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Crop Protection Using Intelligence Surveillance System

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I. Abstract:

There are many places where surveillance is needed, such as home, hospital, school, public area, farm and many others . The following are some of the benefits which are associated with it: Security by maintaining territorial control and prevention of theft and other criminal activities through surveillance. there is always needed to enhance stewardship and ensure animals do not invade the farmland, or any arable land. Besides this, other techniques are just spying with an intruder being a human being but we don't think of that fact that the biggest enemy of these farmers is the cattle that invades their farmland. The latter always hits the farmers hard because crops which are the main source of income will now yield a lot less than before. This equipment also operates in parallel with the function of preventing wild animals from straying into farmlands as well as a surveillance tool enhancing protection of crops and avoiding intrusions of any animal by using IoT augmented with artificial intelligence. He stated this in a way that I really could not understand how farmers cannot patrol their farmland or clear huge areas. For this reason, the need to implement an automatic plant protection system is imperative today here. In this project, we have incorporated many sensors including PIR Sensor, GSM module, ISD1820 Voice recording Playback Module and deep learning and machine learning aspects too.

In order to separate animals from people Haar based classifiers were employed. When there is the animal, A Convolutional Neural Network (CNN) categorize the type of the animal. To this end, an ISD1820 Voice Sound Recording Playback Module play out different sounds depending on the sensor value which informs of the type of the errant animal in order to repulse

the animal. Likewise, the GSM module lets the farmer know that an undesired result has occurred and at what time so that the farmer makes the right decision. This is where IoT and AI comes into the picture; what is being provided is a smart and self-operated system to monitor or protect crops. As the picture identification of the areas and the IoT sensors in actuality get ameliorated, the above undesirable occurrences may be brought and prevented prior they turn to be hazardous to the crops farmers can remain informed on the web from their comfort.

II. Introduction

Recent developments in smart agriculture systems have included technology to improve crop protection and intruder detection. To identify burglars and notify farmers, one method makes use of Arduino-based systems outfitted with motion detectors, infrared sensors, and a customizable alarm system. In order to guarantee ideal plant growth, these systems often include sensors to track soil characteristics. The design is economical, energy-efficient, and efficient in agricultural and environmental monitoring. This makes it the perfect way to stop crop loss and animal damage without endangering either the people or the animals.

Fig 2.1. Animal Monitoring System

Another approach focuses on preventing agricultural vandalism and animal encroachment, which are major sources of financial harm to farmers. By using the YOLO algorithm to recognize animals, categorize them by type and location, and transmit real-time photographs of the invaders to farmers and forest officials, this approach enables real-time surveillance. It also has a repellent system that works without the help of humans and doesn't hurt the animals. The technique is economical and flexible, lowering human-animal conflict and safeguarding crops in the process.

Another method employs embedded technology and image processing techniques for segmentation, statistical analysis, and feature extraction in order to address human-animal conflict, a significant problem in agriculture, especially in areas such as India. When an animal is detected, a CNN model classifies it, setting off an alarm, electrifying fences, and alerting the farmer. The outcomes are then forwarded to a control board. The use of IoT, wireless sensor networks, and machine learning in precision agriculture to enhance the farming process as a whole is also highlighted in the article.

Another innovation is the protection of agriculture through the use of drones, IoT devices, and Raspberry Pi. Through visual processing, the system guards against harm from birds, domestic animals, and wild animals. Drones take pictures, which are then processed on a Raspberry Pi with OpenCV [19]. GSM modules are used to send SMS alerts to forest officers and farmers. The goal of this project is to increase agricultural security while lowering crop losses.

III.BACKGROUND & RELATED WORK

The Smart Crop Protection System makes use of IoT and AI to ensure identification, tracking, and keeping off of wild animals from agriculture fields [1]. Here it concerns the application of sensors, digital cameras and deep learning models of threat detection. This system affirms Agriculture 5.0 objectives of enhancing farming practices and resultant costs with a view of making farming economically and environmentally efficient. In Agriculture 5.0, these are introduced to support sustainability and optimize farming practices with the use of Artificial Intelligence (AI), Internet of Things (IoT), and Machine Learning (ML) [27].

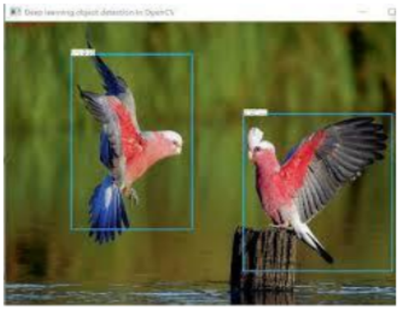

Fig.3.1. Image Detection of Birds

The performance comparison and improvement of animal species detection in photos using several R-CNN models are covered in this work. In computer vision, object detection is an essential activity that supports real-world applications including shipping, surveillance, and medical diagnostics. A variety of methods seek to identify items belonging to specific target classes within an image and allocate a class label to each object. As a first step to lessen the detrimental effects of wildlife-human and wildlife-vehicle contacts in isolated wilderness areas and on highways, the authors concentrate on animal species detection. Using four distinct R-CNN models and a deformable convolutional neural network, the objective is to improve the accuracy and speed of animal species classification while summarizing object detection methods based on R-CNN models. Four assessment indicators are used to evaluate and analyse the outcomes of each model's application to three animal datasets. A system for detecting animal species is suggested in light of the evaluation. In order to improve animal species detection performance, the authors stress the significance of deep learning, convolutional neural networks (CNN), region-based CNN (R-CNN) models, and deformable CNN (D-CNN).

Fig.3.2. IOT & Smart Sensors in Agriculture

An essential stage in computer vision and image comprehension is object detection, which locates things in an image by using bounding boxes. The majority of object detectors nowadays make use of Convolutional Neural Network (CNN) designs and Deep Learning Neural Networks (DNNs). CNNs locate and identify objects in an image by extracting features like edges, textures, and forms. The four stages of region-based CNN (R-CNN) models are region of interest selection, CNN-based feature extraction for each region proposal, region classification, and object localization, which uses bounding box regression to combine overlapped region proposals into a single bounding box around each detected object..

R-CNN is slow, nevertheless, because these procedures take a lot of time[2]. To speed up object detection, a number of models have been proposed to enhance R-CNN, such as Fast R-CNN, Faster R-CNN, and Mask R-CNN. The most crucial stage in object detection is the extraction of critical features, which is necessary for highly accurate object identification and localization. Deformable CNN (D-CNN) is utilized in this animal species detection study to enhance object feature extraction under various geometric deformation conditions, hence increasing object detection accuracy.

The goal of this paper is to increase animal species detection speed and accuracy.

by including deformable convolutional layers into the four R-CNN models for identification and localization. To the best of our knowledge, this method has not yet been applied to the detection of animal species. Three animal datasets are used to assess the effectiveness of the four R-CNN detectors in order to examine the impact of adding these convolutional layers. In order to assess a model's suitability for use in numerous applications that demand a low false negative rate, such as the detection of animal species in remote wilderness areas and on highways to alert drivers and hikers to the presence of potentially dangerous animals, the False Negative Rate (FNR) evaluation metric is added to performance evaluation.

The article is divided into several sections, including a summary of relevant object detection work, an outline of the fundamental CNN architecture, an introduction to the four R-CNN models of interest, a description of the three experimental datasets, an explanation of the animal species detection methodology, a comparison and analysis of the outcomes of animal species detection using different R-CNN models, and a discussion of desired improvements and future work.

