Crop Protection and Monitoring from Animal Attacks Using IOT Sollutions

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Abstract- We address the problem of wild animals damaging agricultural land from several perspectives. Farmers who are impacted by this everywhere are quite worried about it, and it causes them a great deal of social and financial hardship. An investigation was carried out in Katli village, Rupnagar, India, to find the cause of this issue. The primary goal of the current research is to create a device that will minimize agricultural damage without endangering the crops themselves by directing wild animals away from fields. An infrared camera and a convolutional neural network (CNN)-based machine learning model have been coupled to produce an Acoustic Repellent System, which can identify target animals such as deer, wild boar, and nilgai. With the help of a frequency generator and camera, a Pic Microcontroller module can identify various animal species and generate sounds that deter them from visiting the farms of interest. Furthermore, a thorough explanation of the suggested solution's architectural features has been given. Finally, an analysis has been conducted about the possible outcomes of the suggested resolution.

Keywords- Crop Destruction, Crop-Raiding, Wild Animals, Human-Wildlife conflict, ML, CNN, Acoustic, Repellent, IoT, PIC.

I. INTRODUCTION

Farmers all around the world are extremely concerned about protecting their crops from animal attacks because these attacks can have a significant negative economic impact and reduce yields. Conventional protective techniques often lack the necessary efficacy and efficiency. But there is hope for better crop monitoring and protection thanks to the emergence of Internet of Things (IoT) solutions and cutting-edge technologies like microcontroller-controlled high-frequency coils. Here, the pairing of high-frequency coil repellents with PIC microcontrollers shows how complementary hardware and software solutions are when it comes to reducing the damage that animals cause to agricultural regions. Known for their versatility and effectiveness, PIC microcontrollers provide the backbone of Internet of Things systems, making it possible for sensors, actuators, and communication modules to be seamlessly integrated. An innovative method of preventing animal intrusions is the use of PIC microcontrollers in conjunction with high-frequency coils. These coils are powered by a microcontroller, which creates high-frequency electromagnetic fields that frighten or disturb animals, deterring them from entering protected areas. Microcontrollers ensure the repellent signal's effectiveness and minimal energy consumption by giving exact control over its frequency, intensity, and duration. By using IoT technologies, farmers can accomplish proactive crop protection and monitoring, which can significantly cut crop losses and remove the need for harmful pesticides or physical barriers. Additionally, the Data collected by Internet of Things (IoT) sensors can provide valuable insights into animal behaviour patterns, enabling educated decision-making and adaptable management strategies. In conclusion, the combination of PIC microcontrollers, high frequency coil repellents, and Telegram communication enables a robust system for crop security and animal assault monitoring. By using the potential of IoT technologies, farmers can proactively safeguard their crops, lower losses, and promote sustainable agricultural practices. As technology advances, future advancements in IoT-based crop protection could totally revolutionize agricultural practices and enhance global food security.

Figure 1: wild animal attacks in agriculture lands

These days, this is becoming a big deal in a lot of places worldwide. For example, in Tanzania, the annual loss resulting from crop destruction for villages bordering forests is around 250% of the loss experienced by other villages outside protected forest areas. Elephants, deer, nilgai (blue bulls), tigers, foxes, and other wild animals are regularly spotted in the country's agricultural areas. These creatures put the farmers' lives and their crops in grave danger; they even endanger their own lives. In the paper, we have put up a solid and secure method to address this issue.

