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Original Article

Internet of Wild Things with the Integration of Vision Technology and LoRa Network

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Abstract *- Sustainable Development Goals (SDGs) are significant in protecting the habitat of wild animals and preventing animal fatalities resulting from human development. The construction of land transportation systems through the wildlife habitat has compromised the life of wild animals, thus invoking the implementation of advanced technologies such as the Internet of Things (IoT). Motivated by these aspects, this article proposes a system incorporating IoT and LoRa-based technology to prevent human-wildlife confrontations by creating a real-time warning to commuters about animal movement on the road. The proposed system, consisting of a vision node, a display layer and a data visualization layer, was realized in real time by deploying the system on a selected road on the animal corridor. Vision node data is transmitted through LoRa communication and visualized on the serial monitor.*

Keywords *- IoT, Vision technology, Server, Smart alert, LoRa, Wildlife.*

1. Introduction

The United Nations' SDG 9 (Industry, Innovation, and Infrastructure) and SDG 15 (Life on land) are two significant goals that need to be achieved by 2030 in the context of wildlife [1], [2]. Protecting wild animals' habitats and preventing animal fatalities resulting from human developments are significant areas that need to be addressed [3], [4]. Current highway development resulted in land transportation systems crossing animal corridors, thus swelling the number of human-wildlife conflicts causing fatalities on both sides [5] [6]. Traffic infrastructure worldwide impacts nature, both directly and indirectly, and the physical presence of roads degrades habitats, fragments them, and disrupts biological processes [7]. Wildlife vehicle collisions are frequently observed effects of roads and traffic on the environment, as wildlife remnants are a familiar sight along roadways [6]. According to the report U.S. Public Lands and Rivers Conservation 2021, an estimated 1 million to 2 million collisions between motorized vehicles and wild vertebrates in the United States each year, resulting in approximately 200 human deaths, 26,000 injuries, and at least $8 billion in property damage and other costs. It is estimated that 194 million birds and 29 million animals have been killed annually on European roadways [8]. Over 500,000 wildlife-vehicle collisions are recorded annually in nineteen European nations for ungulates alone [9], with estimates for Europe as a whole topping 1 million per year [10]. Because wildlife corridors are frequently blocked or obstructed by roads and highways, economically important species are cut off from seasonal migration routes, endangering population stability.

According to Uttarakhand's Chief Wildlife Warden Report 2019, over 700 animals have died in incidents. The Ministry of Forestry and Environment reported 460 leopard deaths in 2018, of which the highest number of leopard death is recorded in Uttarakhand, i.e., 93. Since 2001, about 222 animals have died as a result of wildlife-vehicle incidents on NH 74 in the Haridwar forest division in Uttarakhand [11]. All these incidents have paid attention to implementing preventive measures to boost animal safety. The traditional measures implemented by the forest department need can be enhanced, as the govt of India has already implemented camera modules in the forest to monitor the movement of wildlife animals crossing the road.[18] As researchers amass more and better data regarding wildlife movements and collision hot spots, experts and policymakers know where and how to maximize return on investments in wildlife-friendly transportation infrastructure that will benefit humans and wildlife alike. That scientific advancement, coupled with strong bipartisan support for reducing these collisions and conserving migration corridors, validates the need for increased federal efforts to address this issue.

Elephant conflict monitoring has been an integral part of wildlife tracking systems accompanied by other methods in wildlife ecology for observation, assessment, and forecasting of the human environment [12], implementation and identification by means of the Wi-Fi-based wireless controller, consuming transmitter node, pillars consisting of a vibration sensor, an electronic unit with buzzer, laser diode, and laser detector [33], accompanied by global positioning system (GPS) technologies. Wireless sensor network (WSN). Animals that escape from wildlife sanctuaries and natural parks can be monitored [14], random mobility a major cause of network issues, can be tackled by implementing an effective data-gathering device named Location-based Clustering and Opportunistic Geographic Routing (LCOGR) along with a BYPASS beacon-based geographic routing system [15].

