SecFarm: An IoT Application Framework to Aid Farmers with a Secured Farm System.

Mahdi Shamsa
Dept. of Computer Science and Engineering,
University of North Texas,
Denton, USA
mahdishamsa@my.unt.edu

Laavanya Rachakonda
Dept. of Computer Science,
University of North Carolina Wilmington,
Wilmington, USA
rachakondal@uncw.edu

Saraju P. Mohanty
Dept. of Computer Science and Engineering,
University of North Texas,
Denton, USA
saraju.mohanty@unt.edu

Elias Kougianos
Dept. of Electrical Engineering,
University of North Texas,
Denton, USA
elias.kougianos@unt.edu

***Abstract*—As humans, we coexist alongside animals on our planet. Depending on this truth; adapting to them is essential for several reasons. Some people obtain their sustenance from Livestock, preserving our lives, etc. Agricultural products are crucial for humanity, and their preservation is a fundamental human responsibility. Animals are one of the threats to crop production. In this phase, it is forbidden to kill, harm, or imprison them. Simultaneously managing crops and animals is one of the most challenging jobs farmers undertake. Monitoring crop growth on the farm and protecting them from animals is an addressed issue in this paper. A system has been developed to aid farmers in safeguarding crops and preventing animal-related losses. The proposed approach is capable of deterring animals from crops without inflicting harm or damage. The proposed system utilizes You Only Look Once version 5 (YOLOv5) along with a high-quality dataset to facilitate the classification of hazardous objects detected by the camera.**

***Index Terms*—Secured Farm (SecFarm), farm production, Evict Animals, Issue a Sound, Farmer.**

I. Introduction

Agricultural farms are regarded as the most significant natural resource available globally. In terms of natural resources, agriculture and cattle are the biggest sources of food for individuals. Agricultural land globally occupies over five billion hectares, representing around 38% of the Earth's surface [5]. Integrating two natural resources for providing consumers with natural products, the second resource, livestock, acquires its nutrition from agricultural produce [12]. On the one hand, farms supply one-third of the world's natural food to consumers [23]. On the other hand, the consumption of meat is increasing continuously. In 1961, global consumption of meat was 20 million tons, which escalated to 360 million tons by 2022 [17]. The 360 million tons of meat represents 900,000 cows/day, 1.4 million goats, 1.7 million sheep, 3.8 million pigs, 12 million ducks, and 202 million chickens each day (equating to 140,000 chicks per minute). According to the aforementioned statistics, livestock sources (cattle, sheep, pigs, ducks, and chickens) along with other animals and birds are consumed on farms. These consumptions may adversely affect farm production when animals continue to assault farms without any protection. It is entirely unacceptable to prioritize either the production of farms or the welfare of animals while disregarding the other, whether by preserving agricultural output at the expense of animals or vice versa.

Agriculturalists have obstacles from animal species that assault their crops and damage their yields [9].The matter must first be addressed by the farmer to identify the obstacles, followed by researchers to provide the solutions. Animal species consume many types of food, indicating that they may target any farm, regardless of the crop produced [15]. This necessitates continuous surveillance of all farms to prevent animal destruction. Decreasing crop production due to animal attacks results in a decreased quantity of products available for consumer consumption. Fig. [1] illustrates the lifetime of living organisms. Farm, consumers, and animals. These three objects are interdependent. People safeguard farms to protect their agricultural products for sustenance. Farms supply animals with sustenance; nevertheless, they negatively impact crop production. The last relationship relates to consumers and animals/livestock. Consumers utilize livestock and animals for their way of life. It is necessary to build a system that protects the farms from animals without causing harm or suffering losses.

Securing farms and livestock simultaneously should be a significant priority in human life, as they offer food. Securing farms is crucial in our lives, as they provide nutrition for both humans and animals. The reduction in crop production impacts the quality of life; therefore, it is the responsibility of humans to protect crops from animals and cattle for several reasons. Such as the global population is expected to rise from 8.0 billion in 2022 to 9.7 billion by 2050 [18], [21]. This indicates that agricultural production is augmented to fulfill human demands. Conversely, it is crucial to ensure the safety of animals and livestock, as they play an essential part in