Accuracy, precision rate, recall rate, F1 score, mean average precision (MAP), and intersection over union (IOU) are additional evaluation metrics used to analyze the performance of CNN-based systems used in these kinds of applications. Many models have been developed with high efficiency that might be more than 90% accurate. However, individual models are much worse and the worst one reached the performance level of approximately 34% [3, 21]. The latter agrees that fluctuations in model performance are due to problems like underfitting or overfitting and application of lightweight models.

Sensor and IoT-Based Approaches: Different systems use Passive Infrared (PIR) sensors and ultra-sonic sensors connected with microcontrollers including Arduino or ESP32-CAM for identifying animals and switching alarm bells or lights on [13]. These alerts are important because GSM modules give real time information on events to the farmers and they are able take remedial action. However, these systems have certain limitations what were discussed below [8]: From these impacts we find that the sensors can be very sensitive at certain moments yet this may give us false alarms and high energy intensity. Besides, limited availability of network coverage can be a problem most of the time particularly in reluctant regions of the world, or a suburban area, which hampers communication often [13].

Deep Learning Advancements: The evaluation of the most recent You Only Look Once (YOLO) schemes like YOLOv7 and YOLOv8 implies a much higher rate of detection both in speed and efficiency. These models are also capable of real time object detection with high accuracy. For instance, when using the YOLOv8 algorithm the system is able to identify intruders with a high probability of them being animals or people at a 96% success rate. Furthermore, the system is capable of granting notifications to a cloud service so that the farmers receive timely signals of the threatened area. This real-time capability and high detection accuracy make YOLOv7 and YOLOv8 great improvement in the field of smart crop protection and monitoring.

IV.PROPOSED WORK

Some of these common measurements which are used most often to evaluate the accuracy and Accuracy, precision, recall, F1-score, mean average precision (MAP), and intersection over union (IOU) are among the performance metrics of CNN-based computer vision systems that are detailed in the PDF.

The review also shows that most of the researchers obtained more than 90 percent accuracy in the models they developed and the highest being 100 percent in some instances [7]. However, it could be rather low and reach the level of 34 in some cases. 7 percent out of which 64 percent was caused due to underfitting, 9 percent due to overfitting, and 27 percent due to using models that have less weightage. [3,21].

A camera is used to take pictures of the trespassing animal on the farm using an LDR (Light Dependent Resistor). A portion of this data is sent to the server for additional processing. If the presence of an animal is sensed, the system will give an alarm by sound or light to scare the animal. To achieve this, it utilizes signals to other devices such as the speakers and the LED lights in order to switch them on. By employing the GSM module, the farmers are provided with information on the available new information through their mobile phones [14]. The sensors used may not have a wide range or a high sensitivity therefore may not be effective for large fields or identifying animals from a distance. It also uses IoT and GSM for the system information exchange and for transmitting the alert signals. Hypothesis.txt on page 30 shows that inadequate notification system relevance due to poor network coverage in the remote agricultural areas reduces the success of the system. Continuous operation of the sensors, light and sound systems requires power and would preferentially consume a lot of it, and may be affected by power fluctuations in some regions of the world [9].

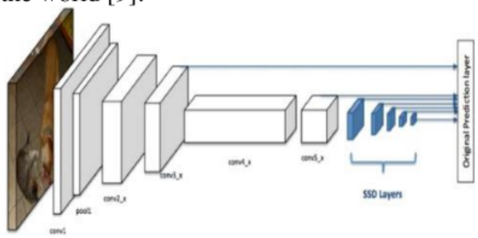

Fig 4.1. Application of IOT & ML

With a focus on five deep learning tasks—image classification, object detection, semantic/instance segmentation, position estimation, and tracking—this research examines the application of Convolutional Neural Network (CNN)-based computer vision systems in animal farming. Preparations for system construction, camera settings, variations in data recording, graphics processing units, image preprocessing, and data labeling are all covered in the research. CNN architectures are examined, and methods for developing algorithms are discussed, such as choosing evaluation metrics, data augmentation, data distribution, and hyperparameter tuning.[15]

The IoT-based Smart Crop Protection System against Wild Animals is also covered in the study. To identify animal movement and communicate with a controller, the system makes use of PIR and ultrasonic sensors. By creating a sound and signal that are sent to GSM, the technology diverts animals and gives farmers an instant alarm. The Long-Delay Relay (LDR) and microcontroller that make up the Internet of Things concept take pictures of trespassing animals and upload them to a server [26]. To get rid of the animals, the server removes the pictures and runs features like lights and annoying noises.

The work presents a new method for animal intrusion detection and deterrence systems that integrates Edge AI, tiny ML-based deep learning algorithms, and the Internet of Things (IoT) [25]. The goal of the technique is to create a remotely controlled defensive system that will safeguard sizable agricultural areas.

It combines an AI-CAM with lightweight deep learning algorithms for animal infiltration detection and classification with a laser detection system. With an accuracy of 96.7%, the suggested model, Evo Net, outperforms the others. Building on the preceding digital revolution in the agrarian sector, agriculture 5.0 is the next stage of agricultural growth that aims to make the agricultural sector smarter, more efficient, and environmentally conscientious.

The advancement of digital technologies, such as big data, robotics, artificial intelligence (AI), the Internet of Things (IoT), and virtual and augmented reality, has already begun to improve the efficiency of farming processes. This data-driven strategy enables farmers to efficiently grow and maintain crops on arable land by maximizing the resources available to them. Through the Green Deal and its farm-to-fork, soil, and biodiversity initiatives, zero pollution action plan, and future sustainable use of pesticides regulation, the European Union (EU) seeks to create equitable, healthy, and environmentally sustainable food systems.

The EU market does not now have many of the old synthetic pesticides registered. Additionally, the possibility for insect, disease, and weed resistance increases when a small number of active chemicals with the same mode of action are used consistently. Innovation and clever solutions are needed for crop production in light of the growing issues in plant protection and the reduction in the use of chemical pesticides [20]. Although biopesticides often present fewer hazards to the environment and human health, their effectiveness is contingent upon a number of variables that are beyond the control of conventional application techniques. The purpose of this research is to reveal how robotic systems contribute to Agriculture 5.0 ecosystems while pointing out the technology's drawbacks and difficulties.

This book specifically details the threats that agriculture is currently facing, including illnesses, invasive pests, climate change, and expenses, as well as how robotics and artificial intelligence (AI) can be used as defenses against these threats. Lastly, the architecture for our intelligent decision system is suggested after a thorough analysis of certain case studies and the application of intelligent robotic systems to them.

Fig.4.2. ANIDERS - Animal Detection & RepellentSystem

Global agronomy 5.0 elaborates biological agriculture, the careful cultivation of plants that integrates artificial intelligence (AI), the IoT industry, and machine learning into agricultural practices in order to increase yields without sacrificing environmental impact or making poor management decisions. The key aim of enhancing traditional farming practices and moving toward automation and adaptable technology is risk reduction, enhanced sustainability and providing growers with impact based decisions. Technologies integrated with robotic systems, artificial intelligence driven methods, lay the groundwork for advanced requirements of farming for sustainable global future generation agriculture.

The integration of Agriculture 5.0 is seen as crucial for the sustainable future of farms and the gradual shift towards smart, autonomous energy-efficient farms. By integrating advance technologies and alternative energy sources into agriculture 5.0, future energy solutions for smart farm installations, weather forecasts, operational surveillance, and cost-effective means of financing can also be achieved.