An operator by means of a microfilm reader to examine the activities of numerous animals carries a transmitter radio and locations established by triangulation spanning many miles [16]. Currently, the technological advancement in sensors, communication and vision-based technology has enabled to implementation of real-time monitoring systems with hardware implementation. Implementing an IoT-based system in the forest requires an efficient communication system to transmit the real-time in a reliable and scalable manner [8, 17]. Communication like LoRa has inspired the implementation of the IoT in a wide range [31]. With the motivation from these aspects, this study implemented LoRa and a vision node-based system for real-time animal detection on the forest road for the safety of animals and humans moving across the forest road. The main contribution of the study is:

- The study proposed a vision node-assisted architecture for the motion detection of wildlife.
- Realized proposed system and visualized on serial monitor regarding the motion of the wildlife.

Section 2 of this article covers the literature review; section 3 covers the proposed architecture; section 4 covers the real-time implementation of the proposed system, and the article concludes in section 5.

2. Review of Literature

This section presents previous studies that have presented different approaches and implemented different methodologies for wildlife monitoring. Exploiting sink mobility system to collect data from where they are gathered by moving mobile sinks is a typical and difficult operation in a wide range of sensor network applications, ranging from animal monitoring to security surveillance [7]. The use of an Intelligent Trust Collaboration Network System (ITCN) to gather data through interaction with mobile vehicles and Unmanned Aerial Vehicles (UAV) for IoT is proposed to gain the trust of data participants while also ensuring the system's security and privacy [19]. Intelligent video surveillance, based on the IoT, designed from the sensing, network, and application layers, is an important and irreplaceable part of environmental monitoring, command, and rescue. It is especially suitable for remote, large-scale monitoring, and real-time monitoring of animal protection areas [20, 23]. IoT technology is adopted to develop and arrange smart sensors that deliver steady supervising of soil and air quality. The attained data will be demonstrated on a graphical user interface (GUI) which offers real-time data that can be utilized to characterise the existing situations of the area being observed, create trends, and identify any irregularities [21]. There is a significant demand for the implementation of an infrastructure for a smart animal administration platform relying on AI and IoT to automate some tiresome activities for caring for animals using AI and IoT to assist animal administrators in taking better care of and managing them [22].

A method for tracking animals based on learned features of particular animals using a CONDENSATION particle filtration structure can be a significant contributor in a regular intervals model of animal motion premised on the relative locations over all of the time of trackable features at substantial body points by preserving a multi-modal state density inside the particle filtration system over all of the time to allow sustained monitoring of numerous animals [32]. Wireless distributed networking strategies in a wireless sensor network built to assist wildlife monitoring, including custom tracking collars carried by animals consisting of GPS and wireless transceivers, could be used in the event of a lack of cellular communication facilities covering the region [24].

The use of new technologies on sensors and algorithms, aerial platforms, vision sensors on UAVs, and usage of sensors to regulator quadrotors throughout autonomous vehicle monitoring and autonomous landing for supervising poaching activities [25]. A system is implemented to deviate an animal that deviates outside of the GPS-distinct zone, and where a buzzer system situated in the human-populated zone will sound and alert people to the impending danger [26]. Poaching activity can be monitored and curtailed by utilising video traps to keep a closer eye on the protected area.