II.RELATED WORK

There have been a few contributions to the solution of this problem thus far. Research on Internet of Things-based strategies to stop animals from entering fields has been conducted. Using a PIR (Passive Infrared) sensor to identify the animals, one method uses ultrasonic repellers. After recognizing the animal, it triggers the driver, which then emits ultrasonic waves at a frequency of 20 to 40 kHz to terrify it and send it back into the forest. But because this PIR sensor can't distinguish between multiple animals at once, the device always outputs the predetermined frequency for the intended animal, which can be unsettling and startling for both humans and domestic animals. A WSN (Wireless Sensor Network) system positioned in nodes at key points throughout the field was the basis of another suggested method. The field's perimeter is continuously scanned by a variety of lasers and sensors, including photo detector cameras, to look for signs of incursion. Then, a mix of buzzers and flashers is used to deflect the animals. The maximum amount of crop destruction that this technique could prevent was 5%. Another study detected the animals and scared them away using ultrasonic sensors and the ORB algorithm. Since each study carried out here had a distinct goal and set of optimum parameters based on its needs, each study's functional efficacy and efficiency differs. Advancements in Machine Learning (ML), particularly in deep learning, a branch of ML, have expanded the automation potential across multiple domains. Among them is, of course, agriculture. Convolutional neural networks (CNNs) have been extensively used in computer vision technologies since their remarkable success in the 2012 Large Scale Visual Recognition Challenge ImageNet. A plethora of CNN models have been put out with the goal of outperforming conventional computer vision approaches in solving intricate picture identification problems faster and with more accuracy. For the same reason, we turned to CNN. Our method makes use of an PIC microcontroller module, which has greater memory and performs far better than an Arduino. In order to maximize performance and prevent alarming humans and domestic animals, we have additionally engineered our system to generate frequencies specific to each species.

III. SURVEY

Survey and Data Collection Method

We acquired the panchayat committee's and CENSUS 2011 data for Katli village's fundamental information. To examine the issue more closely, we went to a few key areas. To gather the village's ground report and obtain precise, in-depth information on the problem, we got in touch with the residents. In our poll, we spoke with over 70% of farming households and inquired about the losses they suffer annually as a result of wild animals. We also asked about the effectiveness of their customary animal-repelling techniques, pertinent governmental regulations, and how these tackle their issue.

Principal Discoveries

After doing the survey, we found that there is a significant issue with wild animals destroying crops in and around the Katli village. The Indian state of Punjab has the village of Katli in the Rupnagar district. It lies 43 miles from Chandigarh, the state capital, and 6 km north of Rupnagar. Fig. 2 shows a view of the village's terrain. The similar issue is present in Sadabarat, the community adjacent to Katli. Every year, over half of the crops are destroyed by wild animals such as deer, barasingha, wild boar, and nilgai. While barasingha, nilgai (blue bull), and deer primarily damage rice, potatoes, and sugarcane, wild boars eat all kinds of crops. .. Animals typically enter the community from the Sadabarat village, where the fence is broken as a result of inadequate maintenance, according to our geographical assessment of the village. The fact that the woodland is not entirely fenced off from all sides allows the animals to enter the fields through a number of points. A point of reference is the open space next to St. Carmel School.

Figure 2: shows a view of the village's terrain.

Through our surveys, we also obtained some insights on the steps taken by the villagers to tackle this wild animal problem. Some of the methods that have been put into practice by them are as follows:

1) Fencing for agriculture For years, fencing has been a well-liked and reliable method of keeping wild animals at bay. Nonetheless, the government frequently regulates the construction of fences as a protective measure. specified types of fences may be restricted or used only in specified situations by municipal and governmental entities. For this reason, it's crucial to review the legal rules before selecting a fence. The fence's material determines its quality.

Some animals might not even be able to get through these fences because, for example, barasinghas can jump up to two meters. In certain situations, building fences of such heights could not be practical or cost-effective. Furthermore, fences may not provide protection because they are prone to being broken by animals or by environmental factors. Figure 3 depicts a damaged fence that was broken by animals two years ago, but the villagers lacked the money to fix it. In the course of our survey, we also discovered that both humans and animals could not survive an electrified fence.

Figure 3: Villagers' broken fence, damaged by animals, left unrepaired for years.

2)Organic Repellents Farmers also employ a variety of natural repellents, such as smoke, fish or garlic emulsion, beehive fence, and other repellents based on eggs, although none of these are very effective over the long run. Furthermore, there are negative impacts associated with each of these solutions.

3) Employing Security Guards Numerous villagers have constructed hut-like structures in the middle of the farm. These are employed for nighttime field security. Rich farmers may find this to be a workable option, but impoverished farmers cannot afford a watchman, and watchmen face harsh and cold winter conditions. Even animal attacks against watchmen are a possibility.

