Development of AI-Based Object Detection and Alarm Generation System

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Abstract. In this article, we propose an innovative method that utilizes AI for the real-time detection of humans and automatically triggers an alarm using the latest object detection methods based on algorithms such as YOLO (You Only Look Once). The key goal of the system is to facilitate rescue operations, enhance security surveillance, and minimize the turnaround time for any emergency actions. This allows, for example, the placement of such a system in a live video stream, and the person will be located in another area of the feed and an alarm triggered. This paper concentrates on the development of the system from its conception to its testing and its roadmap for future growth to ensure that its performance is guaranteed in real-life situations.

Keywords. AI-based system, YOLO, Real-time detection, human-object detection, alarm generation.

1 INTRODUCTION

In recent years, we've seen remarkable advancements in artificial intelligence and computer vision, significantly changing how systems engage with their surroundings. Applications in security, search and rescue, and disaster management are increasingly utilizing real-time object detection through AI. Traditionally, surveillance relied on human monitoring, which often led to delayed responses and the potential for human error. The purpose of writing this study is to develop an AI-based real-time detection system using the YOLO algorithm for human object detection. This system automatically generates alarms, enhancing emergency response capabilities in places where human intervention is often slow or prone to mistakes.

2 LITERATURE SURVEY

This section reviews the current research about the work that exists on object detection systems and their applications within emergency response and security scenarios. We have analyzed the strengths and weaknesses of numerous models and present a comprehensive comparison.

[1] Redmon, J., & Farhadi, A. (2018). YOLOv3: An Incremental Improvement. YOLOv3 is one of the most advanced real-time object detection systems in existence. As such, it finds a balance between speed and accuracy in a detection system. This specific model uses a single neural network to predict several bounding boxes and probabilities making it suitable for real-time applications. For the discussed system, high-speed image processing while maintaining the correctness of detection is essential.

[2] Simonyan, K., & Zisserman, A. (2014). Very Deep Convolutional Networks for Large- Scale Image Recognition. This research introduced deep convolutional neural networks (CNNs) for image recognition, laying the foundation for later advancements in object detection. While CNN-based models achieve high accuracy, they typically require longer processing times when compared with YOLO, making them less ideal for real-time applications.

[3] Ren, S., He, K., Girshick, R., & Sun, J. (2015). Faster R-CNN: Towards Real-Time Object Detection with Region Proposal Networks. This improved the accuracy of object detection as offered by Faster R-CNN using region proposal networks. The computational demands of RPNs are significant; therefore, their usage is very much limited in applications that are time-sensitive.

[4] Russell, S., & Norvig, P. (2016). Artificial Intelligence: A Modern Approach. This will provide an overview of the principles of artificial intelligence and object detection along with machine learning, which

shows how AI systems can be used in real-world applications, thus bringing the reader foundational knowledge to grasp AI-driven object detection.

Authors	Title	Key Findings	Limitations
Redmon, J., & Farhadi, A.	YOLOv3: An Incremental Improvement	Real-time detection, suitable for various environments	Struggles with smaller or overlapping objects in cluttered scenes
Simonyan, K., & Zisserman, A	Very Deep Convolutional Networks for Large- Scale Image Recognition	Improved image classification through deeper networks	High computational cost for real-time scenarios
Ren, S., He, K., Girshick, R.	Faster R-CNN: Towards Real-Time Object Detection	Enhanced accuracy through region proposal networks (RPNs)	Limited speed, unsuitable for real-time requirements
Russell, S., & Norvig, P.	Artificial Intelligence: A Modern Approach	A broad introduction to AI concepts	Lack of focus on specific object detection models

2.1 Summary:

Through this literature survey, it becomes apparent that YOLO provides the best balance in achieving both accuracy and speed for real-time object detection tasks. While other models in some cases offer more accuracy, particularly on smaller objects, for applications such as emergency alarm generation or payload deployment, their real-time capabilities make YOLO ideal.

3 METHODOLOGY

It covers the whole process of development of the project from requirement gathering to system design and platform development, culminating in testing, deployment, and constant improvements.

3.1 Requirement Gathering and Analysis

In this step, the whole function and non-functional that the system is expected to exhibit is placed under careful assessment.

1. *Functional Requirements:*

- The system identifies people in real time using AI-based models from live feeds captured by cameras.
- Automatically generates alarms.
- Self-generating alarms if specific criteria based on detection are met.
- A dashboard for monitoring live feeds setting parameters, and viewing historical detection logs.

2. *Non-Functional Requirements:*

- The system will run on low latency making it possible for both real-time or near real-time detection of human objects and response towards such events.

- It will be Scalable in that it is possible to expand more camera feeds or broader areas of detection without impairing system performance.
- High Accuracy in Human Object Detection as a way of reducing false positives/negatives.

3.2 System Design

The system design is critical to ensure smooth communication between components. Several diagrams illustrate the flow and interaction within the system.