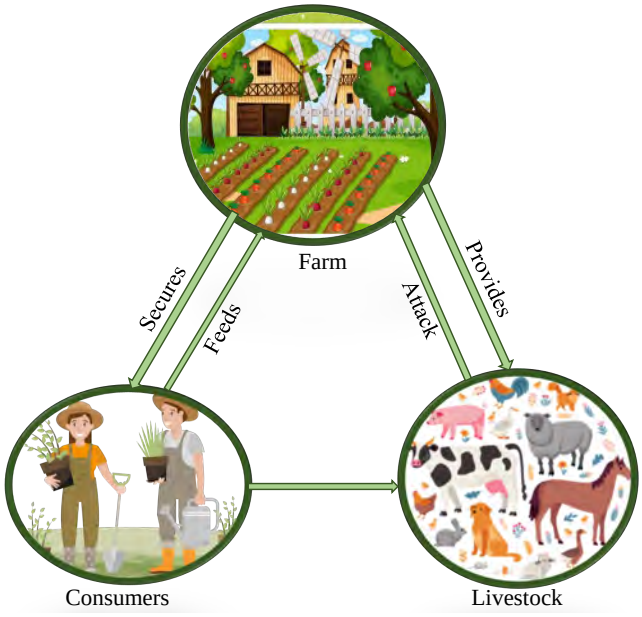

Fig. 1. Motivation for SecFarm to Keep the Crop Safe From Animals

agricultural production for human nutrition. The author of this paper designed a system to protect agricultural products from animal attacks without causing harm to the animals during the eviction process. The designed system is called Secured Farm (SecFarm). It utilizes sensors along with a digital device and cloud technology to identify the targeted animal. This system is developed within the framework of the Internet of Things (IoT) [11].

The rest of this paper has been organized as follows: Sec. II is the proposed contribution of the SecFarm system. This section discusses the primary concept of the proposed application by identifying the problem, proposing the solution using SecFarm, and the significance of the proposed solution. Sec. III illustrates the related work through the compression of the existing systems with SecFarm. In Sec. IV the author depicts SecFarm's architecture including the proposed novel methodology by showing an algorithm of SecFarm processes and the gain result for the end user. Sec. V presents the experiment and validation steps and the utilized dataset along with the trained model illustrations. The last Sec. is VI. In this section, the author concludes the paper with a brief on the SecFarm application and future improvements.

II. Proposed Contribution of the SecFarm System

This study introduces a state-of-the-art approach for safeguarding farms across different aspects:

- Under the umbrella of Artificial Intelligence (AI) [22] and utilizing Computer Vision (CV) [7] techniques, this system has been aimed to address one of the most significant issues faced by farmers.
- This system is a fully automated system that requires no human intervention to fulfill its purposes.
- The proposed approach enhances usability by enabling farmers to determine the specific types of animals that require detection and exclusion from their fields.
- SecFarm is a secure system that operates without causing any harm to animals or crops.

SecFarm is considered one of the most effective technologies utilized by farmers to improve agricultural production by eliminating animals from their farms. Permitting farmers to select the region, country, and animal renders SecFarm a simple system. The primary objective of permitting farmers to select a single choice for each one is to facilitate the detection and eviction of SecFarm, hence enabling rapid action. Another reason is that not all regions contain the same species of animals; therefore, by identifying the region, the system will focus on specific types of Animals common in that area.

A. Problem Addressed

SecFarm is an application developed to assist farmers with challenges encountered throughout their farming sessions. Animals are beings that coexist with us. However, adapting to them is vital for us. The loss in farm yield looks similar to a specter that haunts farmers during farming. Safeguarding crops necessitates an effort to enhance farm production without negatively impacting animal health or causing harm to them. Employing people is an alternative cost-effective strategy.

Farmers are unable to afford the costs of labor. If labor is affordable for certain farmers, crop production will remain unsatisfactory. The primary objective of the SecFarm application is to provide farmers with a secure farming environment, eliminating the necessity for third-party support in crop security. According to the Texas Farm Bureau website, the agricultural sector demands over 300,000 workers, excluding farmers, however, the number of migrant visas issued is approximately 250,000. This indicates that around 50,000 workers are still required in the agricultural sector [19]. SecFarm can provide protection instead of labor, hence reducing costs for farmers.

B. Proposed Solution Through SecFarm

Multiple approaches have been developed by multiple authors in the past. Certain systems operate exclusively on specific animals, such as livestock or cattle. Other systems detect all moving objects by the use of motion sensors. Assistance to farmers should be predicated on their specific requirements. SecFarm is an application that provides sufficient support to farmers on their needs. A dangerous animal can be recognized by SecFarm to protect crops.