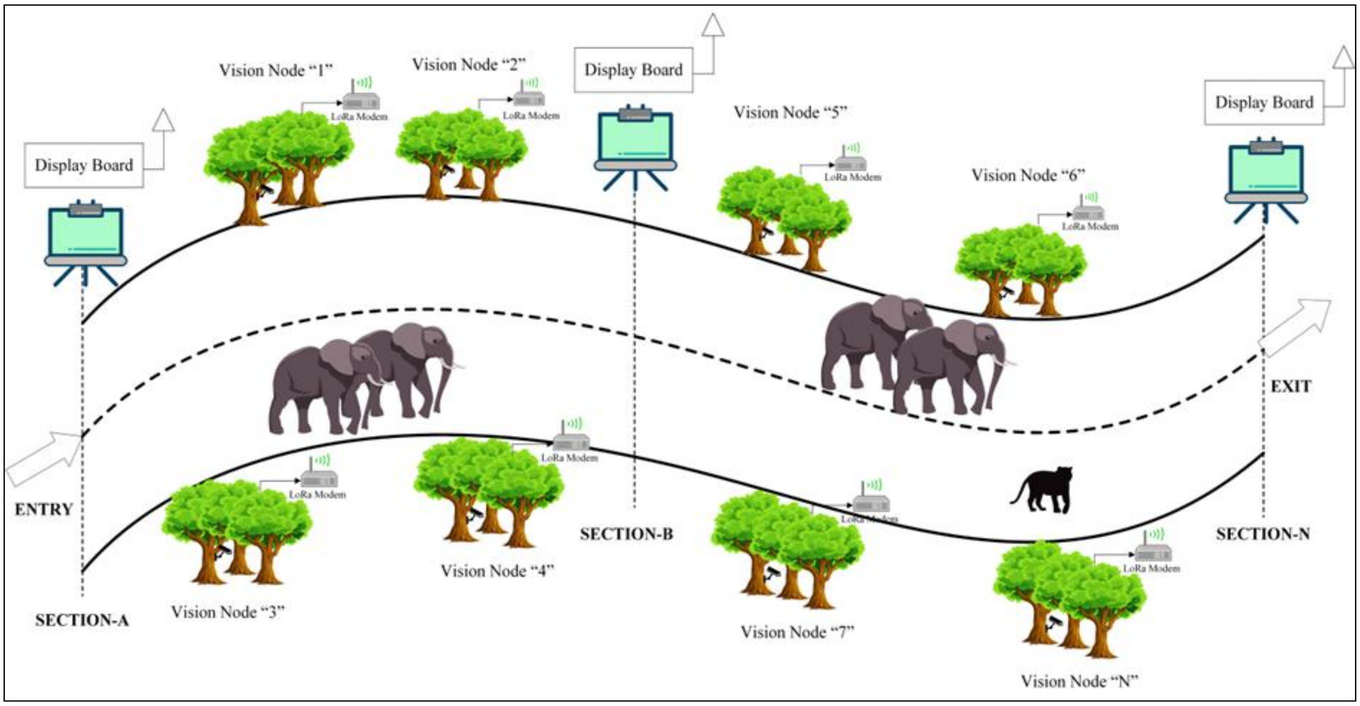

Fig. 1 Vision node-assisted architecture

The images will be analysed with a human detection algorithm based on frame differencing and orientation information [27]. The space-time scan method is used to perform a novel spatio-temporal analysis of attacks on humans by lions, bears, leopards, wild boars, and tigers to evaluate the risks of additional occurrences in the same localities [28]. A cost-effective, distributed, scalable, and resilient cross-camera tracing system for animal intrusion recognition, employing Raspberry Pi devices associated with Raspberry Pi devices implementing object detection, is installed along the borders of sensitive areas [29].

3. Proposed Architecture

With the advancements in the field of IoT and increasing concerns over fatalities related to wild forest animals, along with the efforts for sustainable development, new technologies incorporating advanced digital technologies such as IoT, vision monitoring, and wireless communication have been emerging. This study proposes a hybrid architecture (Figure 1) with a vision node comprising a data acquisition layer combined with a data processing/analytics layer. The vision node communicates the processed data to the warning layer. The processed data is also communicated to the data visualization layer, which with the help of a cloud server, makes the data available on various devices to the concerned authorities or persons. The proposed architecture monitors the movement of wild animals on roads passing through their habitats by capturing, analysing, and communicating the processed data to the display board and thus apprising the commuters about the movement of the wild animals in the nearby zone of the road. The various components of the hybrid architecture have been discussed below.

The vision node (Figure 2) comprises of data acquisition layer and data processing/analytics layer. Data is acquired by cameras installed on trees devoid of anthropogenic and animal activities alongside roads at appropriate distances to cover the entire animal corridor. The camera collects continuous video data of the animal road corridor. The collected data is continuously analysed through the data processing/ analytics layer comprising a computing unit. In case of detecting any animal movement on the road, the computing unit communicates with the warning layer with the help of the LoRa modem installed on both the vision node and the warning layer. The LoRa modem facilitates communication between the vision node and the warning layer in remote locations devoid of internet facilities. The camera, computing unit and LoRa modem are powered by a dual power supply system, which derives power from the battery and solar energy. The vision node also sends the data to the cloud server through a gateway equipped with LoRa and Wi-Fi for data visualization. The data visualization layer enables data access by the concerned person(s) or authority on a mobile or web platform. The warning layer (Figure 3) consists of a LoRa modem, a computing unit, a display and LED lights of red and green colour, all of which are powered by a dual power supply deriving energy from a battery and solar energy. LoRa modem facilitates communication between the warning layer and the vision node. As per the data received by the vision node, the computing unit instructs the display and the LED lights to warn the commuter.