Figure 4: Watchman’s stand in the middle of the form

4) Shooting Animals with Approval from the Government Since poaching first seemed to be the most practical remedy, the authorities allowed farmers to hunt the animals that were encroaching on their farms. This policy states that one can only hunt

animals if they intrude into their field and they have a government-issued authorization. The poacher is not protected by this legislation, though, if they are killed in their native habitat. In addition, the legal quirk is that the farmer must possess both a firearm license and the necessary expertise to handle it securely. The possibility of animal vengeance, such as that from elephants or wild boars, is always present.

There are currently no long-term, financially viable answers to this issue. Keeping in mind everything said above, we suggest that the issue be resolved by developing a long-term, practical solution that spares the crops and doesn't endanger the animals.

First, the suggested system will identify the species of animal that occurs to be inside its detection range. This device will sense its environment with an infrared camera and use computer vision to interpret images. Using a variety of machine learning methods, it will examine the information and determine which specific animal is present. The PIC microcontroller serves as a coordinating tool. A frequency generator will emit the animal-corresponding frequency waves to scare off the target animal if it detects the animal and sends a positive signal. It would depart the sensor's coverage area since it couldn't stand the high-pitched sound.

IV. BLOCK DIAGRAM

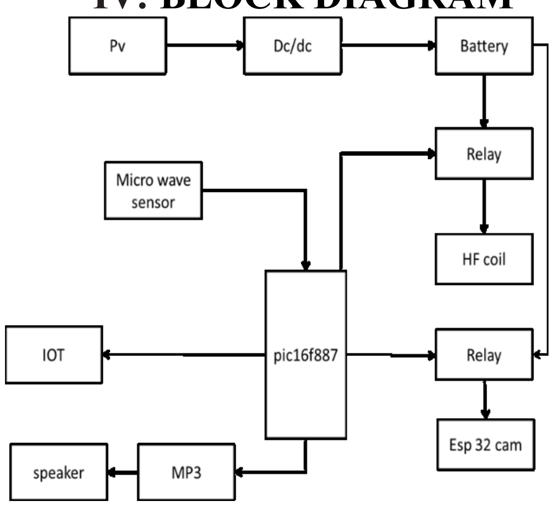

Figure 5: Block Diagram

A proposed IoT-based crop protection system against wildlife attacks would use sensors, cameras and deterrents to detect and prevent animals from entering a crop field. The platform would also provide real-time alerts and notifications when an intrusion is detected. When the sensors detect an intruder, the cameras record images and videos of the intruder. The farmer would be notified of the intrusion through the IoT platform and could monitor the system remotely so that preventive measures are effective. The system would help reduce crop losses due to animal incursions and improve yields.

V. SYSTEM ARCHITECTURE

We now talk about the system architecture we have presented. First, we enumerate the different hardware parts that the suggested module will have.

A. Electronic Parts:

- Micro Wave Sensor
- LiPo batteries
- ESP 32 Camera
- Ultrasonic Frequency Generator
- Module Casing

B. Finding the Animals:
A high-resolution Infrared Night Vision camera would pick up movement and photos of the approaching animal. This will assure security at night, in inclement weather, and in limited visibility, even in the absence of humans. The PIC microcontroller that serves as the coordinator and overall module brain, will receive the video straight from the camera, which will record it continually. The PIC will begin to spontaneously record frames at predetermined intervals. The Python OpenCV library will be used to capture and process the frames.

The machine learning model will then be fed the collected frames, and it will use them to forecast the correct animal with a high likelihood of accuracy.

How to close the gap between two frames that must be recorded is the challenge. The amount of data generated and the computing expense would be enormous if we attempted to record every frame. Furthermore, since the animal will undoubtedly be filmed for a few seconds in the movie (if it is inside the camera's field of view), there is no need to do this. However, if we maintain a large distance, the animals might escape without being noticed. We came to the conclusion that a frame capture rate of one frame per second to one frame every ten seconds would be adequate after researching the mobility of wild animals and doing some thinking. Every five seconds would be a good interval to take a picture.

C. Predictive Machine Learning Model for Animals
The acquired frames will be utilized to forecast which wild animal, if any, is present in the vicinity. A machine learning (ML) model built on the Convolutional Neural Network (CNN) architecture will be used to make the prediction. A popular deep learning technique for image recognition is the CNN framework.

