Smart aerial monitoring system to prevent human wildlife intervention

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Abstract—In India, agriculture is one of the crucial factors for inspecting India’s economy. Proper supervision of this sector leads to an exceptional yield. India, being a densely populated country, has encountered frequent and often fatal conflicts due to the share of land and other natural resources among humans and the elephants, in specific. Recent statistics have exhibited that approximately 28000 elephants are distributed over 3% over India’s geographical area. Human encroachment continues to grow around elephant habitats which results in colossal damage to the crop yield and human life. Technologies like AI and ML are prominent in unraveling the distinct challenges of the modern society. This paper focuses on the design and implementation of a IoT and ML enabled smart drone to intervene the association between humans and elephants to protect both human life as well as the crop yield.

Keywords— Internet of Things (IoT), Machine Learning (ML), Unmanned Aerial Vehicle (UAV), Image Processing, TensorFlow

1. INTRODUCTION

Over the past few years, Unmanned Aerial Vehicles (UAVs) became the epicenter in implementing the functions of various businesses and government organizations and have deeply penetrated through sectors which were stagnant or lagging behind in solving the problems of the society. Unmanned aircraft systems, proved efficient for military applications (greater than 80%), in recent years are being integrated with smart technologies for environment protection and forested areas, agricultural sector, etc. areas. They are interfaced with smart technologies like Image Processing, IoT, Data Analytics, Computer Vision to tackle nearly everything from disease control to vacuuming up ocean waste and crop management. Use of drones in multiple domains increased exponentially as more and more industries and businesses started realizing scope and potential it has in becoming the driving technology of the future globally. Agriculture is an essential domain where it provides basic employment opportunities and self-sustainability and hence it is the backbone of Indian economy. Technology has a crucial role to play to satisfy the demands of the farmers for a good harvest. Drone advocates have cited precision agriculture by employing GPS and Big Data to gather statistics, automate redundant processes to increase the crop yield while resolving water and food crisis in various geographical locations. [1] UAV’s armed with GPS and high precision digital and thermal cameras have therefore become a prime point of research all around the globe. The GPS, inertial measuring techniques, and other sensors helped in the autonomous navigation of UAV’s. [2] Today’s situations demand surveillance to maintain the integrity at a particular habitat and ensure the safety and freedom of its people. An aerial monitoring system is most reliable technology in agricultural sector in terms of surveillance and assistance.
Statistics explicate that crop-raiding has been the most widespread form of human-elephant conflict and results in devastating economic losses for farmers, loss of human lives and the killing or capture of elephants. With an estimate between 24000 and 32000, 60% of Asia’s elephants live in India. In 2001, 150 people were killed in elephant attacks in India. This was down from a peak of around 300 people a year in the early 1990s. Between the period 1999 to 2004, at least 150 people and 200 elephants have been killed in the state of Assam with rice beer being the sole attraction and the reason for the devastation. According to WWF (World Wildlife Fund), 900 people get killed annually due to elephant conflicts, and over 100 elephants end up getting electrocuted. Crops over 330 sq. km is destroyed every year amounting to billions of dollars. The population of elephants in India has decreased approximately by 10% over the last 5 years. Indian environment ministry stated that between April 2014 and May 2017, 1,144 people were killed in elephant conflicts. Illegal poaching, habitat destruction for farming lands, and change in global climatic conditions stand as the major factors contributing to this issue. Human Elephant Conflict (HEC) has become a challenging task for wildlife conservationists all over the world especially in the Asia and Africa. [3] Most attacks are a consequence of the clearance of the forests for human settlements. Agriculture is disrupting traditional elephant migration routes leading to violent raids of crops. Small and light weight drones have large advantages over satellites and other aerial photography techniques, with the spatial analysis of regions without the interference of clouds. Drones’ flight at lower altitudes leads to higher spatial resolution of images than that of the satellites. [4] Smart Technologies like IoT (Internet of Things) and Image Processing are independently acclaimed for their applications in smart security, pattern recognition etc. but their combination so far is non-existent. [5] This paper concentrates on a real-time smart drone system to construct a barrier between the farmer’s and the elephants to protect his assets for a profitable harvest. An Aerial Monitoring Drone equipped with Machine Learning, Image Processing and IoT (Internet of Things) is employed to design a monitoring system to alert the farmers and to execute the counter action to prevent the elephants’ conflicts.