Because of the increasing demand for agricultural products and the expanding global population, the European Agricultural Industry (EU-27) has increased the demand for higher production yield. In order to boost quality production with a minimal environmental impact, the Third Agricultural Revolution has blossomed by introducing essential technology pillars in the agricultural area, such as chemical fertilizers, synthetic pesticides, and selective breeding. New technical innovations must be applied in traditional agriculture systems to support the EU aims [27]

The performance of object detection in photos using different R-CNN models is investigated in this work. In computer vision, object detection is essential for real-world applications including shipping, monitoring, and medical diagnostics. By employing a flexible convolutional neural network and four distinct R-CNN models, the researchers hope to increase the precision and speed of animal species detection. Because of its deeper structure, high-performance parallel processing systems, and complex network structures, DNNs have become more and more popular since the middle of the 2000s.

Sustainable crop protection with robots and AI technologies is also covered in the paper. The goal of agriculture 5.0, the next stage of agricultural development, is to make the sector more intelligent, efficient, and environmentally conscientious. Through the Green Deal and sustainable pesticide control, the European Union (EU) is attempting to create food systems that are equitable, healthful, and environmentally sustainable. For farmers' health and energy usage, the shift to Agriculture 5.0 from digital farming is essential. Intelligent gardening and manufacturing automation are made possible by contemporary mechatronic technologies.

The Edge AI Deep Learning-Powered IoT Framework and Smart Crop Protection System have disadvantages, such as the use of R-CNN, bounding box adjustment, feature extraction, classification, and selective search. These techniques provide thousands of possible zones, but they are slow and computationally costly. By running the entire image through the CNN, a single CNN feature extraction speeds up detection. Proposals are generated, classified, and located via Region of Interest (ROI) pooling. This approach speeds up the model and eliminates computational redundancy. A Region Proposal Network (RPN) provides quicker region solutions in place of selective search[15].

IV.1SMART CROP PROTECTION SYSTEM FROM BIRDS AND ANIMALS

PIR and ultrasonic sensors are used to identify animals and communicate with the controller. This system is based on Arduino. This technology detects birds and animals close to the field using a motion sensor. In this scenario, the sensor instructs the Arduino to act. Here, we made the decision to keep an eye on the birds and animals where the PIR sensor picks them up. A lot of damage is done to crops by stray animals including cows and buffaloes, wild creatures like monkeys, elephants, wild pigs, deer, wild dogs, bison, and nilgais, and even birds like parakeets, who run over, consume, and utterly destroy them. The proprietors of the field suffered a large financial loss as a result of the low crop production. Because of the frequent animal attacks, this issue is so severe that farmers occasionally choose to abandon the areas [3].

Total annual loss in agriculture produce	
Reason	Percentage
Insects	30%
Weeds	45%
Diseas	20%
Others	5%

Fig 4.1.1Total annual loss in agriculture

The aforementioned table displays the overall yearly loss in agricultural produce as a percentage of the total loss caused by weeds.A power supply section, PIR sensor, Arduino, buzzer, and LED make up the implemented model. Each device was created and tested independently. The block diagram that follows illustrates how the components function.

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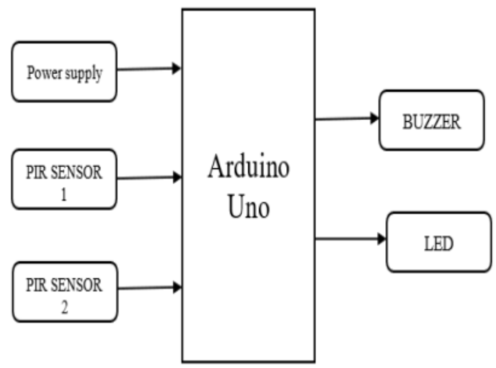

Fig 4.1.2. Block diagram of Arduino Uno

In our suggested project, PIR sensors are utilized to identify animals and birds as soon as they reach the agricultural area. The Arduino board will turn on instantly, and the sound will be produced to distract the animal. The LED will be turned on at night. The embedded PIC microcontroller is used in this gadget. It includes an LED, a 12v adapter, a PIR sensor, and a piezo buzzer. This technology identifies and generates the buzzer sound whenever an animal attacks crops in an agricultural field. This model has limitations that make it ineffective for real-time work and ineffective for all crops, so it is not flawless and efficient.[10]

NAM-YOLOV7: An Improved YOLOv7 Based on Attention Model for Animal Death Detection Analysis on animal detection is displayed

Animal Detection	Focussed On
YES	Vehicle-animal collisions.
YES	Protection of crops.
YES	Animal Counting.
YES	Classification of Animals.
YES	Detection of Dead animals and remove them immediately to safeguard public health.

Fig 4.1.3 Analysis on animal detection

On roads and highways, collisions between cars and animals can be decreased with the deployment of an autonomous animal detection and warning system. Significant crop damage results from animal trampling by "cows," "monkeys," "rats," "deer," "peacocks," "elephants," and others. It illustrates how to discover deceased animals using object detection techniques.

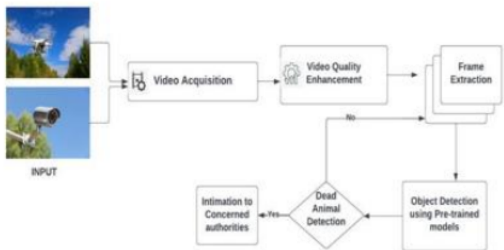

Fig 4.1.4. Overview of dead animal detection

The dataset used in this study were obtained from the internet for animal detection.

Fig 4.1.5.Dataset collection process

The below figure illustrates sample images from.dataset.

Fig 4.1.6.sample images from dataset

The data set needs to be annotated. We utilized the "labeling tool" to annotate the picture. We must mark the class and draw the boundary box around the region of interest. We must save after choosing the class in order to obtain a text file as the output. Each text file's class id is represented by the first decimal value, which is followed by the x- and y-axis centers, and then the width and height. For additional processing, the dataset is subsequently split into train and test segments. The classes used in our object detection are shown in the figure.procedure

Class No	Class
0	Live
1	Alive

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Fig 4.1.7.classes in our dataset

Figure below shows how the data annotation is done for our dataset using Labeling tool.

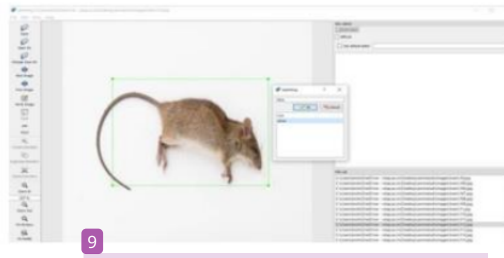

Fig 4.1.8.sample of data annotation in dataset

Deep learning and machine learning algorithms frequently use the attention mechanism. Channel attention, pixel attention, multi-order attention, and other important features are highlighted by the computer vision attention mechanism, which also identifies correlations between the original data.