C. Significance of the Proposed Solution

The paper presents a productive system named SecFarm, developed using several sensors to offer farmers a fully automated solution. SecFarm improves the everyday life of farmers by protecting their agricultural products from animals and cattle. The significance of this system SecFarm is the ability to determine the harmful animals and livestock through the application. This determination facilitates the system's rapid analysis of the captured object, enabling identification

TABLE I
NOVELTY OF SECFARM VS. EXISTING SYSTEMS

Authors	Year	ML model type	Automation	Drawbacks
Manikandan, et al. [10]	2024	Detection	Needs human interaction	Issuing fog and LED by farmer is useless
Chandralekha , et al. [4]	2023	Classification	Needs human interaction	Farmer must evict animals
Charles, et al. [2]	2023	None	Fully automated	System generates acoustic sound gun 24/7 which evokes panic
Borah, et al. [1]	2020	Classification	Fully automated	Using RTPPS for classifying and an siren for evacuation
Chitra, et al. [3]	2023	None	Fully automated	Utilizing only ultrasonic for detection might evict the owner
Raksha, et al. [13]	2020	None	Needs human interaction	Using temp. and soil sensors do not help to evict animals
SecFarm	2024	Classification	Fully automated	SecFarm securely eliminates animals and livestock

and categorization of any potential damage it may cause. This faster procedure would help save time and energy while ensuring a high degree of accuracy in the results.

III. STATE-OF-THE-ART LITERATURE

Despite farmers' efforts to assure the safety of their agricultural products, human means of removing animal species from farms are costly, labor-intensive, and do not guarantee the complete protection and elimination of all animals or livestock [8].

The safeguarding of agricultural produce remains a challenge that farmers keep encountering. Even the recently built devices for farm protection occasionally necessitate human interaction. Table I compares SecFarm with existing methods to reach satisfactory results. All mentioned systems concentrate mostly on particular categories of animals, such as wildlife, livestock, etc. SecFarm promotes farmers to select the region for identifying frequent animal species in that place. The SecFarm application enables the farmer to specify the country and/or animal. SecFarm uses cloud technology to analyze and evaluate the threat that detected animals pose, allowing the administrator to remotely update the list of at-risk animal species at the farmer's request. This is the novel aspect of my research among the following studies.

A purchasing method for farmers to assist them in agriculture without requiring their participation. The system for detecting animals using ultrasonic technology, emitting animal sounds, transmitting SMS and photographs via Telegram, and maintaining continuous monitoring is fairly efficient. Nevertheless, farmers are hesitant to provide LED and fog for two reasons. Initially, farmers would prefer not to have the system disturb them while manually removing the animals during the day and at night. Secondly, LED lights and fog lack sufficient power to either be a threat to animals or drive them away [10].

A proposed system that continuously monitors animals by recording video, analyzes the recordings using machine learning, and notifies the farmer. The farmer should quickly come back to the farm to eliminate the dangerous object. Agriculturalists have their own lives. If they have the time to evict the attacking animals, they have better refrain from purchasing the system and incurring its expenses [4].

Continuously utilizing the system to observe animals is an excellent approach to guarantee the farm's safety. Conversely, prioritizing the safety and convenience of people is essential. 24/7 signifies continuous availability, day and night. The system evacuates animals using an acoustic sound gun. The sound evokes panic among individuals when it occurs at 3:00 AM. [2].

A study using the RTPPS algorithm to safeguard farms with infrared cameras, transmitting SMS notifications to the owner, and utilizing gray coloration to identify the presence of animals for eviction via siren activation. RTPPS disregards cost efficiency if a Personal Computer (PC) is attached to the camera for photo processing following the signal reception from Raspberry Pi. [1].

An approach uses two ultrasonic sensors to identify animals without the use of cameras, ensuring accurate detection of the object, as ultrasonic waves can detect any moving entities. The system will expel humans, including farmers, who walk around the farm [3].

The latest study proposed a system utilizing sensors that do not assist farmers in safeguarding their farmland from animals. For instance, temperature and humidity sensors, as well as soil sensors. Additionally, the system captures an image of the farm and evaluates it to determine the presence of an animal. Animals may infiltrate the farm after the initial photograph is taken, perhaps causing damage prior to the following image capture. A PC is an integral component of the system alongside the Arduino. Given this complicated structure, the animal ought to be removed by the farmer [13].

