviour into consideration.

(iv) Denying elephant access to a critical water source or foraging area.

(v) Human activities create abundant secondary vegetation that brings elephants closer to human settlements.

(vi) Artificially maintained water sources attract elephants during drought.

(vii) Traditional migration routes severed by human intervention (e.g., canals, power installations, and cattle fences)

This research suggests an early warning system to reduce conflict between people and elephants in forest boundary regions. The device aims to reduce such conflicts in two ways:

(i) by informing people about elephants' potential intrusion into human settlement.

(ii) by giving authorities advance notice so they can take measures to drive the pachyderms back into the forest.

Conclusions:

In this paper we proposed and analysed an elephant image detection system and how this process has made significant impact to the human beings. It followed by the identification of animals, feature extractions, involvement of machine learning algorithms, classifications of animals, giving alert to the forest officials and to the nearby living areas. It plays a major role of animal identification and to eradicate the Human and animal's conflicts. The IoT technology used here plays a crucial role for giving alert to the people in the nearby forest areas.

There are various significant methods to identify the elephants and other animals but sometimes it is difficult to identify due to technical reasons. To overcome the limitations of individual detectors and hence enhance the overall detection quality, the construction of a reliable early monitoring system in the future would necessitate the combination of several complimentary modalities.

References:

A, B. T., A, J. D. H., & A, E. O. M. (2011). *Wildlife tracking technology options and cost considerations*. *2010*, 653–663.

Adu-Manu, K. S., Abdulai, J. D., Engmann, F., Akazue, M., Appati, J. K., Baiden, G. E., & Sarfo-Kantanka, G. (2022). WSN Architectures for Environmental Monitoring Applications. *Journal of Sensors*, *2022*. https://doi.org/10.1155/2022/7823481

Bakker, K., & Ritts, M. (2018). Smart Earth: A meta-review and implications for environmental governance. *Global Environmental Change*, *52*(November 2017), 201–211. https://doi.org/10.1016/j.gloenvcha.2018.07.011

Bal, P., Nath, C. D., Nanaya, K. M., Kushalappa, C. G., & Garcia, C. (2011). Elephants also like coffee: Trends and drivers of human-elephant conflicts in coffee agroforestry landscapes of Kodagu, Western Ghats, India. *Environmental Management*, *47*(5), 789–801. https://doi.org/10.1007/s00267-011-9636-1

Bjorck, J., Rappazzo, B. H., Chen, D., Bernstein, R., Wrege, P. H., & Gomes, C. P. (n.d.). *Automatic Detection and Compression for Passive Acoustic Monitoring of the African Forest Elephant*.

Bohrer, G., Beck, P. S. A., Ngene, S. M., Skidmore, A. K., & Douglas-Hamilton, I. (2014). Elephant movement closely tracks precipitation-driven vegetation dynamics in a Kenyan forest-savanna landscape. *Movement Ecology*, *2*(1), 1–12. https://doi.org/10.1186/2051-3933-2-2

Clark, P. E., Johnson, D. E., Kniep, M. A., Jermann, P., Huttash, B., Wood, A., Johnson, M., McGillivan, C., & Titus, K. (2006). An advanced, low-cost, GPS-based animal tracking system. *Rangeland Ecology and Management*, *59*(3), 334–340. https://doi.org/10.2111/05-162R.1

Curtis, A. R., & Kim, W. (2011). *Mahout : Low-Overhead Datacenter Traffic Management using End-Host-Based Elephant Detection*. 1629–1637.

Cushman, S. A., Chase, M., & Griffin, C. (2005). Elephants in space and time. *Oikos*, *109*(2), 331–341. https://doi.org/10.1111/j.0030-1299.2005.13538.x

Dabarera, R., & Rodrigo, R. (2010). Vision based elephant recognition for management and conservation. *Proceedings of the 2010 5th International Conference on Information and Automation for Sustainability, ICIAfS 2010*, 163–166. https://doi.org/10.1109/ICIAFS.2010.5715653

Dampage, U., Thajudeen, R., Jasenthuliyana, S., & Jayawardena, J. (2021). Automated virtual elephant fence based on detection, alarming, and coordinated redirection of wild elephants. *Environmental Monitoring and Assessment*, *193*(4), 1–14. https://doi.org/10.1007/s10661-021-09024-y

Deka, R. N., & Sarma, K. K. (2012). Pattern Recognition Based Anti Collision Device Optimized for Elephant-Train Confrontation. *IRNet Transactions on Electrical and Electronics Engineering (ITEEE)*, *1*(2), 92–97.

