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Review TOEOC

Animal/Object Recognition and Monitoring

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Abstract

This study focuses on teaching a computer to identify leopards in images through a process called Object Detection and Image Recognition. We created a special set of pictures (dataset) containing thousands of leopard images. Using a small camera module called ESP32 CAM, we trained the computer to recognize leopards by comparing the images it captures with the ones in the dataset. The results were obtained using a Convolutional Neural Network (CNN). Leopards are elusive creatures, and accurately identifying them in images can be challenging due to their camouflaged coats and the diverse environments they inhabit. Existing methods might not be efficient or portable, often requiring expensive equipment and extensive manual labour. By leveraging the ESP32 CAM, a cost-effective and compact solution, we can deploy this technology in remote and rugged terrains, making it accessible for widespread use. This survey can be particularly useful for wildlife conservation efforts, helping researchers monitor leopard populations more effectively. A system that recognizes the presence of animals and alerts people to it is necessary for security reasons since animals that invade agricultural regions close to forests can damage crops or even attack humans. This article identifies wild animals that penetrate human habitation. Automated leopard detection can enhance data collection accuracy, reduce human error, and allow for real-time monitoring. This technology can also assist in identifying individual leopards based on their unique spot patterns, aiding in population tracking and behavioural studies.

Keywords: CNN, object detection, image recognition, ESP32, Tensor Flow

INTRODUCTION

Introducing a groundbreaking system called Animal/Object Recognition and Monitoring (AORM), which uses advanced technology to identify and track animals and objects in real-time. This system we wish to design to improve surveillance and management in various areas like wildlife conservation, security, and industry. We find the main problems it aims to solve.

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Existing surveillance systems face challenges in accurately detecting and tracking endangered animals and their habitats, thereby impeding conservation efforts. Current object recognition technologies exhibit prolonged processing times, resulting in delayed responses to potential security threats or anomalies in various industries. Monitoring systems often lack sufficient data to comprehend animal behaviour patterns, which are pivotal for conservation and ecosystem management.

We created images of objects belonging to four different categories: cars, motorcycles, ships, and animals. These images were varied across four dimensions: scale, position (horizontal and vertical), in-plane rotation, and in-depth rotation. Depending on the specific experiment, the number of dimensions in which the objects varied was determined.

All two-dimensional object images were generated from three-dimensional models. On average, there were 16 different three-dimensional models per object category, with cars having 16 models, ships having 18, motorcycles having 16, and animals having 15. One of the most important uses of computer vision is the detection of moving objects. It is easy for people to detect and distinguish items, but it is more difficult for computers to do the same. For this reason, it is crucial to create an object detection and recognition system that is flexible and simple. A video camera in a scene is used for optical surveillance to watch the movements of the interested object, such as people, animals, cars, etc. Background subtraction is used because extracting the foreground item is crucial for categorizing, monitoring, and analysing the actions of the relevant object.

The lack of interoperability among various monitoring devices complicates coordination for emergency responses and efficient resource allocation. Additionally, the algorithms utilized for recognition demonstrate limited effectiveness, leading to erroneous identifications of animals and objects, consequently diminishing the reliability of monitoring systems.

METHODOLOGY

The study findings and latest literature on animal/object recognition and monitoring are summarized in this overview. It examines a range of methods and approaches used in this domain, such as data fusion strategies, deep learning models, sensor networks, and image processing algorithms [1].

Key Findings

The review identifies important developments in animal/object monitoring and recognition, such as:

1. Creation of advanced computer vision algorithms to track and identify objects and animals in challenging conditions.
2. Combining machine learning methods for precise classification and identification, such as recurrent neural networks (RNNs) and convolutional neural networks (CNNs).
3. Installation of sensor networks and Internet of Things devices to gather and monitor data in real time.
4. Employing data fusion methods to combine data from several sources and increase the precision of monitoring.
5. Application of these technologies in a variety of fields, including as industrial automation, security surveillance, precision agriculture, and wildlife conservation.

Theories of Human Object recognition

Object recognition across changes in viewpoint poses a significant theoretical challenge, as depth rotations can drastically alter the visual information reaching our eyes. Two main classes of theories have been proposed to explain how humans recognize objects from novel views.

In the first class of theories, shape representations are object-based, consisting of structural descriptions of an object's 3-D properties. Examples include the recognition-by-components theory and the geon-structural-description theory, which posit that objects are represented by simple volumetric parts (geons) and their spatial relations. According to these theories, object recognition should remain invariant across viewpoint changes as long as certain conditions are met, such as the object being decomposable into geons and the spatial arrangement forming a distinct structural description.

In contrast, the second class of theories, known as view-based theories, assumes that objects are encoded in memory based on the poses in which they are seen. These theories propose that the representation of an object emerges as a collection of stored views, each reflecting the specific appearance of the object from that view. Recognition of an object from a novel view requires matching the current percept to one of the stored views, with recognition accuracy decreasing as the rotational distance between the novel view and the nearest stored view increases.

In essence, object-based theories emphasize the importance of object structure and spatial relations, predicting invariant recognition across viewpoint changes, while view-based theories focus on memorized views and predict decreased recognition accuracy with increasing rotational distance between views [2].