SecFarm is an efficient and automated system that provides accurate and cost-effective solutions that meet the specific needs of farms. It utilizes a Passive Infrared sensor (PIR) sensor, Light Dependent Resistor (LDR), camera, and speaker interconnected with one another. The farmer can remotely activate and deactivate the SecFarm system to automate the entire process from detection to eviction, eliminating the need for human intervention and preventing harm to the trespassing animals.

IV. PROPOSED NOVEL METHODOLOGY

A. Methodology

Comparing existing systems with SecFarm, SecFarm is an application developed utilizing high-performance sensors on the hardware side while providing superior results on the software side as depicted in table II. Compared to existing solutions, the SecFarm application emphasizes farmer convenience by offering two essential characteristics. Observe the farm remotely with an in-depth report issued at the end of

each day. Automatically evict the selected assault animals or livestock. Fig. 2 depicts the procedure for safeguarding farms. The farmer would configure the application to "run" mode when necessary or switch it to "cease" mode when not required. In run mode, the system is activated to identify, classify, and remove the assault animal from the farm by emitting a sound. SecFarm is a fully automated system reliant on hardware and software. The hardware contains various sensors and a processor, while the software resides within the processors, such as an Arduino, a Computer, or within the cloud. SecFarm utilizes a Wi-Fi-enabled Arduino system integrated with sensors. This Arduino connects to the cloud via the internet to analyze the taken images, subsequently determining whether to evacuate the animal or leave it based on the farmer's choices via the SecFarm application as explained in algorithm 1.

Algorithm 1 SecFarm Object Detection Methodology

Require: Light Dependent Resistor LDR, Passive Infrared Sensor PIR, Object Caption OC, Cloud, Connectivity $WiFi$, Speaker, Report.

Ensure: Running or Sleepy Mode chosen by the farmer through the SecFarm App.

LDR is running for light detection when the farmer runs the application
if LDR detects light **then**
  SecFarm in Running Mode and sensors begin to sense
  PIR starts sensing the heat energy
  if PIR sensed a heat energy **then**
    PIR notifies the system that an object is passing
    The system turns on the camera
    The system takes a OC
    Internal system takes OC and introduces it to DL Model in the cloud
    The Cloud receives the captured object
    Deep Learning Model uses OC as an input
    The model classifies the object in OC
    The model outputs animal species
    if The animal is harmful **then**
      Alter the system to the risk mode
      The cloud sends a signal to the internal system
      The internal system produces animal distress calls for 30 sec.
      SecFarm turns activation status to safe mode
      Generate a report and send it to the owner and MoA
    else
      PIR is sensing
    else
      SecFarm maintains on Sleepy Mode
    end if
  end if
end if

B. The End User

In all systems, the end user is the most critical component, as systems are designed with the end users in mind. SecFarm's cloud generates a daily report to record and document the actions performed during the day. The completed report is finalized in the cloud and generates two copies. A copy will be dispatched to the owners to notify them of the situation on the farms including the animal's detection, risk assessment by classifying it, eviction, and eviction time, then enabling the owners to determine whether to continue utilizing SecFarm or to suspend its use due to the absence of detected animals. This would accomplish cost efficiency. The duplicate will be dispatched to the Ministry of Agriculture (MoA). The MoA archives the report for reference in the country's statistical analysis.

V. Experiment and Validation of the Proposed SecFarm System

A. Model (software)

SecFarm is an application that requires high-performance characteristics. To attain the desired outcome, utilizing YOLO v11m is currently the most suitable model that fulfills SecFarm's specifications [20]. SecFarm application has assembled an effective dataset of over 9,000 photos utilizing one of the advanced YOLO models, specifically YOLO v11. Various methodologies exist to train models. The research may select from any of the accessible hardware accelerators. Utilizing the dataset in SecFarm, I used a T4 GPU. The T4 GPU utilizes up to 100 epochs or more, regarded as one of the rapid accelerator processors used by Google Colab. Google Colab is a platform employed for model training [6]. If the researcher opts to utilize the T4 GPU in Google Colab, it indicates that the T4 GPU employs 40 GB of RAM to execute the model. The author of this research assesses the model on a device with the following characteristics. Core i5 processor, 16 GB of RAM, and a 512 GB Solid-State Drive (SSD) for data storage. Fig.? illustrates the evaluation of SecFarm's results, while Fig.3 presents the Confusion Matrix generated by the model.