Dhillipan*, D. J., Vijayalakshmi, D. N., Suriya, S., & Shanmugam, D. B. (2020). A Secure Wild Animals Alert System for Preventing the Farming Land using IoT. *International Journal of Recent Technology and Engineering (IJRTE)*, *8*(5), 5585–5587. https://doi.org/10.35940/ijrte.e5644.018520

Douglas-Hamilton, I., Krink, T., & Vollrath, F. (2005). Movements and corridors of African elephants in relation to protected areas. *Naturwissenschaften*, *92*(4), 158–163. https://doi.org/10.1007/s00114-004-0606-9

Duporge, I., Hodgetts, T., Wang, T., & Macdonald, D. W. (2020). The spatial distribution of illegal hunting of terrestrial mammals in Sub-Saharan Africa: A systematic map. *Environmental Evidence*, *9*(1), 1–14. https://doi.org/10.1186/s13750-020-00195-8

Fernando, P. P. S., Perera, K. Y. L., Dissanayake, P. N., Jayakody, J. A. D. M., Mieee, J. L. W., & Mieee, M. W. (2020). *Gaja-Mithuru : Smart Elephant Monitoring and Tracking System*. 461–467.

Fernando, P., Wikramanayake, E. D., Janaka, H. K., Jayasinghe, L. K. A., Gunawardena, M., Kotagama, S. W., Weerakoon, D., & Pastorini, J. (2008). Ranging behavior of the Asian elephant in Sri Lanka. *Mammalian Biology*, *73*(1), 2–13. https://doi.org/10.1016/j.mambio.2007.07.007

Foley, C., Pettorelli, N., & Foley, L. (2008). Severe drought and calf survival in elephants. *Biology Letters*, *4*(5), 541–544. https://doi.org/10.1098/rsbl.2008.0370

Fukunaga, T., Kubota, S., Oda, S., & Iwasaki, W. (2015). GroupTracker: Video tracking system for multiple animals under severe occlusion. *Computational Biology and Chemistry*, *57*, 39–45. https://doi.org/10.1016/j.compbiolchem.2015.02.006

Galanti, B. V., Preatoni, D., Martinoli, A., Wauters, L. A., & Tosi, G. (2006). *Original investigation Space and habitat use of the African elephant in the Tarangire – Manyara ecosystem , Tanzania : Implications for conservation*. *71*, 99–114. https://doi.org/10.1016/j.mambio.2005.10.001

González-Rivero, M., Beijbom, O., Rodriguez-Ramirez, A., Bryant, D. E. P., Ganase, A., Gonzalez-Marrero, Y., Herrera-Reveles, A., Kennedy, E. V., Kim, C. J. S., Lopez-Marcano, S., Markey, K., Neal, B. P., Osborne, K., Reyes-Nivia, C., Sampayo, E. M., Stolberg, K., Taylor, A., Vercelloni, J., Wyatt, M., & Hoegh-Guldberg, O. (2020). Monitoring of coral reefs using artificial intelligence: A feasible and cost-effective approach. *Remote Sensing*, *12*(3), 1–22. https://doi.org/10.3390/rs12030489

Goud, B. P. R., Rao, A. P., Sravan, K. S., & Sathiyamoorthi, V. (2020). Patient monitoring system using internet

of things. *Challenges and Applications of Data Analytics in Social Perspectives*, *25*(4), 275–289. https://doi.org/10.4018/978-1-7998-2566-1.ch015

Hall, E. L., Kruger, R. P., Samuel, J., Dwyer, D., Mclaren, R. W., Hall, D. L., & Lodwick, G. (1971). A Survey of Preprocessing and Feature Extraction Techniques for Radiographic Images. *IEEE Transactions on Computers*, *C–20*(9), 1032–1044. https://doi.org/10.1109/T-C.1971.223399

Harish, S. S., Rao, S., Chethan, P., & Chandra Naik, G. (2019). Survivalence of Rouge Wild Animals Using Image Processing and IOT. *1st IEEE International Conference on Advances in Information Technology, ICAIT 2019 - Proceedings*, 540–543. https://doi.org/10.1109/ICAIT47043.2019.8987324

Hassanien, A. E., Kilany, M., Houssein, E. H., & AlQaheri, H. (2018). Intelligent human emotion recognition based on elephant herding optimization tuned support vector regression. *Biomedical Signal Processing and Control*, *45*, 182–191. https://doi.org/10.1016/j.bspc.2018.05.039

Jayasinghe, G., Fahmy, F., Gajaweera, N., & Dias, D. (2006). *A gsm alarm device*. *August*, 8–11.

