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Detect Wild Animals and Alerts in Mountain Regions

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Abstract: *Wildlife populations throughout mountainous environments cause frequent human-wildlife confrontations which endanger human safety as well as animal well-being. An intelligent alert system detects wild animals in the area to enhance safety standards. This system utilizes Arduino UNO microcontroller as its central processing unit to implement various sensors and communication interfaces which enable quick real-time monitoring and responsive capabilities. The system incorporates six main components that consist of an ultrasonic sensor together with an ESP32 CAM and a DF Mini player and speaker and LCD display and a Node MCU module with SMS and GPS capabilities. The ultrasonic sensor maintains constant operations as it conducts surveys of the environment for any movement. After the detection, the ESP32 CAM system takes images that an analysis process verifies the presence of wild animals. The Arduino UNO functions to start the alert process if data verification is completed successfully. The LCD panel shows current device statuses which enable user monitoring. The DF Mini player operates through a speaker to warn away animals as it detects them with its sensor input. Node MCU modules perform two tasks by simultaneously delivering SMS alerts containing GPS data to authorities who can respond quickly. A dedicated power supply operates this system to maintain continuous functionality irrespective of remote settings. The system demonstrates efficiency in detection and notification functions which gives it reliability as a solution to minimize human-wildlife confrontation, Monitoring technology acts as an early warning system which supports the safe tracking detection of hikers and forest officials and creates better conditions for wildlife human coexistence. Multiple technology applications within this system create an efficient and cost- effective implementation for wildlife monitoring alongside mountain region conservation.*

Keywords: Animal detection, Wild animal monitoring, Alert system, ESP32 camera, Ultrasonic sensor, NodeMCU, Arduino UNO

I. INTRODUCTION

The animal species present in mountain regions include leopards together bears and elephants and wild boars. The important ecological functions that this animal perform get in conflict with human settlements when they enter populated areas. Many wild animals are compelled to enter mountain regions and farmlands because deforestation and habitat destruction create shortage of food and water due to climate change. Moreover, the unauthorized access leads to damages in private property as well as ruined drops and occasional violent actions against human and their livestock. The remedies used in the past for managing these conflicts including manual patrolling and fencing have failed to provide sufficient resolutions. A modern technologies based solution must detect wild animals in real time to generate timely alarms which stop dangerous wildlife encounters.

Human wildlife conflicts in mountain areas recover automated detection and alert system because these occurrences keep increasing. A detection system needs to recognize untamed animals during their entry into human residential areas and generate instant notifications for both official responder's community residents. Real time detection and image acquisition and alert creation becomes possible through smart system because they go past human observation based

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traditional methods. This system successfully combines sensors with cameras as well as communication modules to take prompt detection which reduces both human injuries and death risks.

GPS position data that gets delivered to both resident and wildlife officials after an animal recognition event. A DF Mini player connected to a speaker through an audio deterrent system can create loud noises which successfully drive away animals away from human population areas. Through this combination of hardware along with its associated software communities gain sufficient information and preparedness in responding to wildlife intrusions.

A smart wild animal detection together with an alert system presents an effective solution for improved human-wildlife interactions in mountainous areas. The system enables residents to prevent themselves through staying inside their homes or protecting their livestock because of its timely alert functions. The implementation of these programs reduces the necessity to use detrimental wildlife control methods such as trapping or killing because they harm the natural ecosystem. The tracking of animal movements with their natural patterns enables environmental scientists to establish better protection methods for endangered species and their natural environments. The system promotes safety through wildlife management while encouraging respect for nature to maintain a balanced relationship between human population and wildanimal.