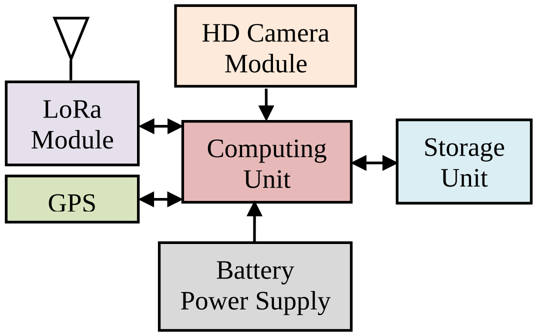

Fig. 2 Vision node

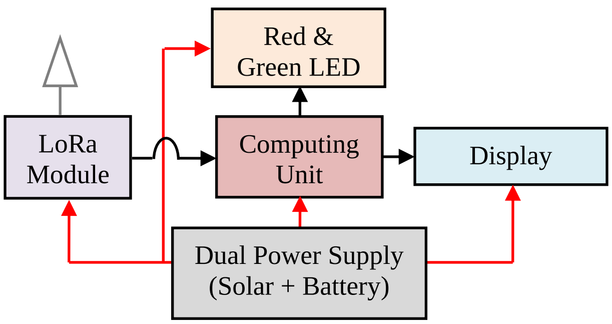

Fig. 3 Warning layer

In case of any wild animal movement on the corridor, the commuters are warned by displaying a warning message on display as well as turning the red LED lights on. In case of no movement of wild animals, the green LED lights on display boards will signal the commuters of free movement along the road.

4. Results and Discussion

Real-time animal detection on the forest road is significant for the smooth journey of humans and individuals. In this study, we have proposed a vision-based system for detecting wild animals on the forest road to enhance human security while travelling on the forest road. LoRa communication and vision technology is embedded in the proposed system to enhance reliable and real-time monitoring.

The vision node, display unit and gateway are embedded with LoRa communication so that the vision node can transmit the sensor information long-range with low power consumption. In the vision node, the camera module enables the capture of the image and transmits it to the display unit that is connected to it. The vision node data transferred through LoRa communication is visualized on the serial monitor connected to the gateway. Here the vision node is deployed at different locations, where the animal's presence is displayed on the serial monitor as "Present or not present". Figure 4 illustrates the serial monitor of the animal status at different time intervals.

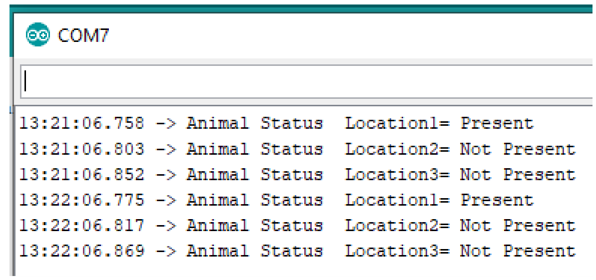

Fig. 4(a) Vision node data '1'

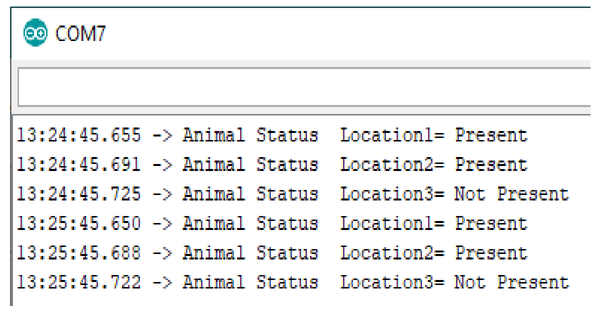

Fig. 4(b) Vision node data '2'

Figure 4(a) illustrates the vision node data of the three different locations, where the animal presence information, i.e., Present, is detected from location '1'. This information is visualized at the display unit of the entrance of location '1', location '2' and location '3'. Information visualized on the display unit enables the vehicles to halt until the animal presence status shifts to "not present".