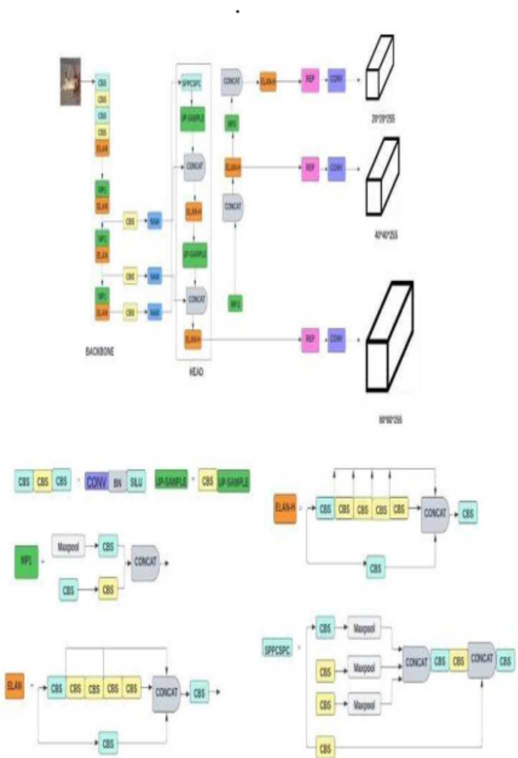

Fig 4.1.9. Improved YOLOv7 with normalization-based attention module

A variant of the CBAM module for image categorization is called NAM. The modified channel and spatial attention submodules are depicted in the figure. By altering the training weights of variance measurements across channels and spatial dimensions, attention can be rebalanced. Normalization of batches is a scaling factor.

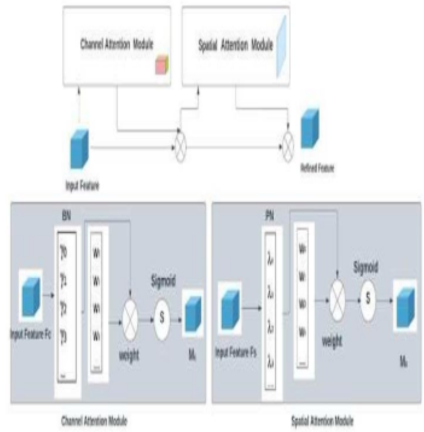

Fig.4.1.10. architecture of NAM with two attention submodules

The intersection over union (IoU) threshold is a number that determines how much an object's anticipated and real bounding boxes overlap in object detection. When the intersection and IoU values are high, it is expected that the bounding box values will resemble the actual bounding box values more. Figure displays the YOLOv7 sample findings.The best weights for the 50 epochs that the "YOLOv7" model was trained on are stored in the runs folder. It takes 0.54 hours to run "YOLOv7." F1 score for the "YOLOv7" model is 0.552.

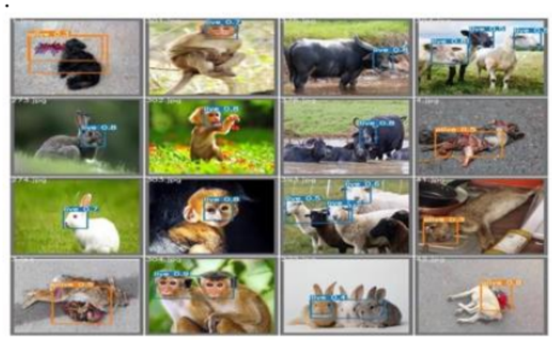

Fig4.1.11. YOLOv7 results

The camera (ESP32-CAM) is triggered by ultrasonic sensors to take a picture when an animal or human intruder approaches the field. The A server using the YOLOv8 model for object detection receives the captured image. Following processing, the photos are sent to FCM, which controls notifications for the farmer's Android app. ESP32-CAM: This low-power Internet of Things gadget takes pictures and videos. The Raspberry Pi is the system's brain, handling communication and data processing. Ultrasonic sensors are used to identify movement by intruders. Enhanced The YOLO (You Only Look Once) model, often known as YOLOv8, is a well-liked object identification technique. Impressive precision (97%), recall (96%), and accuracy (96%) are attained by the optimized YOLOv8 model.

Farmers can receive real-time notifications using an Android application using Firebase Cloud Messaging (FCM).[16]

An IoT-based animal detection system using an interdisciplinary approach

Therefore, in order to deal with the aforementioned system, we must create an architecture design that clearly explains how the model operates. While the GPS module records the animals' whereabouts, the camera and ultrasonic sensors identify whether there are any animals in the campus hallways. After receiving data from the GPS module and camera ultrasonic sensors, the Arduino UNO microcontroller transmits the identified animal information to the database and GSM module. The identified animal data is kept in the database for later reporting and analysis. When an animal is spotted, the GSM Module notifies the user by SMS of its location, as shown in the illustration figure.

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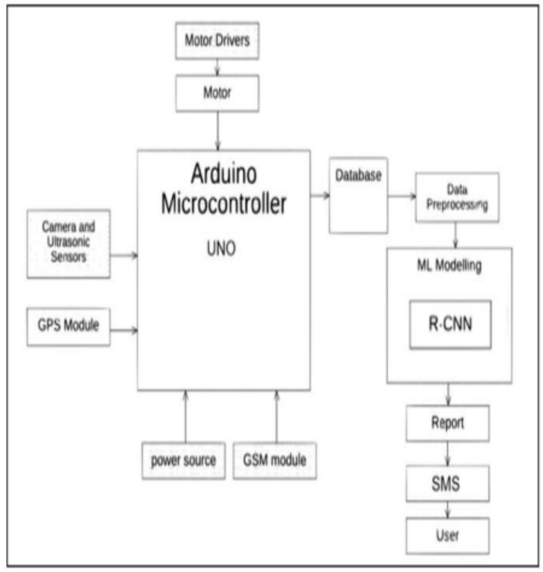

Fig 4.1.12. Architecture diagram

Arduino Microcontroller: An Arduino microcontroller is used in the system. The hardware, machine learning, and notification modules of the suggested work are connected, as shown in the provided figure.The Arduino serves as the primary power source for the entire architecture. All sensors, including cameras and ultrasonic sensors, can gather data and send it to the Arduino, which then controls the detected data and stores it in a database. The collected data will then go through a number of processing methods to produce a final output that is sent to the controller, where it will be pre-processed and subsequently modelled with the aid of R-CNN algorithm in a way that will enable it to generate a report, which the user can then get by SMS.

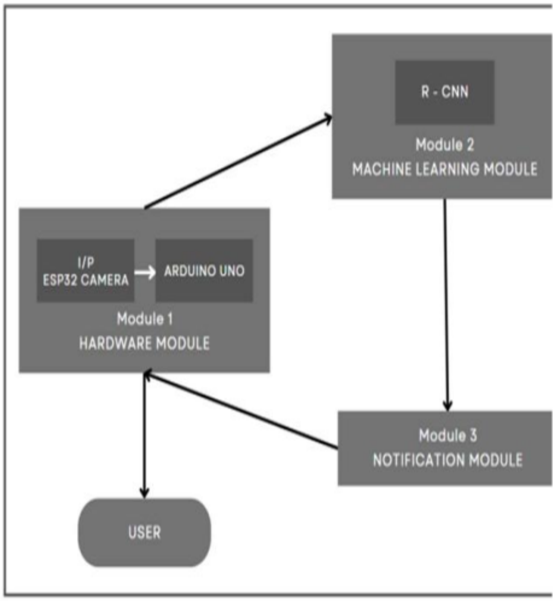

Fig 4.1.13.Module connectivity diagram

The ESP32 camera takes unprocessed pictures of the robot's surroundings to start the image capture and preprocessing process. In order to guarantee compatibility with the R-CNN models, Module 2 next carefully preprocesses these images, modifying their dimensions, standardizing values, and carrying out any required changes. that the ESP32 camera can capture photos, and the model can obtain the image by preprocessing the raw images it receives.