II. RELATED WORK

The Detection of wild animals has become a priority in current times because it provides critical benefits for wildlife conservation alongside assisting human wildlife conflict resolution. The traditional methods for wildlife observation through patrolling and camera trapping require intensive labor and extensive time and do not effectively generate real time notifications. Researchers employed sensor based as well as image processing along with IOT enabled methods to develop improved detection systems of wild animals through technological progress. Ultrasonic sensor represent one of the most popular methods because they identify objects through measuring reflected sound waves. Several wildlife system detection systems use these sensors to detect animals moving toward or away from a specific area because they provide a dependable yet affordable method. Studies apply infrared and thermal sensors to discover warm blooded animals especially in circumstances where standard cameras demonstrate reduced performance under low light or dense bushy regions. The use of microcontrollers especially Arduino Uno enables effortless combination of sensors and communication in modules for wildlife monitoring systems. The widespread application of Arduino based systems occurs because they provide affordable solutions combined with straightforward programming options and support numerous peripheral devices. Researchers and forest rangers together with farmers benefit from real time status report thanks to the integration of LCD displays with Arduino in varied studies. Through IOT based solutions wild animal detection has achieved complete transformation by offering remote monitoring systems with automatic alert capabilities. Research makes extensive use of NodeMCU modules because these devices enable wireless data transmission to cloud platforms and mobile devices. The combination of GSM and GPS modules enables researchers to establish systems which trigger SMS alerts and transmit GPS positions about detected animals to enable prompt authority intervention. Quick alert systems have demonstrated have demonstrated their success at detecting elephants in areas that regularly experience such animal activities. The research on wild animal detection requires developing methods to keep animals outside human habitations and defined boundaries. The DF Mini player modules connected to speakers serve as sound based deterrents to warn animals away by playing warning sounds and distress calls. Science demonstrates that both predator sound effects and high frequency noise signals successfully prevent deer as well as elephants and wild boars from entering farmlands and residential areas. Some modern systems make use of flashing LED lighting features as well as ultrasonic repellent units to reinforce their deterrent measures. Through working with enormous animal image database machine learning software develops the ability to detect animal species and track movement patterns along with distinguishing humans from wildlife. Studies now use LiDAR technology for exactly identifying animals within dense forest environments. Modern technologies breakthroughs in wild animal detection face various ongoing difficulties. False alarms together with environmental components including harsh weather or thick vegetation reduce the precision of sensor based and image processing systems.

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III. METHODS AND MATERIALS

A methodology description follows that explains the system development process which integrates Arduino Uno devices with sensors and communication components and alert systems. The planned system works by detecting obstacles and taking pictures before sending alerts which includes audio notifications. The system functions through an assembly of Ultrasonic sensor and ESP32 Camera with LCD display and DF Mini Player and NodeMCU under control of Arduino Uno.

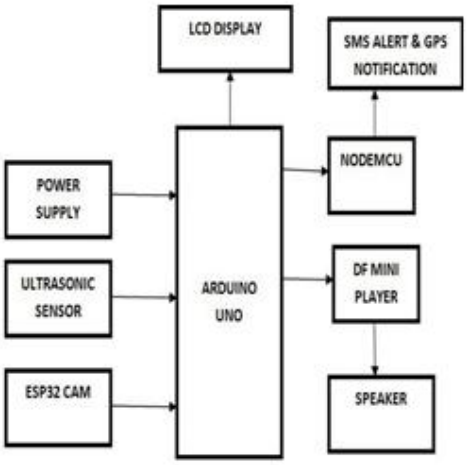

FIGURE 1. Block Diagram SYSTEM ARCHITECTURE

The system uses microcontroller based structure with the Arduino Uno unit as its primary processing elements. The Arduino Uno system uses different peripherals and sensors that connect to it to implement specific tasks. This system follows these operations: Arduino Uno, power supply, ultrasonic sensor, ESP32 Camera, LCD Display, NodeMCU, DF Mini Player and SMS alert and GPS notifications.

ARDUINO UNO ATMEGA 328P

Arduino Uno, The Arduino Uno microcontroller board serves as the core component because it analyzes sensor information before managing output signals to all connected elements. It functions as the central interface the acquires Ultrasonic sensor and ESP32 Camera signals before directing LCD display and Speaker activities together with the communication modules. The Arduino Uno was selected because it provides simple programming and reasonable cost together with broad sensor and module compatibility.

FIGURE 2. Arduino UNO atmega 328p POWER SUPPLY

The alerts system depends on consistent power supply because it needs to work continuously even in distant mountain settings. The system can be powered by the combination of rechargeable Li-ion solar panels along with DC power adapters represents suitable solutions for settlements.

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ULTRASONIC SENSOR

FIGURE 3. Ultrasonic sensor

The motion detection performance of the Ultrasonic sensor relies on transmittance ultrasonic waves and record the signal return time. The sensor technique identifies the proximities of animals as well as humans across a set distance.

ESP32 CAMERA

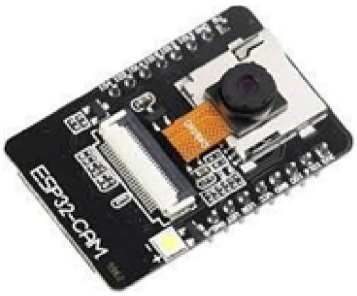

FIGURE 4. ESP32 Camera

The ESP32 Camera represents a wireless camera module which records video and image data from detected items. The system allows wildlife monitoring through following features:

The system enables remote monitoring with Wi-Fi or mobile networks to perform surveillance duties. The research organization can save visual data for analysis and the development of new insights. Identification of animals and differentiation between wildanimals and human movement rely on the ESP32 Camera as a fundamental component.