This paper is divided into eight sections. Section 1 explicates the statistics of human-elephant conflicts and their reasons across various countries. Section 2 elucidates the design specifications of the UAV or the drone. Section 3 expounds the literature survey and Section 4 illustrates a brief idea of the proposed system methodology to intervene the conflicts. Section 5 illuminates the construction of the custom classifier model for refining and analyzing the captured images through Image Processing and Machine Learning algorithms. Section 6 describes a IoT-Enabled alert system to generate real-time user alerts and Section-7 exemplifies a concise description of the counter-action implementation to confront the scenarios of conflicts arising all over the world. Section-8 delineates the conclusion and the future scope of the system discussed in this paper followed by the references section.

2. UAV SYSTEM DESIGN AND SPECIFICATIONS

The proposed smart sprayer system has been illustrated in Figure 1. It is controlled by the Pixhawk Flight Controller which has a 32-bit ARM Cortex M4 core with FPU. The quadcopter embodies four BLDC (Brushless DC) motors, four ESCs (Electronic Speed Controllers) and four propellers correspondingly. [6] When the UAV is armed, the flight controller operates in correspondence to the transmitter and the receiver. Receiver receives the signal from the transmitter and the corresponding signal is sent to the raspberry Pi for controlling the servo motor. This servo action is used to expel the chili powder from the container.
The forces: thrust and lift and the rotary motions: roll, pitch and yaw are accountable for the stable flight of a quadcopter. The thrust force can be altered by varying the speeds of the four motors by means of the remote controller.

Technical details of the distinct modules of the drone have been described in Table 1. The weight of the completely built structure is approximately equal to 1000 gms. The calculations and the weight approximations of the payload of the drone system are exemplified in Table 2.

The most crucial detail to be considered while designing the UAV is that the thrust to weight ratio must be greater than or equal to 2:1. [7] The total average weight approximated from Table 2. equal to 1000 gms.

The total thrust to hover the quadcopter is calculated below.

By multiplying the average weight with 2, the thrust required is 1000*2=2000 gms.

The result is bumped by a factor of 20% to prevent the complexity of hovering through extreme climatic conditions.

2000*(20/100) = 400 gms.

Hence, the total thrust required is 2000+400=2400 gms.

On the whole, 2500 gms of thrust is required for hovering the drone or the UAV. Since there are 4 motors employed in the drone, the average thrust on each motor becomes 2500/4= 625 gms.

Table 3. illustrates the variation of the thrust with the variation in the propeller size. The thrust produced by 1045 propellers will be approximately equal to 800*4 = 3200 gms which is much greater than 2500 gms. Therefore, 1045 propellers are equipped to the drone to produce sufficient thrust and lift to implement the necessary action.

Pixhawk 2.4.8 with its in-built accelerometer, gyroscope and barometer stabilizes the flight consequently. FS-iA6B, 6 channel, 2.4 GHz transmitter and receiver are deployed to hover the quadcopter. The radio controller is used to govern the transmission and reception of commands to the drone. It is calibrated through Mission Planner software on a PC. Electronic Speed Controllers (ESCs) of 30 A each are maneuvered to control and regulate the PWM signals monitor the motor speeds based on the instructions of Pixhawk. The sprayer payload is basically a compact canister of 200 gm to spray the chili powder on the elephant. The servo motor receives the control from the flight controller and subsequently expels the powder from the canister.
Table 1. Technical Delineation of components of the UAV

| Component Name                  | Specifications                      |
|---------------------------------|-------------------------------------|
| Brushless DC motor              | 1000 kV                             |
| Pixhawk flight controller       | 2.4.8 version                       |
| Transmitter and receiver        | 2.4 GHz (10 channel)                |
| Frame (Glass fibre and polyamide nylon) | Length: Width: 450mm: 450mm Height:25mm |
| Electronic Speed Controllers(ESC) | 30 A                                |
| Propellers                      | 1045R,1045 Diameter: 10 inch Pitch: 4.5 inch |
| 3s Li-Po Battery               | 11.1 (nominal) 12.6V(max) 2200 mAh 30C |
| Flight Time                     | 10 min (avg)                        |