Convolutional Neural Networks employ the technique of first extracting simple patterns from each layer of the image, then integrating those patterns to determine the image's complex features. We use a filter matrix to operate the image in each layer to apply convolution. After that, a process known as pooling is used to extract a specific value from a designated sub-part of the image that reflects the entire subpart. Consequently, the features get coarser while the dimension gets smaller significantly, making computation easier and preventing overfitting in the model. An activation function is used to determine the weights of the neurons in each layer. It attempts to minimize the error in the training dataset by varying the weight of each neuron through forward and backward propagations.

The main parameters are the total number of layers, the number of neurons in each layer, the size of the filter matrix, the kind of activation function, and the form of the pooling layer. The values of these parameters are selected based on the applications, input parameters, and the programmer's expertise.

In Jupyter Notebook, we trained the CNN-based machine learning model. The training dataset was sourced from the Kaggle database, Shutterstock, and Google Images. More than 10,000 photos of various animals, including blue bulls, hens, boars, canines, etc., were included in the dataset. Additionally, a training set consisting of 80% of all photos was created from the dataset. Twenty percent more were kept in the testing dataset. Since each image needs to specify which animal it represents, a Python script was then used to rename the training dataset. A categorical matrix is then used to represent that data. Prior to supplying the dataset to the model, duplicates and watermarked photos were eliminated from the image collection. The dataset was then prepared and divided into training and testing sets. The model consists of four convolutional layers, each of which comprises a 2 x 2 pooling layer that performs max-pooling and an activation function of the Rectified Linear Unit. The output is a layer with the activation function "Softmax," and it has one dense layer with a Rectified Linear Unit as the activation function. The model was compiled with 'Binary Cross entropy' as the loss function and 'Adam' as the optimizer.

D. Repelling detected animals with sound:
The PIC microcontroller will communicate with the Ultrasonic Frequency generator by sending a signal based on the animal that our model has predicted. We would employ an ultrasonic repellant that has a frequency range of 15 to 65 kHz. With a 110 degree width, it offers a good 10 to 15 meter audible range. For greater efficacy, we would employ an amplifier to extend that auditory range even further. The PIC will transmit an instruction to create a specific range of frequencies corresponding to the predicted animal once it has identified one. Our review of the literature indicates that in addition to generating a significant acoustic diversity, wild animals have evolved to be sensitive to detecting ultrasonic sound frequencies. As a result, almost every animal has a certain frequency range that it can hear and a frequency range that irritates it; the majority of these frequencies are far above what humans can hear. The target animals' hearing frequencies fall within the following range:

- Nilgai (blue bull) and deer: 33 Hz – 50 KHz
- Wild Boar (Sus Scrofa): 250Hz – 40 KHz

E. Networking via the Cloud:
Using a Wi-Fi connection, the animal recognition module will routinely communicate the data over the cloud. A computer running an Amazon/Microsoft cloud instance will make up the cloud configuration. The shared data will be used to examine wild animal behaviors and patterns. If there are any mistakes, we can see them, fix them, and get better outcomes.

F. The entire module's mechanical design
We created the outer casing/box that could house all the hardware and offer protection from external disturbances based on the standard dimensions and shapes of all the hardware components. We created a computer-aided design (CAD) model of the casing to provide greater clarity on the assembly.

VI. Possible Impact

Reduced Crop Damage: Farmers will suffer less losses as a result of reducing the harm that wild animals cause, which will boost output. This helps the agriculture industry remain stable and ensure food security in addition to directly benefiting the farmers.

Enhanced Crop Productivity: Crop productivity will probably rise overall if crop damage losses are reduced. Repercussions from this could be felt all the way up the agricultural supply chain, resulting in reduced consumer prices and higher farmer revenue.

Better Living Conditions: Farmers' living conditions should get better if their income levels rise as a result of more productivity and lower losses. This might show up as improved housing, easier access to healthcare and education, and an all-around higher standard of living in farming areas.

Improvements in Technology: With increased disposable income, farmers can decide to make an investment in modernizing their agricultural technology. This may result in larger yields, greater efficiency, and eventually more gains in income and productivity.