Figure 4(b) illustrates the vision node data dof the three different locations at different times, where the animal presence information, i.e., Present, is detected from the locations '1' and '2'. This information is visualized at the display unit of the entrance of location '1' and location '3'. Information visualized on the display unit enables the vehicles to halt until the animal presence status shifts to "not present" for the vehicles at locations '1' and 3'.

Figure 4(c) illustrates the vision node of the three different locations, where the animal presence information, i.e., Present, is detected from location '2'. This information is visualized at the display unit of the entrance of location '1' and location '3'. Information visualized on the display unit enables the vehicles to halt for a time till the animal presence status shift to "not present".

Figure 4(d) illustrates the vision node of the three different locations, where the animal presence information, i.e., Present, is detected from the locations '2' and '3'. This information is visualized at the display unit of the entrance of location '1'. Information visualized on the display unit enables the vehicles to halt for a time till the animal presence status shift to "not present".

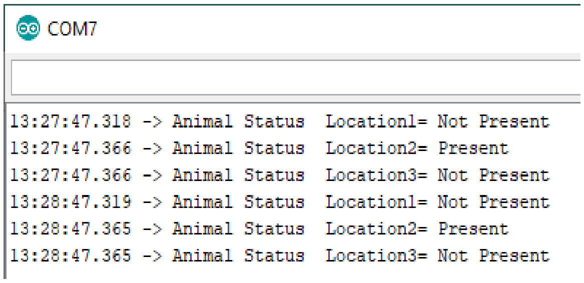

Fig. 4(c) Vision node data '3'

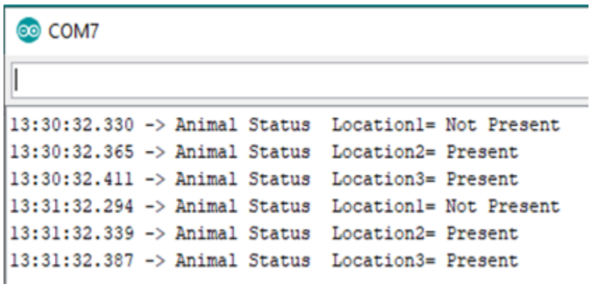

Fig. 4(d) Vision node data '4'

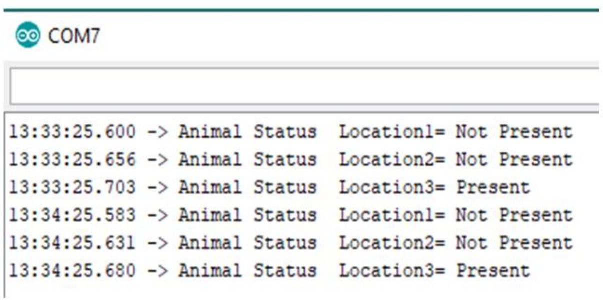

Fig. 4(e) Vision node data '5'

Figure 4(e) illustrates the vision node of the three different locations, where the animal presence information, i.e., Present, is detected from location '3'. This information is visualized at the display unit of the entrance of location '1' and location '2'. Information visualized on the display unit enables the vehicles to halt for a time till the animal presence status shift to "not present".

5. Conclusion

The Internet of wild things is significant because that enables to implementation of IoT for monitoring the wild animals on the forest road to enhance the safety of animals and humans. This article proposed a hybrid architecture for real-time monitoring of animal movement on roads in animal corridors. This system alerts and avoids the conflict between humans and wildlife animals by incorporating smart alert systems and utilizing them to display warnings with the help of display and LED lights. The system was realized in real-time by deploying vision nodes on trees alongside a selected road on the animal corridor. The serial data of the vision node is visualized on the serial monitor.