Table 2. Weight estimation of the payload of the UAV

| Component         | Weight In Gms | Quantity | Final Weight In Gms |
|-------------------|---------------|----------|---------------------|
| Flight Controller | 40            | 1        | 40                  |
| Propellers        | 7.5           | 4        | 30                  |
| Receiver          | 7             | 1        | 7                   |
| Motors            | 30            | 4        | 120                 |
| Esc               | 12            | 4        | 48                  |
| Battery           | 190           | 1        | 190                 |
| Frame             | 250           | 1        | 250                 |
| GPS Module        | 33            | 1        | 33                  |
| Raspberry Pi      | 42            | 1        | 42                  |
| Sprayer(Loaded)   | 200           | 1        | 200                 |
| Miscellaneous     | 40            |          | 40                  |
| Total             |               |          | 1000 (Approx)       |

Table 3. The effect of propeller size on thrust.

| Propeller Size            | Thrust Produced (Approx.) |
|---------------------------|---------------------------|
| 10-Inch 4.5 Pitch (1045)  | 800gms                    |
| 9-Inch 4.5 Pitch (0945)   | 475gms                    |
| 8-Inch 4.5 Pitch (0845)   | 475gms                    |

It is utmost significant to design the UAV to determine the accurate hardware components for the construction of the UAV depending on the application and its executable functions to fulfill the purpose with high efficiency.

3. LITERATURE SURVEY

Authors in [8] have discussed the numerous techniques for wildlife monitoring and the framework for automatic detection and recognition of individuals in different patterned species like tigers, zebras and jaguars. This paper provides the fundamental method of implementing the system of image detection in a real-time environment using various image processing and machine learning techniques. [9] delineates the attributes of the aerial surveillance system and advancements that were used in constructing it which
include the Firmware ArduCopter 3.2, the 915 MHz Telemetry Radio Transmitter, the Raspberry Pi B+ Microcontroller with Wireless Adapter, the LiPo battery, distinct softwares some of which are Mission Planner and APM Planner. This paper expounds a method of quick and reliable supervision at a challenging cost making it convenient to use it widely at private, institutional and organizational level. [10] expounds the optimization of load on the UAV, adopting and implementing IoT into the drone system and an efficient drone design for handling a real-time crisis. The authors in [11] have proposed a crisis management system for real-time emergency notification of recipients using mobile phones and smart wearables. They have described a mechanism for easy and efficient notification to the users within the range of danger in the occurrence of a disaster through SMS or push notifications to the mobile phone or the smart device. [12] portrays a Region Proposal Network (RPN) that shares full-image convolutional features with the detection network, thus enabling nearly cost-free region proposals. Convolution Neural Networks (CNNs) are one of the most crucial aspects for the application of object detection and classification. The authors in [13] and [14] have propounded a comparative study of the performance of distinct CNNs in detecting and classifying a real-time object. Superiority of the performance of Faster-RCNN over YOLO, in terms of precision, has been explained. [15] sets forth a strategy of setting up a visual based surveillance method in the real time conditions enables a significant use to provide the disaster priory and therefore reduce the human elephant conflict. The attributes such as hue, saturation, color contours and texture are exploited for the detection of elephant in this method. The authors in [16] have discussed a Bolt cloud enabled Internet of Things (IoT) system to visualize and control the basic pollutants like oxides of Carbon, Sulphur and Nitrogen, and Particulate matter, in closed environment of university layouts in real time. Bolt based IoT system provides pollution level information directly to smart device in real time. The proposed system in this paper expounds an efficient mechanism of interfacing the sensor, MQ135, over the Bolt IoT module which has an in-built Wi-Fi module (ESP8266) that is setup using Bolt application that shows the list of all the connected devices and then using a password authentication and Wi-Fi name to transmit the alerts to the user whenever the sensor senses an increase in threshold of the quantity being measured by the sensor, [17] puts forward a productive and a highly optimized notification and security user alerting system. It describes the collaboration of numerous devices in accomplishing a stable and interconnected system. Employing a dynamic and a precise IoT based system is utmost essential in generating user alerts and interfacing various hardware modules such as sensors. [18] describes the distinct factors and parameters that need to be taken into account to model a highly optimized and efficient network of interconnected devices. [19] provides a brief review of the various machine learning algorithms frequently in use. The author highlighted the merits and the demerits of the algorithms from their application perspective. The algorithms were evaluated in terms of their performance, learning rate etc.

4. PROPOSED SYSTEM METHODOLOGY

Drones are capable of reaching to the most remote areas with highest accuracy with no manpower and with minimal amount of effort, time and energy. This is one of the massive reasons for their prominence in evident sectors like military, agriculture, technology and commercial.