Karri, V., & Lim, D. J. S. (2005). Method and Device to Communicate via SMS After a Security Intrusion. *1st International Conference on Sensing Technology*, 664–668. http://www-ist.massey.ac.nz/conferences/icst05/proceedings/ICST2005-Papers/ICST_142.pdf

Kim, S. H., Kim, D. H., & Park, H. D. (2010). Animal situation tracking service using RFID, GPS, and sensors. *2nd International Conference on Computer and Network Technology, ICCNT 2010*, 153–156. https://doi.org/10.1109/ICCNT.2010.40

Korschens, M., & Denzler, J. (2019). ELpephants: A fine-grained dataset for elephant re-identification. *Proceedings - 2019 International Conference on Computer Vision Workshop, ICCVW 2019*, 263–270. https://doi.org/10.1109/ICCVW.2019.00035

Kouda, M., Morimoto, M., & Fujii, K. (2011). A face identification method of non-native animals for intelligent trap. *Proceedings of the 12th IAPR Conference on Machine Vision Applications, MVA 2011*, *4*, 426–429.

Kumar, P., & Kumar, P. (2013). International Journal of Computer Science and Mobile Computing Arduino Based Wireless Intrusion Detection Using IR Sensor and GSM. *Ijcsmc*, *2*(5), 417–424. www.ijcsmc.com

Lahoz-Monfort, J. J., & Magrath, M. J. L. (2021). A Comprehensive Overview of Technologies for Species and Habitat Monitoring and Conservation. *BioScience*, *71*(10), 1038–1062. https://doi.org/10.1093/biosci/biab073

Lloret, J., Garcia, M., Bri, D., & Sendra, S. (2009). A wireless sensor network deployment for rural and forest fire detection and verification. *Sensors*, *9*(11), 8722–8747. https://doi.org/10.3390/s91108722

Madheswaran, K. M. S., Veerappan, K., & Kumar, V. S. (2019). Region based convolutional neural network for human-elephant conflict management system. *ICCIDS 2019 - 2nd International Conference on Computational Intelligence in Data Science, Proceedings*, 1–5. https://doi.org/10.1109/ICCIDS.2019.8862006

Mangai, N. M. S., Karthigaikumar, P., Vinod, S. T., & Chandy, D. A. (2018). FPGA implementation of elephant recognition in infrared images to reduce the computational time. *Journal of Ambient Intelligence and Humanized Computing*, *0*(0), 0. https://doi.org/10.1007/s12652-018-0984-z

Marvin, D. C., Koh, L. P., Lynam, A. J., Wich, S., Davies, A. B., Krishnamurthy, R., Stokes, E., Starkey, R., & Asner, G. P. (2016). Integrating technologies for scalable ecology and conservation. *Global Ecology and Conservation*, *7*, 262–275. https://doi.org/10.1016/j.gecco.2016.07.002

Ngene, S. M., Gils, H. Van, Wieren, S. E. Van, Rasmussen, H., Skidmore, A. K., Prins, H. H. T., Toxopeus, A. G., Omondi, P., & Douglas-hamilton, I. (2009). *The ranging patterns of elephants in Marsabit protected*

area , Kenya : the use of satellite-linked GPS collars. 386–400.

Nguyen, H., Maclagan, S. J., Nguyen, T. D., Nguyen, T., Flemons, P., Andrews, K., Ritchie, E. G., & Phung, D. (2017). Animal recognition and identification with deep convolutional neural networks for automated wildlife monitoring. *Proceedings - 2017 International Conference on Data Science and Advanced Analytics, DSAA 2017*, *2018-Janua*(Figure 1), 40–49. https://doi.org/10.1109/DSAA.2017.31

Nougnanke, K. B. (2021). *Towards ML-based Management of Software-Defined Networks*.

Okaukuejo, P. O., & Outjo, V. (1991). *Satellite tracking of elephants in northwestern Namibia*. *29*(Blumenbach 1797), 196–206.