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References

[1] SDG 9: Industry, Innovation and Infrastructure – Anticipating the Potential Impacts on Forests and Forest-Based Livelihoods (Chapter 9) - Sustainable Development Goals: Their Impacts on Forests and People, Cambridge University, 2019. [Online]. Available: https://www.cambridge.org/core/books/sustainable-development-goals-their-impacts-on-forests-and-people/sdg-9-industry-innovation-and-infrastructure-anticipating-the-potential-impacts-on-forests-and-forestbased-livelihoods/C925D10F6738A9682EE883A6EAA5652C

[2] GOAL 15: Life on Land, UNEP - UN Environment Programme. [Online]. Available: https://www.unep.org/explore-topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-15

[3] P. C. Paquet, and C. T. Darimont, "Wildlife Conservation and Animal Welfare: Two Sides of the Same Coin?," *Animal Welfare*, vol. 19, no. 2, pp. 177–190, 2010. [Google Scholar] [Publisher Link]

[4] E. Distefano, "Human-Wildlife Conflict worldwide: collection of case studies, analysis of management strategies and good practices," *Food and Agriculture Organization of the United Nations (FAO)*, 2005. [Google Scholar] [Publisher Link]

[5] S. Thirgood, and R. Woodroffe, "The Impact of Human-wildlife Conflict on Human," People wildlife, Confl. or co-existence?, vol. 9, p. 13, 2005.

[6] Kari E. Gunson, Giorgos Mountrakis, and Lindi J. Quackenbush, "Spatial Wildlife-vehicle Collision Models: A Review of Current Work and Its Application to Transportation Mitigation Projects," *Journal of Environmental Management*, vol. 92, no. 4, pp. 1074–1082, 2011. [CrossRef] [Google Scholar] [Publisher Link]

[7] David J. Mladenoff, Theodore A. Sickley, and Adrian P. Wydeven, "Predicting Gray Wolf Landscape Recolonization: Logistic Regression Models vs. New Field Data," *Ecological Applications*, vol. 9, no. 1, pp. 37–44, 1999. [CrossRef] [Google Scholar] [Publisher Link]

[8] Van-Nam Pham, and Ngoc-Khoat Nguyen, “Effective LoRa – Based Centralized Digital Water Meters: Real Case Study in Vietnam,” *International Journal of Engineering Trends and Technology*, vol. 71, no. 2, pp. 249-258, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[9] John D.C. Linnell et al., “The Challenges and Opportunities of Coexisting with Wild Ungulates in the Human-Dominated Landscapes of Europe’s Anthropocene,” *Biological Conservation*, vol. 244, p. 108500, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[10] Jamie Langbein, Deer-Vehicle Collision (DVC) data collection and analysis 2016-2018, Scottish Natural Heritage, 2019. [Google Scholar] [Publisher Link]

[11] Uttarakhand Mulls Curbing Animal Deaths due to Accidents, Dehradun News - Times of India, 2019. [Online]. Available: https://timesofindia.indiatimes.com/city/dehradun/state-mulls-curbing-animal-deaths-due-to-accidents/articleshow/71826403.cms

[12] Alexander Prosekov et al., “Methods for Monitoring Large Terrestrial Animals in the Wild,” *Forests*, vol. 11, no. 8, p. 808, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[13] Gone Bi Zoro Bertin, Vroh Bi Tra Aime, and Adou Yao Constant Yves, “Chimpanzee’s (Pan Troglodytes Verus) Activity and Feeding Patterns in Taï National Park, Côte d’Ivoire,” *SSRG International Journal of Agriculture & Environmental Science*, vol. 5, no. 3, pp. 107-116, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[14] M. Gor et al., “GATA: GPS-Arduino based Tracking and Alarm System for Protection of Wildlife Animals,” *2017 International Conference on Computer, Information and Telecommunication Systems (CITS)*, pp. 166–170, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[15] Kalaivanan Karunanithy, and Bhanumathi Velusamy, “An Efficient Data Collection Using Wireless Sensor Networks and Internet of Things to Monitor the Wild Animals in the Reserved Area,” *Peer-to-Peer Networking and Applications*, vol. 15, pp. 1105–1125, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[16] Ricklef Wohlers et al., “Twinroute: Energy-efficient data Collection in Fixed Sensor Networks with Mobile Sinks,” *2009 Tenth International Conference on Mobile Data Management: Systems, Services and Middleware*, pp. 192–201, 2009. [CrossRef] [Google Scholar] [Publisher Link]