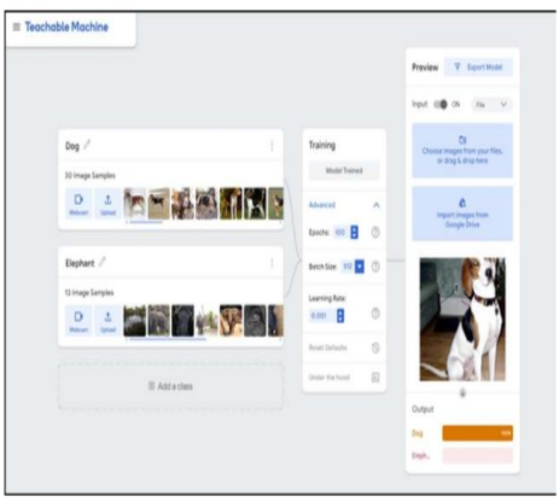

Fig 4.1.14. Training model in teachable machine

Refining Search Space (Animal Detection and Classification with Custom-Trained R-CNN) All of the above models use enhancement to achieve a more refined level of visual understanding—M2 deploys custom-trained R-CNN models specifically designed for animal detection. These models are search the animals on the list from the objects which are detected by the previous stage. When an animal is detected, it uses to classify an animal to the correct species, this provides the monitoring system with valuable information, as seen in provided Figure

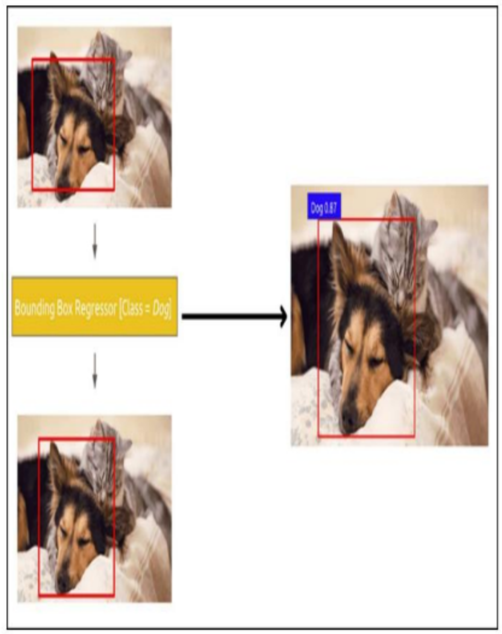

Fig 4.1.15. Animal detection and classification

Our proposed approach is based on a well-defined dataset that includes 500 images from different websites. This dataset is not a publicly available one; it was custom created to suit the needs of the paper, on two types of animals i.e. Dogs & Elephants. The dataset consists of a separate view of the same scene from each image, providing for adding to a visual tapestry during model training.

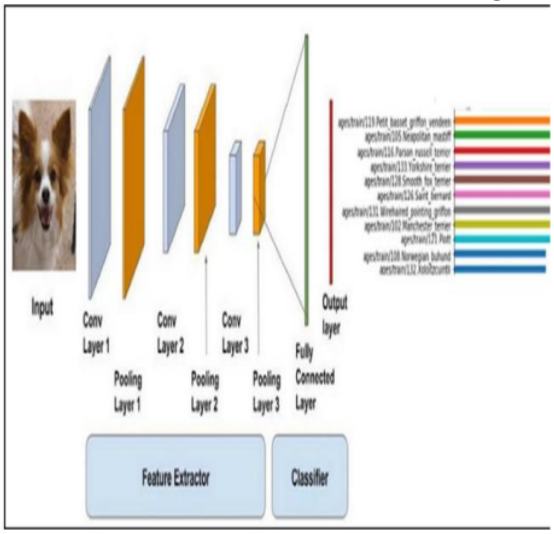

Fig 4.1.16. sequence of feature extractor and classifier

GPS Module Activation: As shown in the provided figure, as soon as the robot turns on, it activates the GPS module to obtain coordinates.

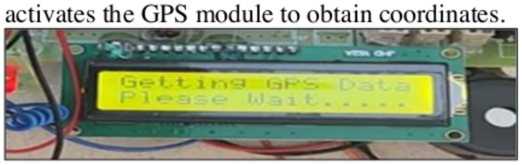

Fig 4.1.17.GPS module activation

The coordinates are shown clearly on the LCD screen when they have been retrieved, as shown. in Figure.

Fig 4.1.18.GPS coordinate dislay

The LCD screen directs the sender to use the format "*SenderNumber" to send a registration SMS to the recipient, as shown in Figure. GSM SIM number associated with the robot.

Fig 4.1.19.LCD screen instruct the sender

Connect the robot to the Wi-Fi network "iotserver", which is configured to connect to the ESP32 Camera to enable live streaming. When connected, get the ESP32 Camera IP address. Remote viewing of the live stream is depicted in Figure: Access the live stream by plugging in the obtained IP address

Fig 4.1.20. remote viewing

The robot looks for impediments all the time. If it is found, it notifies the registered sender via SMS with the subject line "Obstacle Detected: GPS Coordinates" as seen in Figure.

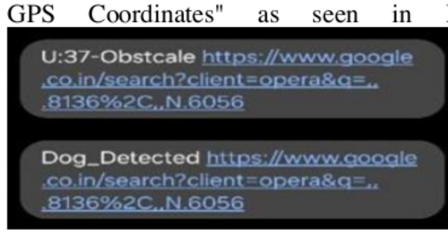

Fig 4.1.21. Obstacle and animal detection along with location

The robot's location when an animal is identified can be seen in the provided figure..

Fig 4.1.22. Location of robot when animal detected

The animal's name and coordinates are then displayed as well.on the LCD screen.

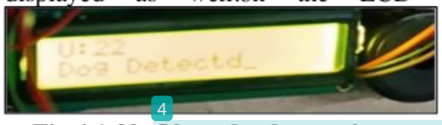

Fig 4.1.22. Obstacle ultrasonic range and animal name on the LCD screen

The experimental outcomes of the animal identification robot depend on a variety of factors, including the remarkable 97.6% accuracy rate attained after 30 training epochs, as shown in the Figure, Model Accuracy Graph. The ability of the ESP32 Camera to distinguish between various animal species in a range of lighting and distance situations is essential for detection accuracy..

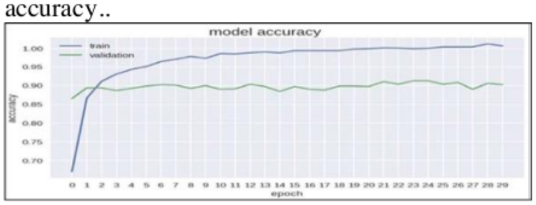

Fig 4.1.23. Model Accuracy Graph

The system incorporates a number of parts, such as a buzzer, panic button, GPS module, and GSM module. The system uses the GPS module to send the user's location via SMS and the GSM module to communicate when the panic button is touched.[22]

Since crops are valuable to wild animals, monitoring and preventing

devices to repel them. Depending upon the sort of produce and the sort of animal they are attacking, conventional strategies have been utilized all things considered. This paper proposes a way to protect farms from wild animals by using ubiquitous wired network devices and applying to farms with traditional methods to enhance the performance of protection. These can be used in animal intrusion outside of farms to detect operational amplifier circuits. The monitoring scheme proposed provides an alarm about potential penetration and destruction by wild animals.