LCD DISLAY

FIGURE 5. LCD Display

The interface incudes a real-time display system that shows feedback and alerts through an LCD screen. The display screen uses liquid crystal technology to present such information. The screen allows field personnel including researchers and forest rangers to check how the system works while they are present.

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NODEMCU

FIGURE 6. NODEMCU

The NodeMCU functions as an IoT device distribute SMS alerts together with GPS notifications. The system sends text alerts automatically when an animal detection event occurs to forest personnel or people in the nearby area.

SMS ALERT AND GPS NOTIFICATIONS

The technology allows users to occur GPS location coordinates that help with tracking and promote safety during emergencies. Users can establish connectivity to real-time monitoring system based in the cloud.

DF MINI PLAYER

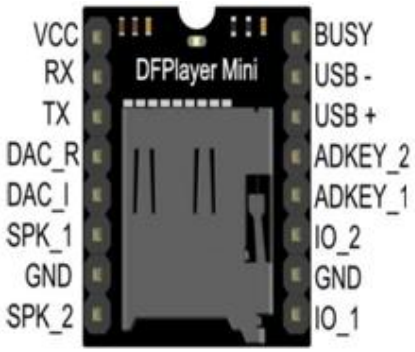

FIGURE 7. DF Mini Player

The DF Mini Player functions as a portable audio module which stores multiple sounds before it plays them back. The speaker plays alert sounds through the connection to the DF Mini Player device. The installation of loud sirens serves to frighten animals from the area. Stimulated predator sounds including tiger roars and wolf, howls are used as well.

SPEAKER

FIGURE 8. Speaker

The speaker is used in conjunction with the DF mini player to produce audible warnings.it plays alarm sounds or predator calls to deter animals from approaching human populated areas or mountain areas. The speaker volume and

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frequency can be adjusted to ensure maximum effectiveness. Arduino triggers the DF mini player to send an audio signal to the mini speaker which then converts it into sound. The feature enhances user interaction and accessibility, especially in cases where users may not always check the LCD display. This speaker can play warning sounds, voice messages or alert beeps, ensuring that important information is conveyed instantly.it operates on low power (3.3 to 5V) and allows for volume adjustments to suit different environments.

IV. PROPOSED METHODOLOGY

The system functions as a detection platform that provides real time warnings about mountain wildlife to humans through wireless connectivity and sensor networks. The solution operates through an integrated system which includes the Arduino Uno board with ESP32 Camera devices along with NodeMCU units and RF Mini Players and Ultrasonic sensors and LCD Displays which operate independently to warn users through sound alerts alongside visual imaging.

INITIAL SETUP AND POWER DISTRIBUTION

The power system design should maintain constant power levels across all devices particularly during unattended operations in remote locations. The designed power system must deliver adequate power to operate all components including the ESP32 Camera and Arduino Uno and NodeMCU plus the Ultrasonic sensor and RF Mini Player. Examination of solar powered system that incorporate battery storage will show how to maintain uninterrupted system operations.

WILD ANIMAL DETECTION MECHANISM

Ultrasonic sensors perform ongoing scans to detect objects approaching the system from its environment. The Arduino Uno system performs sensor data processing whenever objects enter the detection range. The ESP32 Camera triggers video or image recording following the detection of wildlife animals. A detection system controls camera operations through motion based algorithms that minimize power consumption.

IMAGE CAPTURE AND IDENTIFICATION

The Wi-Fi connection allows captured images to transfer for processing on server or cloud platforms controlled by the NodeMCU device. The system requires machine learning algorithms to examine photos which decide whether an animal poses a threat to public safety. The system triggers alert to allow authorities to manage troublesome wildanimals

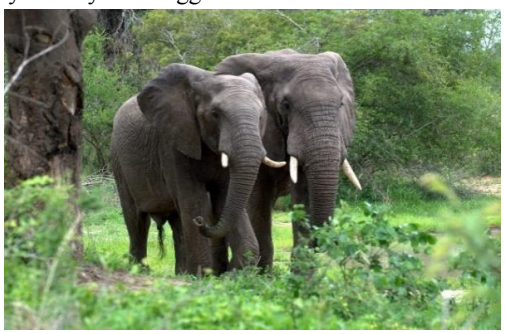

FIGURE 9. Image Capture

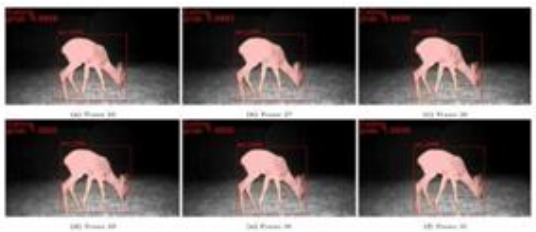

FIGURE 10. Image Processing ALERT MECHANISM

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The RF Mini Player sends alarm sounds to warn animals off from protected areas. The system features remote alert transmission capabilities through NODEMCU which direct notifications to both local personnel and authorities. The NODEMCU serves as a platform to transmit both mobile device notifications and images to servers.