The implementation details for the proposed system for the application of intervention between the humans and the elephants predominantly consists of 3 modules:

i. Custom Classifier for Elephant-Detection

ii. User Alert System

iii. Counter-Action Implementation

Figure 2. expounds the brief principle of implementation of the proposed system by interfacing smart technologies to the Unmanned Aerial Vehicle (UAV). This method uses the basic idea of interfacing IoT and image processing concepts in machine learning to construct a framework for intervening the real-time conflicts of humans and elephants.
The same principle elucidated in Figure 2. can be extended to avoid conflicts between any other animal.

**Figure 2** Block Diagram of the Proposed System

A sensor facilitates the requirement to capture the motion of any object in its vicinity. One such sensor is an ultrasonic sensor which estimates the motion of an object with the application of ultrasonic signals can be employed in the fields of the farmers which is the region of interest but with a lower range. Although the LIDAR sensor is quite expensive, it has a higher range and can be used for higher and complex applications.

The sensors are positioned all around the field to capture and monitor the movements of the wild elephants. Upon detection, the drone flight is initiated. The proposed system focuses on the manual flight of the drone. A Raspberry Pi is mounted on the drone for satisfying the requirement of image processing. The Raspberry Pi Camera Board, which is available in 2 Mega pixels and 8 Mega Pixel variants is mounted to the CSI port of the raspberry Pi. Here 8MP camera is suggested as it provides high resolution images and video streams provide accurate results in processing. This camera board captures the image of the wild elephant. Image Processing and ML algorithms, discussed in the further sections, are embedded in the Raspberry Pi as a software and execute a continuous and rigorous comparison to generate an alert to the user on successful detection of an elephant. The Bolt-IoT module, with in-built Wi-Fi/GSM chip and a cloud platform, is brought into action for transmitting the alert to the famer over a server. A servo motor is interfaced with the Raspberry Pi to accomplish the servo action for expelling the chili powder on the elephant from the container. The chili powder, a natural remedy, acts as a natural repellant for eluding the conflicts between humans and wild elephants.

5. CUSTOM CLASSIFIER MODEL

A large percentage of the human brain dedicates itself to visual process. Images grab and process the attention of a person at an alarming speed. One of Machine Learning’s most successful paradigm is supervised learning which lets us build a generalization model by the continuous processing and rigorous training of images of the desired object.

The main agenda of digital image processing is to extract and predict certain important information and augment its visual quality making it more understandable by human analysts or for autonomous machine perception. For constructing a remote sensing application, vital algorithms and procedures must be developed to process the data to generate the estimated output. Images acquired from the sensors at different times are emphasized to facilitate the extraction of significant information. Further, the images are preprocessed, segmented and then classified to produce an inference graph. [20]

Distinct computer algorithms and object-detection techniques are utilized to accomplish and extract the results from the digital images. Object detection technology has seen a rapid adoption rate in various and diverse industries. A single deep neural network can be designed to automatically solve all the problems reducing the human intervention. One of the major problems is the large amount of time spent in the training of the images to achieve precise results. Ultramodern object detection classifiers
mostly rely on region proposal algorithms for conjecture of object locations. Methodologies like Fast R-CNN reduced the run time of these detection classifiers, depicting the region proposal computation as a bottleneck.

The custom classifier model proposed makes use of several machine learning algorithms to achieve the required results. Generating and designing the custom classifier model comprises of the crucial steps of image labelling, setting up the platform, generating the training data by selecting a specific pre-trained model and extracting the inference graph to detect the elephant.

Image labelling is the fundamental step to gain insights into the distinct entities in an image. It is critical to determine the type of annotation tool prior to labelling the images for precise results and high efficiency of the model. LabelImg is the annotation tool used in the proposed system to label the numerous images in the elephant dataset. Qt is the graphical interface employed and annotations are saved as XML files in VOC format. Each and every image is assigned a unique keyword, metadata, for the application of training the images. This metadata is fed to various Machine Learning algorithms. The obtained dataset is divided into training and testing data. The quality of the training determines the quality of the final model. Fig. 3. represents the sample labelling of an elephant image among the cluster of images collected for the dataset.