The main objective of this project is to reorient the crops in a way that does not harm them and protect them from being destroyed by animals. The aim of an animal detection system is to detect an animal and raise an alarm. The presence of animals is sensed by PIR and ultrasonic sensors that relay messages to the controller. The system prevents animals by making a sound and sending a signal to GSM to inform the farmers quickly.

An IoT model comprising a microcontroller, LDR, and GSM module makes up the suggested system. After taking a picture, the LDR transfers it to the server. Once the image of the trespassing animals has been captured, it is removed from the server. Functions like light or annoying noises to drive the animals away will be carried out based on the amount of animals present. A message about the quantity of animals trespassing on the farm and the action taken to exterminate them will be sent to the user.

The project's primary objective is to build and create an intelligence surveillance system that uses GSM to identify animals and send out alerts. Additionally, it automatically activates a buzzer and LED and enables farmers to regulate the speaker sound through the Internet of Things.

An Internet of Things (IoT) is presented in this study application for crop protection to stop animals from entering the field of crops. The application offers a monitoring and repelling system to stop any agricultural damage from attacks by wild animals. Among other advantages, the Internet of Things has brought forth precision and smart farming. Due to a lack of detection systems, animal attacks are a major problem in India, where they murder residents and ruin their crops. A good detection system could protect crops and save lives.

Farmers' attitudes regarding fields are shifting as a result of the growing rate of forest loss and encroaching agricultural area, which is causing an increase in animal invasion. A microcontroller and an LDR that take pictures and upload them to a server make up the suggested system's Internet of Things paradigm. Depending on how many animals are there, functions like light or annoying noises are used to exhaust the creatures.

Notifications are sent to the user regarding the quantity of animals trespassing on the farm and the actions taken to exterminate them. The LDR communicates with the microcontroller, which uses the GSM module to send SMS notifications to the farmers' mobile phones after capturing an image of the object entering the field. To deter animals without hurting them, farmers can regulate different speaker noises via a web page, and an LED and buzzer will activate automatically.

Analog features such as a 10-bit, up to 8-channel Analog-to-Digital Converter (A/D), Brown-out Reset (BOR), an Analog Comparator module with two analog comparators, a Programmable on-chip voltage reference (VREF) module, and externally accessible comparator outputs are all part of the Crop Protection System's architecture. [9]

Crop Protection from Animals Using Deep Learning

We tackled this issue with deep learning, which emphasizes the crucial aspect of scale.The image dataset was utilized as the project's input. Since we consider these animals to be a threat to South Indian farms, we have three classes: elephants, cows, and monkeys. The model's input comes from a camera that records continuously. The video is then transformed to an image and processed further using the training dataset. To create a model, we employ the Convolutional Neural Network approach. Given an image as input, CNN is a sophisticated image processing tool. ConvNet applies a filter to the picture.

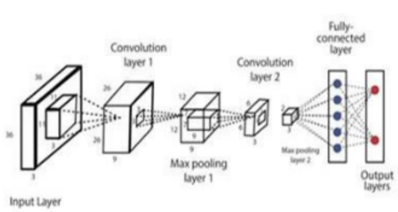

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Fig 4.1.24.convolutional neural network

One such method uses a camera that is connected to a Raspberry Pi module. An image of a wild animal is taken using a camera and sent to the Raspberry Pi module. when the Raspberry Pi can capture an image and compare it to a database image. Following comparison, the GSM module receives commands if the wild animal is identified. Messages were sent to the farm's owner via GSM.

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Fig 4.1.25. Raspberry pi

Since the Arduino is essential to keeping the model works

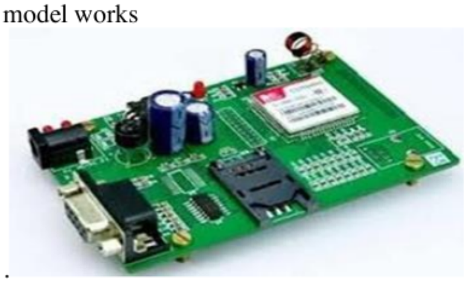

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Fig 4.1.26. Arduino

It is an alternative method of working with microcontrollers that are based on the Pic family. This method detects wild creatures that are close to the field using a motion sensor.

Fig 4.1.27.pic microcontroller

T Following the compilation of these layers, the output will serve as an input for our Artificial Neural Network model, which will then be trained and tested using an Image Data Generator. The model is then saved. Conversely, our monitoring system will provide us with a continually streaming video, which will subsequently be divided into individual frames. If there are any similarities between these frames and our testing data, they are compared.Afterward, it will generate the sound.

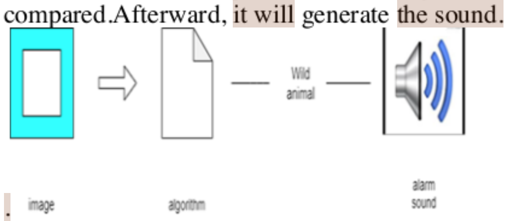

Fig 4.1.28.Flowchart of proposed system

The frame will recognize the animal once it matches our data, and it will then make the proper sound to ward it off the field. It will keep running without making an alarm until the animal is found if the frame does not match the data.

A camera, Raspberry Pi, and several electronic equipment are among the components. Most likely, the system takes pictures for later examination. The Raspberry Pi is the main processor in charge of controlling data flow. Integrated Circuit (IC): May be utilized to operate actuators or interface sensors. The block diagram illustrates how the parts function.

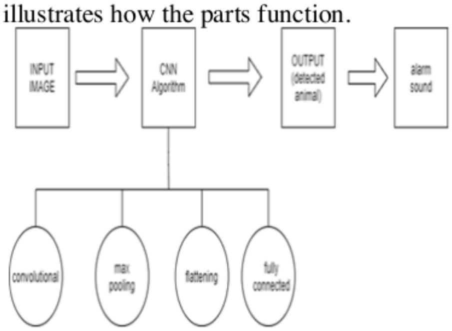

Fig 4.1.29.block diagram of CNN algorithm working

The block diagram provides a clear explanation of the model's operation and flow by showing the flow from the input image to the CNN algorithm to the output alert sound.[28]

V.METHODOLOGY

5.1. Components and System Architecture: It is made up of a number of parts that are used to generate warnings and alarms during the detecting process. The system's components carry out specific tasks in detection, alerting, and function generation.

Various types of sensors are used to detect locomotion, such as the Passive Infrared (PIR) sensor, which is mounted in the various fields and ultrasonic zones.

Fig 5.1.1.PIR sensor

Ultrasonic sensors use the sound that animals make while they move, whereas PIR sensors use the heat radiated from the animal.
Robotic microcontrollers (ESP32-CAM and Arduino): Microcontrollers installed in cars, similar to microprocessors, receive inputs from sensors and turn off other devices, like security alarms and cameras. Additionally, it can start shooting actual images or videos as soon as the detecting gadget detects motion. ESP32-CAM camera. The ESP32-CAM is activated to capture further photographs of the intruder for additional analysis as soon as motion is detected.

YOLO Deep Learning Model: The YOLOv7 and YOLOv8 models are used as an object detection system, and they identify whether an animal or a human is present in the photos that are taken. With the aforementioned accuracy and recall at the level of 0.96, YOLOv3 is utilized in its place because of its increased object recognition speed and accuracy.
GSM Module: This specific component uses a mobile phone to alert farmers, in particular, in the event of an intruder. For alerts that can quickly alert a mobile application for real-time

communication, Firebase Cloud Messaging (FCM) is utilized.