To demonstrate the high quality of the selected dataset, In Fig. 4 Precision, mean Average Precision at 50, and Recall. Precision and mAP50 exceed 80%, indicating a satisfactory outcome that may provide the farmer with accurate detections, while the final parameter approaches 80%. These parameters have been used to demonstrate the model's accuracy [14].

Conversely, confusion metrics significantly influence the model's outcomes. The diagonal line illustrates the correlation between the model's prediction of the captured object and the actual object. The higher the saturation of the square, the more closely the prediction aligns with the real object. The lighter square depicted in the illustration indicates a partial match with other animals, suggesting proximity to reality. Some people occasionally mistake a cheetah for a tiger at first glance.

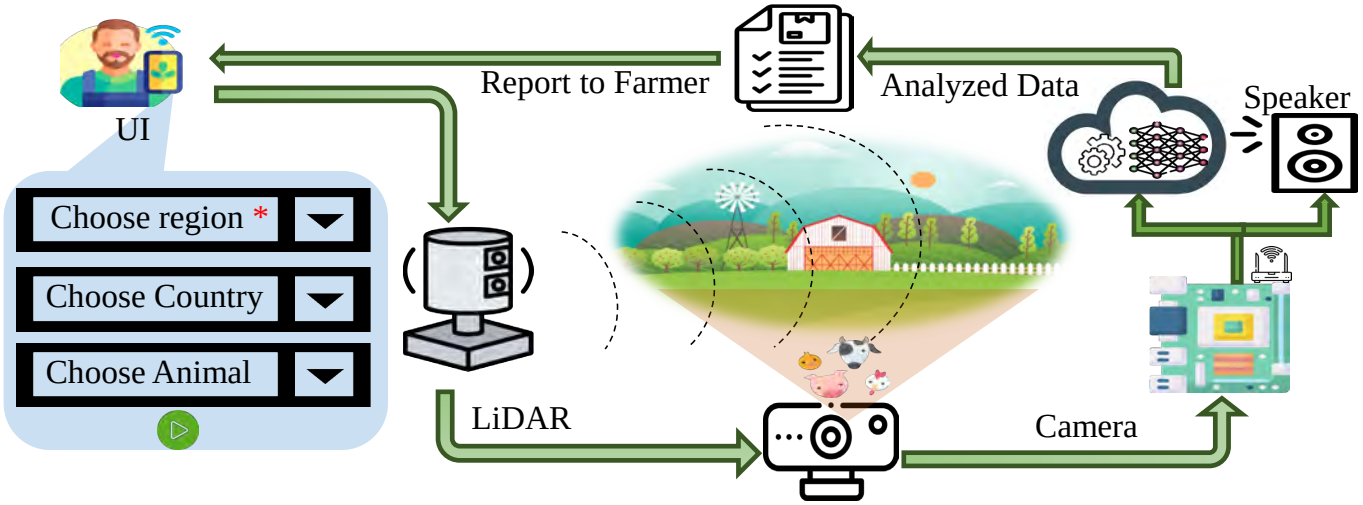

Fig. 2. Architecture of the Proposed SecFarm system

Fig. 3. Obtained Confidence Interval from the Proposed SecFarm Object Detection Model

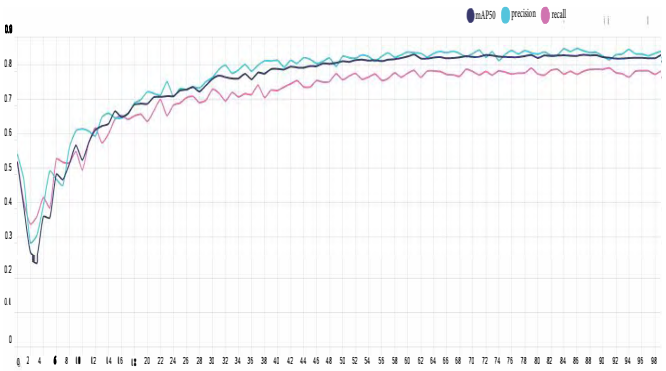

Fig. 4. Obtained Confidence Interval from the Proposed SecFarm Object Detection Model

B. Dataset

SecFarm aims for superior quality outcomes. To attain the desired outcome, the selection of the dataset plays a crucial role. SecFarm utilizes an online dataset of animal species known as the "Wild Computer Vision Project" [16]. The "Wild Computer Vision Project" is a dataset of over 9,000 original photos annotated to 11,000 images. The quantity of photos improves the dataset's quality and the precision of the outcomes.