![Sample Labelling of an image of an elephant](image_url)

**Figure 3** Sample Labelling of an image of an elephant

*TensorFlowGPU* and *TensorFlowCPU* along with tensorboard are preinstalled to setup an environment possible for the application of image processing. *CUDA* and *CuDNN* need to be installed to support *TensorFlowGPU* which is more efficient than the CPU version in terms of the processing and the analysis time. Several additional packages of Python need to be encapsulated to support the modules of the Machine Learning algorithms.

Region proposal methods and region-based convolution networks are the recent advances in object detection. *Region-CNN (R-CNN)* is one of the ultramodern CNN-based deep learning approaches. In Region Proposal Networks, layer judges the anchors that belong to background of foreground by soft max, then it uses method of bounding box regression to modify anchors for obtaining accurate proposals. [21] Region proposals are comprehensively being implemented in several applications of image processing such as computer vision, robotics, pattern recognition and segmentation. These region proposals are superior to the earlier state-of-the-art algorithms in terms of the processing speed, accuracy and computational complexity. The combined algorithm of CNN depends on two critical phases: (1) the use of the region proposal algorithm in generating the most efficient set of region proposals, and (2) process the raw image data into the convolutional neural network. [22]

The object-detection-system of the proposed system in this paper brings Fast-RCNN into play for high accuracy and efficiency of detecting an elephant. It structures on two modules. The first module is a convolutional neural network that proposes regions. The second module is the detector that makes use of the proposed regions. The entire network of F-RCNN applies these two modules. Fast R-CNN network is mainly used to classify the objects and refine the boundaries of these particular regions. Both the modules of Faster RCNN devote the parameters of the convolution layer obtained through the process of feature extraction, making the detection tasks process at a relatively greater speed. Proposal feature maps are utilized by the classifier layer to calculate the required category, and applies bounding box regression again to obtain the exact location of the detection box. Various boxes are scrutinized by a classifier and the existence of objects is detected by the regressor. The CNN recognizes the object class
and the bounding box. After the images iterate through the convoluted areas, the feature map for the image is developed. The location of each unique image is passed through a sliding window where all the features are extracted by the network for detection. The main function of the RPN network is to check the existence of an object. The bounding box will direct this object to the detector for further detection. [23] Fast Region-based CNNs make use of GPUs, whereas the region proposal methods used in the research are processed on the CPU, indicating that the CPU takes longer time for running the training. The inference time is directly proportional to the resolution of the feature map. Thus, the inference time for generating object proposals increase with the number of feature map locations. [24] An obvious way to accelerate proposal computation is to reimplement it for the GPU. The training of data utmost essential in determining the quality and the accuracy of the ultimate custom classifier model. Usually, Faster R-CNN is highly accurate whereas the SSD and F-RCN are quite faster. Faster R-CNN using Inception Resnet feature extractor with 300 proposals gives the highest accuracy at a speed of 1 FPS. PYTHONPATH is utilized to configure the environment variables. Protocol Buffers (Protobufs), methods of serializing structured data, are compiled so that TensorFlow can configure the model and the training parameters. The initial subset of data to rigorously train a model through various technologies to produce sophisticated results is the training set. The set of observations necessary for evaluating the performance and generalizing the classifier model based on a performance metric is the testing data. TFRECORD is employed to generate the testing data, the testing labels, the training data and the training labels. Configure a label map and edit with the training configuration file and finally pipeline the training model. The label map is created and the model is pipelined to improve the accuracy of the model and achieve a successful algorithm. The training data is continuously executed to minimize the error on each iteration for a productive and highly accurate model. The characteristics of the entire training process can be viewed on Tensorboard as explicated in Figure 4. and final inference graph is generated and exported to the main application.

Figure 4 Depiction of the whole training process on Tensorboard
Figure 5 Sets of Images elucidating the detection of an elephant using the custom classifier model in a video stream

Figure 6 Detection of a herd of elephants in a particular region of interest using the custom classifier model

The generated final inference graph is embedded into a Raspberry Pi equipped with a Camera Module V2 for capturing and processing the image for elephant detection through the custom classifier model. Fig. 5. depicts the output images as a result of the object detection of an elephant by the custom classifier model in a video stream comprising of numerous frames. Fig. 6. illustrates the detection of a herd of elephants which is of utmost importance for a real-time application custom classifier object- detection model.