[17] Aloys Augustin et al., “A Study of LoRa: Long Range & Low Power Networks for the Internet of Things,” *Sensors*, vol. 16, no. 9, p. 1466, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[18] Kalletla Sunitha, “Automatically Identifying Wild Animals In Camera-Trap Images With Deep Learning,” *SSRG International Journal of Computer Science and Engineering*, vol. 8, no. 5, pp. 12-16, 2021. [CrossRef] [Publisher Link]

[19] Jialin Guo et al., “ITCN: An Intelligent Trust Collaboration Network System in IoT,” *IEEE Transactions on Network Science and Engineering*, vol. 9, no. 1, pp. 203–218, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[20] W. W. Cochran et al., “Automatic Radio-tracking System for Monitoring Animal Movements,” *Bioscience*, vol. 15, no. 2, pp. 98–100, 1965. [CrossRef] [Google Scholar] [Publisher Link]

[21] Shiny Abraham, Joshua Beard, and Renjith Manijacob, “Remote Environmental Monitoring using Internet of Things (IoT),” *2017 IEEE Global Humanitarian Technology Conference (GHTC)*, pp. 1–6, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[22] Yu-Huei Cheng, “A Development Architecture for the Intelligent Animal Care and Management System Based on the Internet of Things and Artificial Intelligence,” *2019 International Conference on Artificial Intelligence in Information and Communication (ICAIIC)*, pp. 78–81, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[23] D. Geetha et al., “Human and Animal Movement Detection in Agricultural Fields,” *SSRG International Journal of Computer Science and Engineering*, vol. 6, no. 1, pp. 15-18, 2019. [CrossRef] [Publisher Link]

[24] Gang Xu et al., “A Routing Algorithm for the Sparse Opportunistic Networks Based on Node Intimacy,” *Wireless Communications and Mobile Computing*, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[25] Nirit Datta et al., “Automatic Tracking and Alarm System for Eradication of Wild Life Injury and Mortality,” *2016 2nd International Conference on Advances in Computing, Communication, and Automation (ICACCA) (Fall)*, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[26] Ting Feng Tan et al., “Embedded Human Detection System Based on Thermal and Infrared Sensors for Anti-poaching Application,” *2016 IEEE Conference on Systems, Process and Control (ICSPC)*, pp. 37–42, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[27] Rajiv S. Kalsi, “Roadmap for Wildlife Research and Conservation in India,” *Advances in Animal Experimentation and Modeling*, pp. 297–306, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[28] Marie Moinet et al., “Spatio-temporal Dynamics of Tularemia in French Wildlife: 2002–2013,” *Preventive Veterinary Medicine*, vol. 130, pp. 33–40, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[29] Shamukhappa Angadi, and Raghvendra Katagall, “Agrivigilance: A Security System for Intrusion Detection in Agriculture using Raspberry pi and Opencv,” *International Journal of Scientific and Technology Research*, vol. 8, no. 11, pp. 1260–1267, 2019. [Google Scholar] [Publisher Link]

[30] R.Surendiran, and K. Raja, “A Fog Computing Approach for Securing IoT Devices Data using DNA-ECC Cryptography,” *DS Journal of Digital Science and Technology*, vol. 1, no. 1, pp. 10-16, 2022. [Google Scholar] [Publisher Link]

[31] Marco Centenaro et al., "Long-range Communications in Unlicensed Bands: The Rising Stars in the IoT and Smart City Scenarios," *IEEE Wireless Communications*, vol. 23, no. 5, pp. 60–67, Oct. 2016. [CrossRef] [Google Scholar] [Publisher Link]

[32] D. Tweed, and A. Calway, "Tracking Multiple Animals in Wildlife Footage," *2002 International Conference on Pattern Recognition*, 2002. [CrossRef] [Google Scholar] [Publisher Link]

[33] H. Muneera Begum, D. A. Janeera, and A.G. Aneesh Kumar, "Internet of Things Based Wild Animal Infringement Identification, Diversion and Alert System," *2020 International Conference on Inventive Computation Technologies (ICICT)*, pp. 801–805, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[34] Clara Grilo et al., "Roadkill Risk and Population Vulnerability in European Birds and Mammals," *Frontiers in Ecology and the Environment*, vol. 18, no. 6, pp. 323–328, 2020. [CrossRef] [Google Scholar] [Publisher Link]