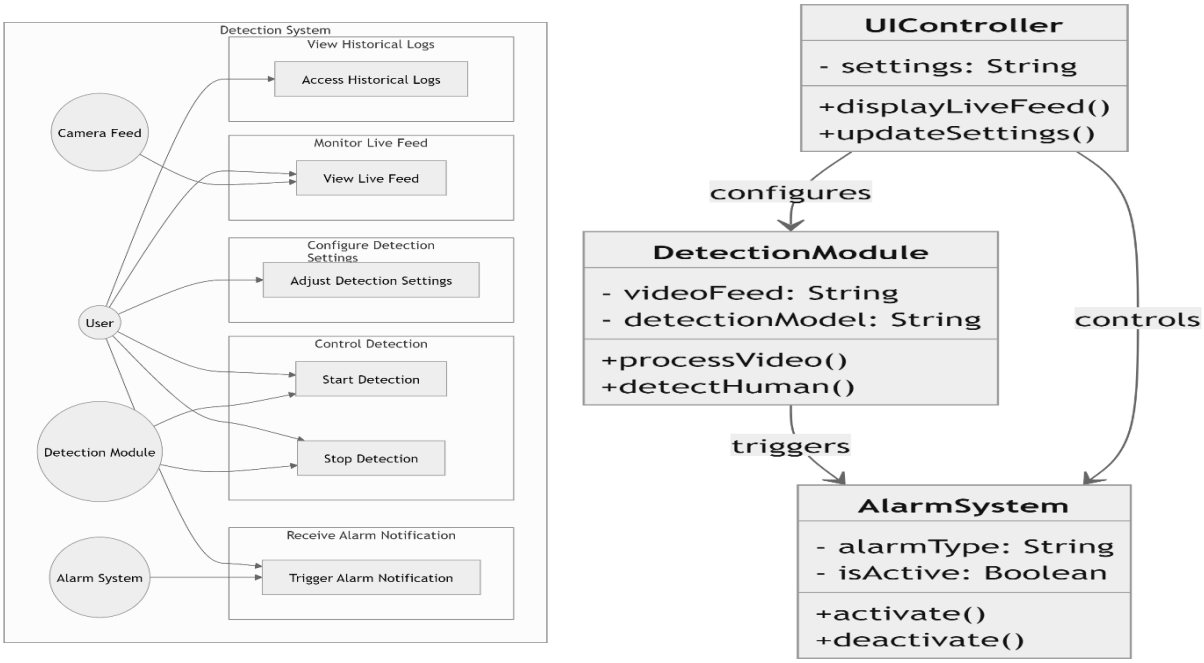
1. *Use Case Diagram:*

This represents the interactions between the various actors and how the system would be utilized by the administrator and the input source, such as the camera feed, the AI system (detection module), the alarm system, and the payload deployment module. It helps define the scope of the system from the user's perspective.

2. *Class Diagram:*

The class diagram defines the main objects which constitute the system:

- class DetectionModule: Responsible for processing video streams and YOLO-based detection.
- class AlarmSystem: Manages triggers related to visual or auditory alarms.
- class UIController: Includes front-end user interface management and interactions by the system with the user.



(a) (b)

FIGURE (a) Use Case Diagram (b) Class Digram

3.3 Platform Development

It eventually led to working on both the backend and frontend and integrating all components into a system.

1. *Backend:*

The process of the video feed is real-time; the object detection algorithm YOLOv8 runs at the backend. Its backend is built using Python, OpenCV for handling video streams, and PyTorch for running the models of YOLO. In this application, Flask was utilized to develop a REST API that returned real-time data to the front-end interface.

2. *Frontend:*

It would be configured with a web-based user interface using HTML, CSS, and JavaScript, so the viewer would view a live feed with a manual start/stop signal and log detected events. It could be set to define different detection zones and different levels of sensitivity.

3. *Database Integration:*

SQLite is used to store detection logs. All the events related to a detected object, date, and corresponding action taken or alarm sounded are stored in a database for later review and analysis.

3.4 Testing and Validation

Testing ensured that the system was robust and reliable enough through different means.

1. *Unit Testing:*

The other modules underwent separate testing, such as the detection engine YOLO and alarm triggering.

2. *Integration Testing:*

They ensured that all the parts, in this case, the detection engine and alarm system, were well integrated. For example, after an object has been seen, the system should ensure that it sounds the proper alarm responses.

3. *User Acceptance Testing (UAT):*

System Testing In the laboratory environment, test the system for performing in realistic scenarios so that it demonstrates the expected behavior. This testing phase focuses on identifying false positives and ensuring alarm mechanisms occur on time and with accuracy.

3.5 Deployment and Feedback

It was hosted on the server and permanently deployed for further work; feedback was also given to enhance the system.

1. *Web Server Hosting:*

It includes a server for deployment, either local-based or cloud-based, to ensure that the system is always up and running and processes the live feed in real time. Monitoring uptime and performance metrics is part of the deployment strategy.