Economic Strengthening: The country's economy may be significantly impacted by these advancements taken together. Better living standards, higher agriculture productivity, and farming technology breakthroughs can all support economic expansion, job development, and general prosperity.

VI. Conclusion

Crop production monitoring and protection may be modernized with a potent toolbox thanks to the integration of hardware solutions like the ESP32 camera, high-frequency coils, and Internet of Things technologies. Using high-frequency coils as animal repellents in your hardware solution is a promising approach. These coils make noises at frequencies that animals find unpleasant or painful, deterring them from accessing the crops. These emit high-frequency sound waves that are inaudible to humans but irritate animals, deterring them from accessing the protected area. Farmers can increase crop output and decrease losses while also improving operational efficiency, supporting environmental sustainability, and feeling more at ease knowing their crops are well-protected by utilizing these technologies.

VII. Future work

Integration with data from weather forecasts to foresee and reduce possible hazards like storms and extremely high temperatures. creation of mobile applications for easy remote system control and real-time data access. use of machine learning techniques to automatically identify and categorize illnesses and pests. Increasing the system's interoperability with more sensors and gadgets to allow for all-encompassing farm management.

References

[1] "Katli Population - Rupnagar, Punjab," *Katli Village Population - Rup NagarRupnagar, Punjab*.[Online].Available:https://www.census2011.co.in/data/village/38644-katli-punjab.html. [Accessed: 10-May-2019]. 15th (IEEE) 2020.

[2] A. Sharma, T. Chaudhary and N. R. Chauhan, "Design and Simulation of Automated Sound System to Protect the Agriculture Farms", *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, 2017.

[3] A. Sood, "Wild animals give Punjab farmers sleepless nights," The Tribune, Nov. 24, 2014.

[4] A. Veeramani, E. A. Jayson, "A survey of crop damage by Wild Animals in Kerala", *The Indian Forester* 1995.

[5] *Animals-10 dataset*, Kaggle.com (Google Images) - Corrado Alessio, March 2020. [Online].Available:https://www.kaggle.com/alessiocorrado99/animals10.

[6] B. D. Charlton, M. A. Owen, and R. R. Swaisgood, "Coevolution of vocal signal characteristics and hearing sensitivity in forest mammals," *Nature Communications*, vol. 10, no. 1, 2019.

[7] Devsmit Ranparia, Gunjeet singh, Anmol Rattan, Dr. Harprit singh, Dr.Nitin Auluck., "Machine Learning-Based Acoustic Repellent System For Protecting Crops Against Wild Animal Attacks"

[8] Jayson, E. A., "Assessment of crop damage by wild animals in Trichur District, Kerala." No. 491, KFRI Research Report, 2012.

[9] L. Fei-Fei, J. Deng, and K. Li, "ImageNet: Constructing a large-scale image database," *Journal of Vision*, vol. 9, no. 8, pp. 1037–1037, 2010.

[10] M. Angela, N. Julius, N. Janemary, and R. Eivin, "The impact of crop raiding by wild animals in communities surrounding the Serengeti National Park, Tanzania," International Journal of Biodiversity and Conservation, vol. 6, no. 9, pp. 637–646, 2014.

[11] M. B. H., D. Janeera, and A. K. A.g, "Internet of Things based Wild Animal Infringement Identification, Diversion and Alert System," *2020 International Conference on Inventive Computation Technologies (ICICT)*, 2020.

[12] *Nilgai Images*, Shutterstock.com, March 2020 [Online]. Available: https://www.shutterstock.com/search/nilgai

[13] P. Simard, D. Steinkraus, and J. Platt, "Best practices for convolutional neural networks applied to visual document analysis," *Seventh International Conference on Document Analysis and Recognition, 2003. Proceedings.*

[14] R. S. Heffner and H. E. Heffner, "Hearing in domestic pigs (Sus scrofa) and goats (Capra hircus)," *Hearing Research*, vol. 48, no. 3, pp. 231– 240, 1990.

[15] S. Giordano, I. Seitanidis, M. Ojo, D. Adami, and F. Vignoli, "IoT solutions for crop protection against wild animal attacks," *2018 IEEE International Conference on Environmental Engineering (EE)*, 2018.