6. USER ALERT SYSTEM

Technology is evolving rapidly every day in today’s era with all the smart physical devices connecting to each other on a network for exchanging info and increasing the productivity. Internet of Things (IoT), a system of interrelated computing devices and physical machines, are provided with unique identifiers and the ability to transfer data over a network of machine to machine communication (M2M). Devices, connectivity and platforms are the inherent qualities of the scheme. To build any IoT application the most critical issue is to select the right combination of sensors and also in choosing networks and communication modules. [25] IoT has distinct applications in the fields ranging from smart grids, wearables to industrial internet. IoT is commonly termed as a network of networks. Due to this, it can accomplish significant number of tasks with utmost efficiency and accuracy. Internet of things (IoT) has gained a lot of importance as the infrastructure required for heavy use of internet is almost available easily and transmission of data over internet has become more efficient by setting up record speeds of
transmission. The next upcoming years are expected to see an exponential growth in this smart technology for securing and interconnecting the devices with cloud. IoT environments encompass three most crucial requirements: Confidentiality, Integrity and Availability. This makes sure that the IoT analytics systems do not inundate with spurious traffic, or that the communication channels or the Network Element are not intentionally jammed. [26]

Bolt, a cloud-based platform, with an in-built Wi-Fi/GSM chip and prominent for an integrated cloud-based operating platform supports a secured connection of devices and sensors to the Internet. With the application of Bolt-Cloud, monitoring and visualizing data, and tracking machine learning algorithms turns out to be more efficient and accurate. It provides the proficiency to control the connected devices and collect the data safely and securely.

Figure 7 depicts the pin schematic diagram of the Bolt Wi-Fi module with ESP8266-12E and Table 4. expound the technical specifications of the distinct parameters in the module.

![Figure 7 Bolt ESP8266-Based IoT Platform Module](image)

### Table 4. Technical Specifications of the Module

| Parameters                              | Details                                                                 |
|-----------------------------------------|-------------------------------------------------------------------------|
| Connectivity and Processor Module       | ESP8266 with custom firmware                                            |
| MCU                                     | 32-bit RISC CPU, Tem micro XM3105                                        |
| Power                                   | 3.3 V via Micro-USB port or 5 V and GND pins                            |
| Operating Voltage                      | 5 V, 1 A DC                                                               |
| CPU, Clock Frequency                    | 80 MHz                                                                  |
| CPU Internal Memory                     | 96 K of instruction RAM, 96 K of data RAM                               |
| MCU External Memory                     | 4 MB Flash memory [QSPI]                                                |
| GPIO pins                               | 5 Digital pins [3.3V logic]                                              |
| ADC                                      | 1 pin 10-bit ADC [0-5V input]                                           |
| PWM                                      | All 8 Digital pins capable of PWM [Software PWM]                        |
| Connectivity                            | 802.11 b/g/n Automatic AP mode if not connected to WPA2 authentication  |
| UART                                    | 5-V-1.35V TTL UART [using TX, RX, GND pins][9600 baudrate]               |
| Cloud                                   | Default: Bolt-Cloud                                                      |
| Boot Time                               | Less Than 1 second                                                       |

Bolt-IoT plays a key role in generating user alerts for implementing counter action for intervening the human-wildlife conflicts. Nevertheless, it can be used for interfacing the position sensors for determining the position of the elephant in the considered region of interest. The proposed system brings this phenomenon of Bolt-IoT into action to generate the user alerts by integrating the Bolt-IoT module with distinct delivery channels like SMS, E-Mail, Telegram. Alerts are typically delivered through a notification system and the most common application of the service is machine-to-person communication. The ability of the alert notification systems to be integrable makes them functional with
third party applications like other educational mobile applications, alarm instruments, IT systems, cloud services, access control systems, weather forecasting systems, and other domestic sensors, manufacturing systems, mining hazardous materials detection systems, and motion and thermal cameras. Each cloud communication platform has a unique API key (Application Programming Interface) and a device id to interface the Bolt device.

The user alert is generated on the successful detection of an elephant by the custom classifier object detection model. This generated user alert enables the user to initiate the flight of the drone and execute the necessary counter action for tackling the problem. Bolt-Cloud, being one of the most significant advantages of the Bolt-IoT module, enables storage of immense amounts of data and transmitting real-time user alerts accordingly.

Fig. 8 expounds the block diagram of the proposed user alert system in this paper. In this paper, a SMS alert system is discussed which focuses on the transmission of real-time SMSs by interfacing a cloud communications platform with Bolt-IoT module for transmitting the user alerts to the user. Twilio, a cloud communications platform as a service, allows users to efficiently interface the bolt device to programmatically make and receive calls, text messages and perform other communication functions using web service APIs. The Bolt device is authorized with the Twilio Account SID, the AUTH Token, the API Key and the Bolt Device Id.