LED system and alarm. In terms of the alert, it is accurate in identifying animals, and when it detects one, it sounds an alarm to pursue the animal. When the burglars enter the house, they will be confused because the LED is meant to be turned on at night.

5.2. Procedure for Intrusion Detection

Step 1: Motion Detection: An Arduino or ESP32-CAM microcontroller receives a signal from a PIR or ultrasonic sensor when motion is detected, turning on the camera.

Step 2: Image Capture: The ESP32-CAM also captures the intruder, and it sends the server images of the intruder it has discovered.

Step 3: Processing Images After examining the photos obtained of the specific location, the Yolov8 algorithm assists the system in identifying the intruder. The incorporation of the YOLO algorithm for real-time object detection in YOLOv8 provides high facility speed and precise object categorization.

Step 4: Notification and Reaction: Depending on the system's condition, a GSM module will notify the farmer via SMS that an animal has been spotted and that alarms or LEDs are being utilized to herd it.

3. Assessment of Performance The following common metrics for CNN-based models are used to assess the system's performance: The metrics systematically used for the CNN-based models are used to do a performance analysis of the suggested system's generalization capability:

Accuracy: The frequency of correctly distinguished animal results relative to the frequency of human differentiation. F1-Score, Precision, and Recall: When recognizing the animals, it is simple to counteract false positive and false negative detections in the model using the remaining values of the aforementioned metrics.

Intersection Over Union (IOU) and Mean Average Precision (MAP): A number of these measures provide some indication of how localized and detectable the items in the indicated signals are.

This strategy has several advantages, such as effectively addressing the threat posed by wildlife in agricultural areas and producing measurable results, such as minimal crop losses.

VI.COMPARITIVE ANALYSIS

In order to produce a comparative analysis of all five papers on the problem of wild animals in agricultural fight for crops, it is possible to assess the papers using criteria such as methodology, technology, scope and efficiency.

6.1. Methodology and Technology

As a part of the project developers have employed GSM technology for remote monitoring and virtual fencing. scope and efficiency to compare five papers for the agricultural problem concerning a fight between wild animals for crops. The first paper uses GSM technology for remote monitoring and virtual fencing using microcontrollers, IR sensors, and GSM modules to provide alerts and control devices.

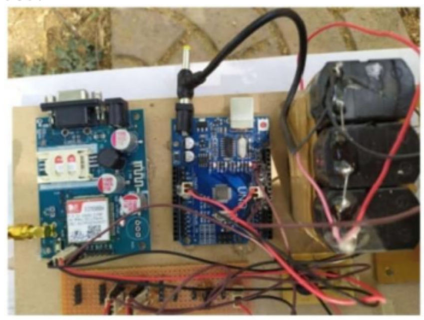

Fig 6.1.1.GSM module waiting for signal

The DNR uses other repellents, like rotten eggs and firecrackers. The system makes use of a microcontroller, IR sensors and GSM modules to give alerts and monitor the device [5]. Other repellents used include rotten eggs and firecrackers as well. In this paper 'Arduino', PIR sensor modules, buzzer LEDs and SIM900 GSM modules are used. The next vehicle, from the projects of arudino using PIR sensor modules with buzzer LEDs, and SIM900 GSM modules were intended to provide a fast response in the form of alerts upon detection of animals. The third paper utilizing arudino with PIR sensor and load cell belches out different sound volume.tunes.

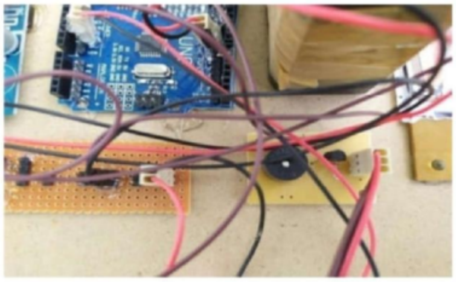

Fig 6.1.2.Buzzer alert due to animal detection

By using relay devices for alerts, at multiple musical nodes (frequencies) as well channelizes surveillance through IoT device on the other hand. When an animal comes, the system sounds the alarm and send a notice. This strategy is mainly aimed at rapid reaction [11].

In this paper Arduino with PIR sensor and load cell is used. It sends alerts through relay devices that produce a variety of sound effects at different

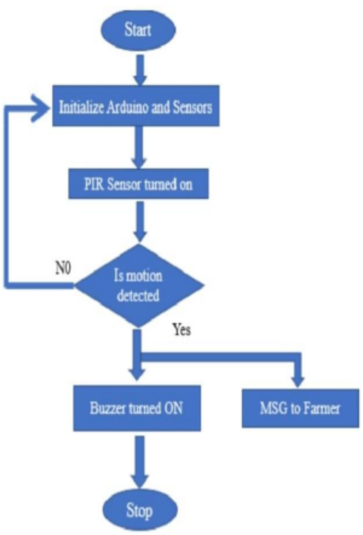

Fig 6.1.3. Flow chart of working process

frequencies. Virtual fencing and remote notifications have told us when an animal has come into the crop protection area. The solution alerts in the modes of prevention and monitoring without any substantial cost impact on a farmer. In the text, there is also a paragraph about applications that use sound and IoT-based zigbee-gateway combined with GSM auto dialer systems for physical security system. LEADING_ALERTS_NOTIFICATION; It provides ease of use though it may be short on some functions available in different approaches. On the other hand, referring to Arduino based systems that includes a sound deterrent and its links to IoT would be too hard for people. Monitoring is done through IoT devices which provide online monitoring [17]. Rather than examining systems that prevent damage, the focus is on methods of estimating damage. The fourth paper outlines damage estimation methods and the degree of crop loss and control compliance recorded for manual, automatic, UAS Crop Height & Yield Methods against ungulates. The focus here is on quantifying the extent of the problem rather than prevention of it .It assesses the damage and control inflicted by ungulates using manual, automatic, UAS Crop Height and Yield Methods [23]. It does not emphasize the prevention of the problem but puts more light on measuring its magnitude. The fifth paper is on other animal containment and surveillance systems such as video, and irradiance images. Papers cover topics such as virtual fencing and notifying residents of remote behaviors to eliminate unwanted animal intrusion. They worry about animals coming to steal but is an affordable way for the farmers to use as mitigation and provide a warning system for these fruits. Surveyed a number of animal control and observation systems including visual, irregular image [29].

6.2. Attention and Utilization

Addresses the issues of eliminating unwanted animal intrusion through the implementation of virtual fencing and sending remote notifications [5]. It adopts a number of different approaches to the protection of crops. Focuses on the prevention of animal intrusion, instead there is a constant monitoring process followed by an action if any animal is present in the vicinity. It provides a cost-effective way for farmers to use an alerting mechanism to protect crops [11].

Related to using sound and Internet of Things based system that emphasizes on accurate reporting of any presence and activity of the animals [17]. Deals with the evaluation of the damage rather than looking for ways to avoid it [23]. It addresses remains the issue of ungulates impact assessment on crops.

Reports a general study of monitoring animals covering systems and technology for image acquisition and its problems [29]. It is more concerns the theory and problems rather than practical means for tackling the problem of crops protection.