LITERATURE SURVEY

Natarajan B et al. introduce a hybrid VGG-19 and Bi-LSTM framework for detecting wild animals, aiding in wildlife monitoring and preventing human-animal conflicts. By sending alert messages to forest officers, it helps save both animals from hunting and humans from sudden attacks. Evaluations on various datasets demonstrate the model's superior performance, achieving over 98% classification accuracy, 77.2% mean Average Precision, and high frames per second (FPS), surpassing previous methods with faster computation [3].

Ibraheam M et al. present a modified YOLOv2 model that improves animal species detection on embedded devices by 5.0% in accuracy and 12.0% in speed. YOLOv2 is faster than YOLOv4, enhancing accuracy without sacrificing speed, making it suitable for wildlife conservation systems. Future work will focus on testing with more images and species and improving accuracy in low-resolution and poor-quality images [4].

Sibusiso Reuben Bakana et al. [5] propose an enhanced version of YOLOv5s designed for efficient wild animal recognition. Their model reduces computational costs associated with model parameters and floating-point operations (FLOPs) by incorporating Mobile Bottleneck Block modules and an improved StemBlock in the backbone architecture.

Adami D et al. introduce a new application to protect crops from ungulate attacks using advanced technologies like AI, Edge Computing, IoT, and LPWAN. It describes a complex system that can detect and repel animals in real-time, considering factors like response time, accuracy, and resource limitations. Lessons learned include the importance of methodological approaches, experimentation for optimal hardware/software configurations, and ensuring reliability in detection mechanisms, utilizing backup systems like cameras when sensors fail. The study highlights the readiness of Edge-AI technology but emphasizes the need for careful customization and integration for innovative applications [6].

Girish H et al. explore using IoT and Deep Learning for animal detection in wildlife, focusing on identifying animals and alerting vehicles on forest highways to prevent accidents. By employing a Raspberry Pi3 Model B, ultrasonic sensors, and a Pi camera, the system detects obstacles, captures live images, and analyses them using deep learning algorithms. This approach aims to reduce animal fatalities and protect rare species by warning vehicles of potential hazards on forest roads [7].

Using images of crop fields, detecting unauthorized entry of animals or people helps in protecting the crops, with alerts sent to the farm owner. While buzzers can deter birds and animals, there is a lack of individual animal classification and alerts. Power-reliant deep learning methods like CNNs may not be feasible. Instead, PIR and ultrasonic sensors detect animals, triggering sound diversion, but there is no alert system for the farmer [8].

Keerthana S et al. [9] compare various object detection techniques for wild animal detection and find that Discriminative Feature-oriented Dictionary Learning and clustering have the highest accuracy. Techniques like Deep Convolutional Neural Networks and Automatic Wild Animal Detection show lower performance in terms of accuracy, F-measure, precision, etc. The comparison highlights the effectiveness of Discriminative Feature-oriented Dictionary Learning and clustering for wild animal detection, making it the preferred approach due to its high accuracy.

Arunabha M. Roy et al. [10] have developed a robust detection framework that addresses the limitations of existing deep learning-based wildlife detection models. Their approach achieves highly accurate species-level localized bounding box predictions efficiently and effectively.

APPLICATIONS

Applications for "Animal/Object Recognition and Monitoring" cover a broad range of tools and technologies intended to detect, follow, and examine objects or animals in different settings. These apps are being used in the following important domains:

- *Wildlife Conservation:* To track endangered species, examine migratory patterns, and keep an eye on population dynamics, conservationists employ recognition and monitoring systems. Threats to biodiversity such as habitat loss and poaching can be countered with the aid of these systems.
- *Precision Agriculture:* These apps aid in the monitoring of crop health, the detection of pests and diseases, and the efficient use of resources in agriculture. Large fields may be swiftly surveyed by drones fitted with object identification software, giving farmers important information for making decisions.
- *Security and Surveillance:* To identify and track people, cars, or suspicious objects in public areas, airports, and other sensitive locations, object recognition technology is used in security and surveillance systems. This improves security protocols and aids in the mitigation of any risks.
- *Industrial Automation:* Object recognition systems are utilized in manufacturing and industrial settings for inventory management, sorting, and quality control. These programs can streamline manufacturing procedures, identify flaws in items, and classify them.
- *Environmental Monitoring:* Using object recognition technology, environmental metrics including pollution, deforestation, and the quality of the air and water may be monitored. For environmental evaluation, policymaking, and conservation initiatives, this data is essential.
- *Biomedical research and healthcare:* Medical imaging analysis, pathology diagnosis, and medication discovery are all aided by object recognition systems. These apps are used by researchers to examine cellular structures, monitor the course of diseases, and create novel therapeutic approaches.

CONCLUSION

In conclusion, these studies present new ways to keep track of wildlife and prevent conflicts between humans and animals. They use advanced technologies like AI, IoT, and deep learning to make detection more accurate and faster. By combining different methods and improving existing models, these solutions are better at finding and keeping animals away, which helps protect both wildlife and people. However, there are still some challenges to overcome, like the need to test these systems more and make them fit better for different situations. Overall, these advances are helping us move towards a safer coexistence with wildlife and building healthier environments.

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