Further, we need to interface the Bolt IoT Device and Twilio for sending SMS Alerts on the To_Number configured in the Twilio dashboard by implementing code in the UBUNTU environment in VMware Workstation 12 Player.

Figure 8 Block Diagram of the Proposed User Alert System

Figure 9 Twilio Dashboard for configuring SMS Alert System

Fig. 9 exemplifies the dashboard of Twilio for configuring the SMS alert system by interfacing the Bolt-IoT device with the implementaion of the code taking into consideration the ACCOUNT SID, the FROM_NUMBER, the TO_NUMBER, the API Keys and the threshold to decide the condition for generating the SMS alerts to the user.
The proposed SMS alert system in this paper can be extended for various other prominent delivery channels such as that of E-MAIL, Telegram which generate the alerts in the same technique based on a threshold.

7. COUNTER-ACTION IMPLEMENTATION

Successful detection of the elephants by the custom classifier model for object detection and an efficient SMS alert system was implemented in the previous sections of this paper. The implementation of the image processing, machine learning algorithms and the user alert system finally leads to the implementation of the counter-action to resolve and intervene the conflicts between the elephants and the humans.

Extensive research and intensive study on animal behaviors explicate that elephants are extremely sensitive to sound, smell and touch. The elephants being sensitive to sound, are terrified of the sound made by the bees. Hence, a ‘Honey Bee Buzzer” is practically being implemented by the Alipurduar division of the North East Frontier Railway (NFR) to avoid elephant deaths and to keep elephants off the railway tracks. This device generates the sound of buzzing bees at two rail gates in the division. This paper proposes an innovative idea based on elephants’ characteristic of being sensitive to smell. Chili powder, known for its pungent smell, is filled in a tank that is armed with a motor that operates the opening and closing of the nozzle of the tank when an appropriate signal is given to it. A servo motor which uses positive feedback system to control motion and the final position of the shaft is deployed for the mechanical servo action of expelling the powder from the canister. Fig. 10. illustrates the SG-90 servo motor for actuating the nozzle of the canister. The servo, being an automatic device that uses error-sensing negative feedback to correct the action of a mechanism and having the ability to generate highly precise angles, is used for the counter implementation as proposed in this paper. The chili powder is inserted into a canister prototype which is equipped with the servo for expelling the chili powder when it receives the appropriate signal from the Raspberry Pi. This setup is mounted to the drone and the servo motor is connected to the Raspberry Pi. When the drone identifies and confirms the presence of an elephant, based on the SMS alert generated after the successful results from the custom classifier elephant detection model, the chili powder is expelled from the canister through the servo action. The elephants are terrified of the smell of the chili powder and retreat in the same path. This is how the conflicts between humans and elephants can be avoided in distinct parts of the world.

8. CONCLUSION AND FUTURE SCOPE

Studies have unveiled that the expansion of human settlements and agricultural fields across Asia and Africa has resulted in widespread loss of animals’ habitat and the extinction of their species relative to their historical size and overall range. These endangered animals either destroy human lives and their vegetation or end up getting killed or injured by the people to ensure safety in distinct geographical locations of the world. Strict measures need to enforced to maintain ecological stability in an environment.
The technology of drones, image processing, and cloud solutions has given us an edge in gathering the requirements for materializing this idea of reducing human-wild animal intervention. The monitoring system discussed in this paper deals with the association of the smart technologies like Image Processing, Machine Learning and Internet of Things (IoT) to generate real-time alerts and provide a constructive servo action to counteract the conflicts to save both the animals and human property. Through rigorous assessments of setbacks and by multiple iterations of testing the sole ideology of this project is achieved to the fullest possible form. In this process, the math and science behind each technology and tool is well understood and brought in a better insight into what one can do with knowledge over such superior and versatile development mediums. Through this project and this application there arises a hope where such advanced equipment can be a boon for protecting wildlife and conserving them amid a rapid increase in human activity. Though this application is a product ready, there is a need for research and development in some areas that help to achieve greater speeds and accuracy while minimizing the cost involved to productize it. With ever-changing technology, new attributes and attachments can be added to the prototype which helps in serving the purpose of the idea.

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