Paradkar, A., & Sharma, D. (2015). All in one Intelligent Safety System for Women Security. *International Journal of Computer Applications*, *130*(11), 33–40. https://doi.org/10.5120/ijca2015907144

Pérez-Escudero, A., Vicente-Page, J., Hinz, R. C., Arganda, S., & De Polavieja, G. G. (2014). IdTracker: Tracking individuals in a group by automatic identification of unmarked animals. *Nature Methods*, *11*(7), 743–748. https://doi.org/10.1038/nmeth.2994

Pineño, O. (2014). ArduiPod Box: A low-cost and open-source Skinner box using an iPod Touch and an Arduino microcontroller. *Behavior Research Methods*, *46*(1), 196–205. https://doi.org/10.3758/s13428-013-0367-5

Pons, P., Jaen, J., & Catala, A. (2015). Developing a depth-based tracking system for interactive playful environments with animals. *ACM International Conference Proceeding Series*, *16-19-Nove*. https://doi.org/10.1145/2832932.2837007

Pons, P., Jaen, J., & Catala, A. (2017). Assessing machine learning classifiers for the detection of animals' behavior using depth-based tracking. *Expert Systems with Applications*, *86*, 235–246. https://doi.org/10.1016/j.eswa.2017.05.063

POVEDA, JIME´ NEZ, K. (2013). C ommunications C ommunications. *Ecological Applications*, *23*(3), 515–522.

Premarathna, K. S. P., Rathnayaka, R. M. K. T., & Charles, J. (2020). An Elephant Detection System to Prevent Human-Elephant Conflict and Tracking of Elephant Using Deep Learning. *Proceedings of ICITR 2020 - 5th International Conference on Information Technology Research: Towards the New Digital Enlightenment*. https://doi.org/10.1109/ICITR51448.2020.9310798

Ravoor, P. C., & Sudarshan, T. S. B. (2020). Deep Learning Methods for Multi-Species Animal Re-identification and Tracking – a Survey. *Computer Science Review*, *38*, 100289. https://doi.org/10.1016/j.cosrev.2020.100289

Sahoo, K. C., & Pati, U. C. (2018). IoT based intrusion detection system using PIR sensor. RTEICT 2017 - 2nd IEEE International Conference on Recent Trends in Electronics, Information and Communica. *RTEICT 2017 - 2nd IEEE International Conference on Recent Trends in Electronics, Information and Communication Technology, Proceedings*, *2018-Janua*, 1641–1645.

Schindler, F., & Steinhage, V. (2021). Identification of animals and recognition of their actions in wildlife videos using deep learning techniques. *Ecological Informatics*, *61*(December 2020), 101215. https://doi.org/10.1016/j.ecoinf.2021.101215

Seneviratne, M. G., Shah, N. H., & Chu, L. (2020). Bridging the implementation gap of machine learning in healthcare. *BMJ Innovations*, *6*(2), 45–47. https://doi.org/10.1136/bmjinnov-2019-000359

Sharma, S., & D.J, S. (2013). A Brief Overview on Different Animal Detection Methods. *Signal & Image Processing : An International Journal*, *4*(3), 77–81. https://doi.org/10.5121/sipij.2013.4307

Sheebha, J., & Kumar, A. (2015). *Jurnal Teknologi Full paper Elephant Tracking with Seismic Sensors : A Technical Perceptive Review*. *1*(1970), 193–203.

Silva, E. M. K. De, Kumarasinghe, P., & Indrajith, K. K. D. A. K. (2022). Feasibility of using convolutional neural networks for individual - identification of wild Asian elephants. *Mammalian Biology*, *102*(3), 931–941. https://doi.org/10.1007/s42991-021-00206-2

Strumberger, I., Beko, M., Tuba, M., Minovic, M., & Bacanin, N. (2018). Elephant herding optimization algorithm for wireless sensor network localization problem. In *IFIP Advances in Information and Communication Technology* (Vol. 521). Springer International Publishing. https://doi.org/10.1007/978-3-319-78574-5_17

Sugumar, S. J., & Jayaparvathy, R. (2014). An improved real time image detection system for elephant intrusion along the forest border areas. *The Scientific World Journal*, *2014*. https://doi.org/10.1155/2014/393958