Fig. 5 illustrates the Size Distribution, a parameter of Dimension Insight, with an average ranging from 0.00 mp to 34.56 mp. It illustrates the clarity of the dataset's photos. The little square in the bottom left corner denotes the median width and height of the photos. This square denotes the pixels at 416 by 400, which is the median picture ratio, with 416 positioned on the X-axis and 400 on the Y-axis. Of the 9,442 photos in this collection, the bulk, consisting of 5,270 images, are of medium size and feature hues of green located between purple and yellow. 3552 photos are depicted in purple and are of an acceptable large size. The reset images are red and tallow-colored. There are 276 photos in the yellow area that are overly small, and 329 random dots that are excessively huge. The great resolution of the photos demonstrates the quality of the dataset employed in the SecFarm application. Utilizing this dataset to train the YOLO v11 model guarantees farmers' fulfillment with the SecFarm application.

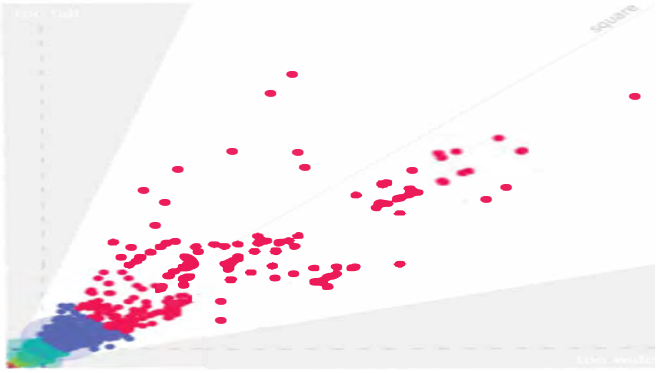

Fig. 5. Size Distribution of the Dimension Insight

TABLE II
SECFARM VS. EXISTING SYSTEMS METHODOLOGIES

Authors	Model type	Accuracy	Confidence Interval	Dataset	Fully Automated?
Manikandan, et al. [10]	None	NA	NA	NA	No
Chandralekha , et al. [4]	MobileNetV2	95%	NA	NA	No
Charles, et al. [2]	None	NA	NA	NA	Yes
Borah, et al. [1]	None	NA	NA	NA	Yes
Chitra, et al. [3]	None	NA	NA	NA	Yes
Raksha , et al. [13]	KNN	76.9-83.5%	NA	1251 images	No
SecFarm	CNN	87%	High Confidence Interval	9442 images	Yes

VI. CONCLUSION AND FUTURE RESEARCH

The present research examines a system within the IoT framework known as Secured Farm (SecFarm). Farmers utilize it to assist with animal eviction procedures. SecFarm offers farmers a means to evacuate aggressive animals without causing harm to either the farm's production or the animals, utilizing effective hardware and software solutions. The SecFarm program will immediately launch animal detection upon the farmer pressing the run button in the application interface. Ultimately, the farmer can review a report detailing the actions undertaken by SecFarm to keep him informed. A duplicate is transmitted to the Ministry of Agriculture via the cloud for record-keeping purposes.

Future enhancements to SecFarm will include an expanded dataset featuring a greater variety of animal species and the use of a more efficient YOLO model for training. Additionally, SecFarm may incorporate supplementary solutions that enhance security for agricultural operations.

REFERENCES

[1] S. Borah, R. Kumar, and S. Mukherjee, "Study of rtpps algorithm in uwb communication medium for a surveillance system to protect agricultural crops from wild animals," in *IEEE International Symposium on Smart Electronic Systems (iSES) (Formerly iNiS)*, 2020, pp. 121–126.

[2] P. Charles, S. Dharmalingam, M. Baskaran, P. Manoharan, and G. Hemanth, "Intelligence harmless animal avoider in agriculture farm," in *International Conference on Computer Communication and Informatics (ICCCI)*, 2023, pp. 1–4.

[3] K. Chitra, A. Tamilarasi, M. Pyingkodi, K. Nanthini, V. Sneka, S. Swetha, and P. Vishalini, "Animals detection system in the farm area using iot," in *International Conference on Computer Communication and Informatics (ICCCI)*, 2023, pp. 1–6.