DATA TRANSMISSION

The NODEMCU enables real time communication to take place between the system and remote monitoring stations. The NODEMCU sends combined information that contains ESP32 Camera photo data together with senor readings and warning messages to basic servers or cloud systems. Alert reach users through SMS messages alongside email systems and mobile application alerts for instances based responses.

LOCAL DISPLAY

User obtain access to information by utilized LCD displays that residents can find at their installation site. The system will display local display data depicting detected animal status. An interface through the system shows the status of the warning system to show the current alarm activation state. The stand-alone device display enables users at the sight to monitor system status functions as a single device.

POWER EFFICIENCY

The system design requirements stress power efficiency as a top priority. The ESP32 Camera and NODEMCU together achieve power conservation through their sleep state capabilities that keep power consumption low between data exchanges. The Ultrasonic sensors requires activation during essential events yet operates independently from the RF Mini Player unless security alerts trigger its activation.

STEPS FOR SYSTEM IMPLEMENTATION HARDWARE SETUP

The Ultrasonic sensor requires connection to an Arduino Uno board. The ESP32 Camera unit requires connection with the NODEMC for wireless internet data exchange. The RF Mini Player must undergo setup for warning sound protection when system detected animals occur. A status notification display requires its connection to Arduino Uno or NODEMCU to operate.

SENSOR AND DETECTION LOGIC

The Arduino Uno demands programmed instructions to activate the Ultrasonic sensor and decode distance information. The detection system employs sensor that stand for objects with in specific areas to detect wild animals before activating an ESP32 Camera trigger.

WIFI AND DATA TRANSMISSION

Detail the NODEMCU nodes development process to control Wi-Fi connections for moving alerts and images to a central server.

ALERTING AND COMMUNICATION

The DF Mini Player system operates by receiving instructions that activate auditory alerts when wildlife detection occurs. The system needs SMS capabilities combined with email alerts and application notifications to reach nearby workers during wildlife detection events.

TESTING AND CALIBRATION

Field tests should be conducted outdoors to modify the Ultrasonic sensors detection range capabilities. Test the image capture capability and transmission functionality of the ESP32 CAM and NodeMCU systems. Design supplementary power systems that are capable of sustaining outdoor long-term observation functions.

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V. RESULT AND DISSCUSSION

The system receives power from a power supply to provide reliable operations in remote areas without grid connections. Wild animal detection operates through an ultrasonic sensor that tracks object distances within its range to produce alerts. The ESP32 Camera functions as an image or video recorder to document detected entities which leads to identification processes and potential subsequent actions. The Arduino Uno operates as the systems main processing unit to receive sensor information and camera input and manage device outputs. The detection of wildlife triggers LCD displays information that helps both individuals present at the scene and authorized personnel prepare appropriate responses. The activation of the DF mini player will emit loud noises from the speaker through prerecorded audio content to detect the animal from the site.

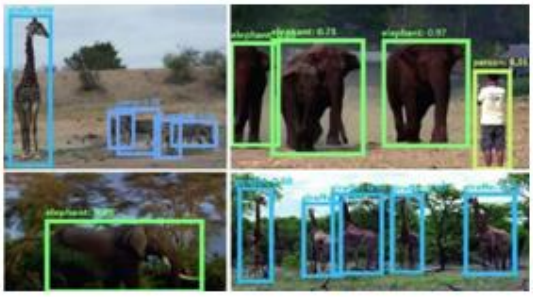

FIGURE 11. Animal Identification

The NodeMCU module delivers SMS alerts and GPS notifications simultaneously to both local authorities and forest officer. This allows for prompt response while maintaining public safety. The system operates through Arduino Uno based platform which detects wildlife in mountains and generates immediate notification alerts. Multiple components such as sensors and communication modules combine with alert systems within the block diagram system to boost safety during operations in remote locations. An ultrasonic sensor provides essential functionality by monitoring distance changes to detect animals. The system utilizes an ESP32 Camera module to record photos and videos which assists with visual animal recognition. The Arduino Uno functions as the systems main processor that gets information from sensors before performing data computations. Users receive prompt onsite information through the LCD display which enhances their situational awareness.