Suju, D. A., & Jose, H. (2017). FLANN: Fast approximate nearest neighbour search algorithm for elucidating human-wildlife conflicts in forest areas. *2017 4th International Conference on Signal Processing, Communication and Networking, ICSCN 2017*, *2*, 2–7. https://doi.org/10.1109/ICSCN.2017.8085676

Tabak, M. A., Norouzzadeh, M. S., Wolfson, D. W., Newton, E. J., Boughton, R. K., Ivan, J. S., Odell, E. A., Newkirk, E. S., Conrey, R. Y., Stenglein, J., Iannarilli, F., Erb, J., Brook, R. K., Davis, A. J., Lewis, J., Walsh, D. P., Beasley, J. C., VerCauteren, K. C., Clune, J., & Miller, R. S. (2020). Improving the accessibility and transferability of machine learning algorithms for identification of animals in camera trap images: MLWIC2. *Ecology and Evolution*, *10*(19), 10374–10383. https://doi.org/10.1002/ece3.6692

TCHAMBA, M. N., BAUER, H., & IONGH, H. H. D. (1995). Application of VHF-radio and satellite telemetry techniques on elephants in northern Cameroon. *African Journal of Ecology*, *33*(4), 335–346. https://doi.org/10.1111/j.1365-2028.1995.tb01043.x

THOULESS, C. R. (1995). Long distance movements of elephants in northern Kenya. *African Journal of Ecology*, *33*(4), 321–334. https://doi.org/10.1111/j.1365-2028.1995.tb01042.x

Tshipa, A., Valls-fox, H., Fritz, H., Collins, K., Sebele, L., Mundy, P., & Chamaillé-jammes, S. (2017). Partial migration links local surface-water management to large-scale elephant conservation in the world ' s largest transfrontier conservation area. *Biological Conservation*, *215*(September), 46–50. https://doi.org/10.1016/j.biocon.2017.09.003

Valletta, J. J., Torney, C., Kings, M., Thornton, A., & Madden, J. (2017). Applications of machine learning in animal behaviour studies. *Animal Behaviour*, *124*, 203–220. https://doi.org/10.1016/j.anbehav.2016.12.005

Vancuylenberg, B. W. B. (1977). Feeding behaviour of the asiatic elephant in South-East Sri Lanka in relation to conservation. *Biological Conservation*, *12*(1), 33–54. https://doi.org/10.1016/0006-3207(77)90056-8

Vidumina, N. (2023). *Train Accident Prevention & Breakdown Detection using Machine Learning based Safty System*. *March*.

Vinod, S. T., Mangai, N. M. S., & Chandy, D. A. (2014). Clustering based image segmentation for elephant detection. *2014 International Conference on Electronics and Communication Systems, ICECS 2014*. https://doi.org/10.1109/ECS.2014.6892635

Wäldchen, J., & Mäder, P. (2018). Machine learning for image based species identification. *Methods in Ecology and Evolution*, *9*(11), 2216–2225. https://doi.org/10.1111/2041-210X.13075

Wang, Z., Wang, H., Liu, L., Song, W., & Lu, J. (2016). Community alarm system design based on MCU and GSM. *Proceedings of 2015 4th International Conference on Computer Science and Network Technology, ICCSNT 2015*, *Iccsnt*, 859–862. https://doi.org/10.1109/ICCSNT.2015.7490876

Wilson, G. (2020). *Identifying the variation in utilization density estimators and home ranges of elephant clans in Aceh , Sumatra , Indonesia*.

Wittemyer, G., Getz, W. M., Vollrath, F., & Douglas-Hamilton, I. (2007). Social dominance, seasonal movements, and spatial segregation in African elephants: A contribution to conservation behavior. *Behavioral Ecology and Sociobiology*, *61*(12), 1919–1931. https://doi.org/10.1007/s00265-007-0432-0

Yadahalli, S., Parmar, A., & Deshpande, A. (2020). Smart Intrusion Detection System for Crop Protection by using Arduino. *Proceedings of the 2nd International Conference on Inventive Research in Computing Applications, ICIRCA 2020*, 405–408. https://doi.org/10.1109/ICIRCA48905.2020.9182868

Zeppelzauer, M., & Stoeger, A. S. (2015). Establishing the fundamentals for an elephant early warning and monitoring system. *BMC Research Notes*, *8*(1). https://doi.org/10.1186/s13104-015-1370-y