[4] C. E, T. P, R. S, and V. K, "Animal intrusion detection system: Protected crops and promoted safety using machine learning," in *International Conference on Research Methodologies in Knowledge Management, Artificial Intelligence and Telecommunication Engineering (RMKMATE)*, 2023, pp. 1–5.

[5] Food and Agriculture Organization of The United State, "Land use in agriculture by the numbers," https://www.fao.org/sustainability/news/detail/en/c/1274219/, May 2020.

[6] Google, "Explore the gemini api," colab.research.google.com/, 2017, accessed: Oct. 10, 2024.

[7] IBM, "What is computer vision?" https://www.ibm.com/topics/computer-vision, accessed: Oct. 5, 2024.

[8] S. P. M. M. Shamsa, L. Rachakonda and E. Kougianos, "qcrop: An iot based framework to enhance crop productivity in smart agriculture," in *in Proceedings of the 32nd IFIP/IEEE International Conference on Very Large Scale Integration (VLSI-SoC)*, 2024.

[9] T. Manikandan, S. J. Kumaresan, A. Muruganandham, V. Nandalal, and Babuji, "Iot based animal detection and alert system for farm fields," in *International Conference on Communication, Computing and Internet of Things (IC3IoT)*, 2024, pp. 1–3.

[10] T. Manikandan, S. J. Kumaresan, A. Muruganandham, V. Nandalal, and R. Babuji, "Iot based animal detection and alert system for farm fields," in *International Conference on Communication, Computing and Internet of Things (IC3IoT)*, 2024, pp. 1–3.

[11] S. P. Mohanty, U. Choppali, and E. Kougianos, "Everything you wanted to know about smart cities: The internet of things is the backbone," *IEEE Consumer Electronics Magazine*, vol. 5, no. 3, pp. 60–70, 2016.

[12] E. Paunova-Hubenova and E. Trichkova-Kashamova, "Smart solutions for control and management in livestock farms," in *Big Data, Knowledge and Control Systems Engineering (BdKCSE)*, 2021, pp. 1–7.

[13] R. R and S. P, "A cohesive farm monitoring and wild animal warning prototype system using iot and machine learning," in *International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE)*, 2020, pp. 472–476.

[14] L. Rachakonda, S. P. Mohanty, E. Kougianos, and P. Sundaravadivel, "Stress-lysis: A dnn-integrated edge device for stress level detection in the iomt," *IEEE Transactions on Consumer Electronics*, vol. 65, no. 4, pp. 474–483, 2019.

[15] S. Roberts, "Feed vs. food: How farming animals fuels hunger," https://awellfedworld.org/issues/hunger/feed-vs-food/, May 2020, accessed: Oct. 01, 2024.

[16] roboflow, "Wild computer vision project," https://universe.roboflow.com/animal-ihvth/wild-cpbq1/browse?queryText=pageSize=50startingIndex=0browseQuery=true, April 2024, accessed: Oct. 10, 2024.

[17] M. Roser, "How many animals get slaughtered every day?" *Our World in Data*, 2023, https://ourworldindata.org/how-many-animals-get-slaughtered-every-day.

[18] P. Sundaravadivel, E. Kougianos, S. P. Mohanty, and M. K. Ganapathiraju, "Everything you wanted to know about smart health care: Evaluating the different technologies and components of the internet of things for better health," *IEEE Consumer Electronics Magazine*, vol. 7, no. 1, pp. 18–28, 2018.

[19] Texas Farm Bureau, "Farm labor resources and information," https://texasfarmbureau.org/advocacy/farm-labor-resources/, 2022, accessed: Oct. 5, 2024.

[20] Ultralytics, "Ultralytics yolo vision 11," https://docs.ultralytics.com/, 2024, accessed: Oct. 10, 2024.

[21] United Nations, "Our growing population," https://awellfedworld.org/issues/hunger/feed-vs-food/, May 2020, accessed: Oct. 5, 2024.

[22] University of Illinois Chicago, "What is (ai) artificial intelligence?" https://meng.uic.edu/news-stories/ai-artificial-intelligence-what-is-the-definition-of-ai-and-how-does-ai-work/, May 2024, accessed: Oct. 1, 2024.

[23] Y. Wu and K. Takács-György, "Sustainable paths to food security from the perspective of food loss and waste management," in *IEEE 21st Jubilee International Symposium on Intelligent Systems and Informatics (SISY)*, 2023, pp. 000 437–000 444.