The alert system gains strength through its implementation of a NodeMCU module that sends GPS notifications together with SMS alerts to both authorities and relevant individuals. The system sends SMS alerts together with GPS notifications to authorities which allows for prompt intervention and protective actions. Wild animals stay away from human settlements through the DF mini player's speaker warnings which are programmed into the device. The system power supply ensures smooth in remote locations.

The consolidated system achieves efficient automated detection through its components which reduces human wildlife confrontations. The combination of real-time alerts and deterrence mechanisms raises security levels in mountainous terrain by stopping potential meetings between humans and wild animals. The system's operating capability becomes more precise through Artificial Intelligence implementations which advance species ID and behavior observation. The rise of human wildlife conflicts requires prompt detection of wildlife and alert systems because of deforestation conditions combined with encroaching habitats and changing climates. The system working schematic composed of Arduino Uno and four other modules including ESP32 Camera, Ultrasonic sensor, LCD Display, NodeMCU and DF mini player and Speaker functions to monitor and alert in real-time.

VI. CONCLUSION

A comprehensive smart animal detection system along with notification capabilities stands as the foundation of the diagram for identifying wild animals in mountain territories. This system relies on the Arduino Uno as its main processing unit to unite sensors and communication platforms that identified and warn authorities or residents to impending dangers. The ultrasonic sensor serves as the movement detector which identifies objects existing within

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defined distance ranges. The sensor performs continuous area scanning that triggers signals to Arduino after detecting an obstruction. By integrating the ESP32 Camera module the detected entity becomes visible through real time imagery or video feed. The LCD Display displays both system status information and critical warnings and essential information.

The system activates several automated protective systems whenever it identifies an animal intruder. The DF mini player operating through a speaker produces undesirable noise to keep animals at a distance from urban areas. Through wireless communication capabilities of the NodeMCU module the system can transfer SMS alerts and GPS notifications to authorities and residents for timely responses. The system depends on a dependable power source for processing data because uninterrupted functionality is particularly important for remote mountainous areas. This wild animal detection platform functions as an essential innovation that protects settlements built in mountain territories. Consisting of sensor based detection. This system produces protective measures that minimize animal assaults while stopping animals from attacking humans and promotes sustainable human wildlife interactions through warning systems.

VII. FUTURE SCOPE

The mountain area wild animal detection system exhibits substantial potential to grow and scale up in the future. The existing model implements Arduino Uno along with ultrasonic sensors combined with an ESP32 Camera module as well as an LCD Display and a DF mini player with built-in speaker and NodeMCU to operate SMS alerts and GPS notifications. The system includes essential components that allow continuous live monitoring while simultaneously enabling prompt reactions which helps create a successful approach to stop human wildlife conflicts. The future development of this system involves AI based image recognition technology to achieve precise animal classification detection. Algorithms paired with ESP32 Camera. The implemented classification system enables authorities to respond correctly according to each detected animals. The system would benefit from an upgrade to solar power operation which makes it sustainable and efficient for areas lacking electricity in remote mountainous regions. The enhancement of the communication module represents an essential future development area. Future updates of the system will use Lora technology to transmit data over extended distances at lower power levels instead of using NodeMCU based SMS and GPS notifications. It provides advantages in forests and rocky path locations that lack strong cellular network access. The establishment of a cloud database will enable researchers and conservation to analyze wildlife behavior patterns through stored information about animal movement patterns. This system establishes integration capability through partnership with drones to conduct aerial surveillance activities. A thermal camera drone activities automatically after animal detection to monitor their movements thus the system delivers an enhanced method for wildlife observation. The system provides great value to conservation areas and national parks because it simplifies the challenging task of tracking through manual methods. The future advancement includes integrating an automatic alarm system into the framework. The DF Mini Player along with the speaker generates sound alarms which functions as animal repellents. The effectiveness of protecting human territories from wild animals gets enhanced by integrating smart deterrent features containing LED flashlights along with Ultrasonic repelled systems as well as scent based repellent options. Different security measures exist that adjust to particular behavioral patterns of various species. The systems have potential for growth since a mobile application for real-time monitoring can be added as an expansion. The ESP32 Camera system uses instant notification features to transmit live video stream data to forest officials as well as authorities and local villagers. The mobile applications allow users to submit animal sightings which contributes to building a network that focuses on wildlife protection. The wild animal detection and alert system presents enormous possibilities for developing its potential in future applications. AI recognition power combined with better communication technologies along with drone capabilities and automatic defense systems partner with mobile applications solutions would result in a smart system for mountain wildlife protection. The introduced innovations will simultaneously protect human safety and preserve wildlife areas which promotes harmonious interactions between human and natural environments.

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