6.3. Effectiveness and Practicality

Provides a diverse solution which combines the use of GSM technology with physical mechanisms of security. This one is useful for remote monitoring but it may be difficult as it may have many parts and needs some kind of service sometimes [5]. Empowers the users with practical and cost-efficient solution that are capable of producing an instant response [11]. It is not hard to use but could be short of some functionalities offered by other types of system. Links between the deployed IoT and Arduino based systems with the sound deterrents. It is more detailed in its approach but may prove to be difficult for some customers due to technicality involved [17].

Effective primarily as a method to assess damages and not so much as a way to avoid them. It aids' planning and other management and also resource utilization but does not keep crops safe [23]. Covers a vast amount of information regarding technologies used in the monitoring of animals but lacks a depth of information regarding its use with repelling crop pest [29]. It also helps in creating new systems since it provides the theoretical construction which would be adhered to.

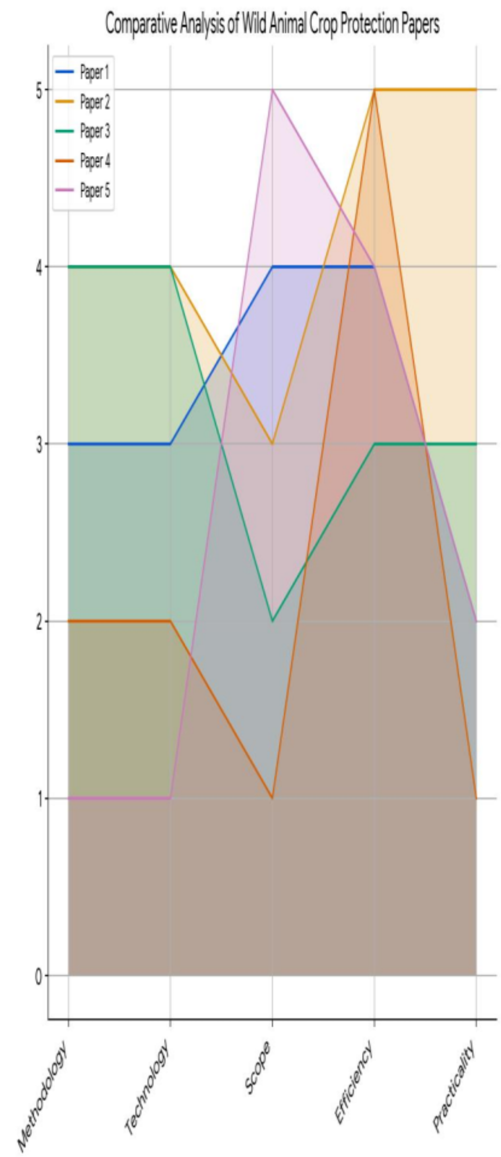

Fig 6.1.4. comparative Analysis of wild animal crop protection papers

VII.CHALLENGES AND LIMITATIONS:

1. Sensor Sensitivity and Range: PIR and ultrasonic sensors are less effective in detecting animals in broad fields or at a distance due to their limited sensitivity and range. Unfavorable

weather conditions may also cause them difficulties.

2. Network Coverage and Connectivity: The system's dependability is diminished in distant agricultural areas with little to no network coverage because GSM modules are required for real-time notifications.

3. Power Consumption: The system needs a lot of power to run continuously, especially for the sensors, lights, and alarms. This might be an issue in places where the electricity supply is erratic or limited.
4.Overfitting and Underfitting of AI Models: CNNs and other deep learning models are susceptible to overfitting or underfitting, which can occasionally result in poor detection accuracy and lower system efficacy.
5.False Positives and False Negatives: The system can include false positives, which is when the system predicts an object's presence when there is none – or false negatives, where the system fails to identify animals – using even better models such as YOLOv8, making the system less credible and efficient.
6.Limited Field Coverage: Sensors and cameras may become less effective in large sized agricultural fields whereby there is need to apply many of these in the field to cover the large area. This may lead to increased cost of installing and maintaining the large number of these instruments in the large sized agricultural field.
7. Dependence on Internet and Cloud Services: Image processing and real-time alert services depend on cloud facilities, which demands appropriate internet reliability. Lack of appropriate internet connection in the rural areas makes notification and data processing slow.
8.Environmental Impact: This could be involving alarms, LED lights and other imaging equipment which could be unkind to the wildlife and disrupt the natural habitats and other foliaged night tenants.
9. Hardware Durability: The hardware part is exposed to germane environment for instance sensors and cameras are exposed to extreme weather condition that leads to their frequent damages and replacement. Frequent maintenance works are done in order to cater for the damages caused by extreme weather conditions for instance rain, heat among others.

VIII. Results:

As per the crop protection system, safety has improved since less damage has been caused on intruding animals towards crops. This system has thus had the phenomena of reducing the costs of doing business that you see, particularly in operation expenses that officers prefer for monitoring fields. Real-time supervision and alert messages give time and chance to attend to the issue and therefore useful in protecting the vitality of crops. Furthermore, it can be operated by solar power, which provides the benefits and lessens harm or demand from outside power source in terms of environmental aspect. In particular, the recommended system demonstrated how one would safeguard plants and lead to the production of more crops.Wildlife detection using IoT-based systems has also advanced in recent years, and this has greatly helped to track animals and reduce human interference with the animals. Equipped with sophisticated sensors, cameras, computing networks, and smart interfaces, these systems enhance real-time detection and warning capabilities, and reduce false positives. the environmental and the economical ones: the crops from pests, the roads from accidents and the rare plants and from threats.It has been demonstrated that using the suggested technology to detect animal movements and promptly warn farmers is an efficient use. Employing non-lethal deterrents (such lights and alarms) ensures real-time notifications while preserving biodiversity without putting animals at danger. [18] The addition of animal deterrence and fire detection alarms further enhanced farm safety with their prompt and trustworthy alarm mechanism. It can effectively monitor farms, detect trespassing animals, and prevent damage by scaring them away. It also assists farmers in remotely monitoring their crops.[6] Testing revealed that the prototype system could detect animals at a distance of 10 feet, identify them, and alert the farmer in ten seconds. [12] The buzzer and flashing LED lights were effective in frightening away animals, and the SMS alerts were sent out on schedule. The system's economic design makes it accessible to farmers and provides a workable option for crop security that doesn't put people or animals in danger.[24] The device proved to be successful at repelling animals within a 6-meter radius in tests carried out in areas containing a range of species. Because the system can instantly alert farmers.

Farmers reported far less crop loss when animals were approaching their fields.[30]

IX. Conclusion:

The crop protection system offers a user-friendly and efficient solution. defending crops against wildlife.[6] It lowers agricultural damage from animals, safeguards farmers, and promotes environmental preservation through automated farm monitoring. The technique works well and may be adjusted to suit different farming scenarios.[12] The system uses simple components like buzzers, ESP32 cam, HAAR, GSM modules, and PIR sensors to ensure real-time monitoring and response without putting people or wildlife in danger. Farmers, who can prevent harm and increase agricultural output.[18] An Internet of Things-based animal detection system provides a practical, economical, and humane means of protecting crops from wild animals. Farmers who move swiftly can reduce their financial losses. By using real-time monitoring and notifications to prevent crop damage, farmers can reduce their financial losses by taking prompt action. [24] Bright light and ultrasonic sound are used in the recommended system to effectively identify, detect, and scare away a variety of animals from agricultural areas. The technology also uses GSM to alert farmers, enabling proactive action. The findings show that this approach has the potential to be extensively applied in the agricultural field and provides a dependable way to reduce crop damage caused by wild animals.[30].

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