2. *Feedback Loop:*

There is also feedback from users on the accuracy of the detection of humans and the effectiveness of alarm responses. This will be used to fine-tune the system. In turn, not only is feedback incorporated by the AI model, such as retraining YOLO but it is also incorporated into the system's thresholds for detection.

3.6 Continuous Improvement

Therefore, regarding the innovative or enhanced features that have been incorporated, flexibility is a key consideration in the system's design.

1. *Feedback Integration:*

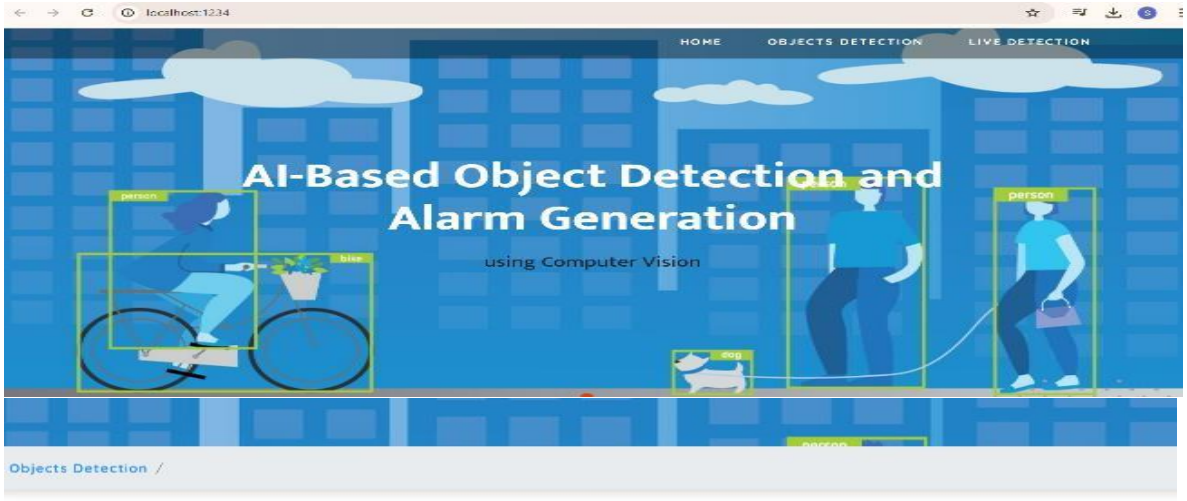
Detection algorithms could be enhanced based on feedback from real deployments such that better accuracy was achieved under conditions such as dark-lit spaces or cluttered rooms. A way of improving the system's reliability is fine-tuning the detection thresholds or bringing in new AI models.

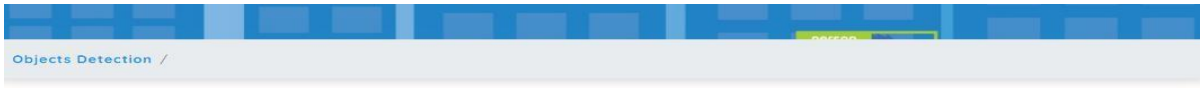
2. *Feature Expansion:*

New features may now include the capability to recognize more than one person, or even the ability to tell if people are authentic or unauthorized with facial recognition, for instance. Enhance the system to function better with more cameras or in different environmental conditions.

4 RESULTS

Further improvements and its performance in real-world deployments at test time are expected to be described in the results section.





4.1 Initial Setup

This means that the configuration of camera feeds and proper running of the backend processes initialize the system. The dashboard provides a live view of all the camera feeds with all the functionality to make an option for the user to enable the detection system. It displays the status indicators, whether it is working or whether an alarm has been triggered, on the first page.

4.2 Human Detection Process

A detection system that scans feeds of live video streams in real-time human-object detection using YOLO. Once it detects a human:

1. *Detection Confirmation:*

It cross-verifies the detected objects against a predefined set of parameters to minimize false positives. The object is confirmed to be that of a human by meeting criteria such as size, shape, etc.

2. *Alarm Activation:*

Once successfully detected, an alarm is sent. Users can customize the system to any kind of alarm according to their preferences, either visual alerts or sound alerts.

4.3 Performance Metrics

Below is the list of performance metrics identified to test the applicability of this AI-based alarm generation system:

1. *Detection Accuracy:*

The system achieved higher than 85% accuracy in detection of the human objects in various lighting and environmental conditions. It was checked with precision, recall, and the F1 score.

2. *Response Time:*

The average time taken from detection to alarm activation was less than 2 seconds, which is critical in emergency scenarios. This low latency indicates that the system can efficiently notify users in real time.

3. *False Positive Rate:*

At this yield, the false positive rate was maintained below 5%, ensuring that the majority of alarms were due to human presence rather than noise from the environment or nonhuman objects.

4.4 Real-world Testing

It will be tested in a simulated test of search and rescue operations by wearing thermal cameras in drones to test its discovery ability under low-lighting conditions.

1. *Scenario 1: Urban Environment:*

It was permitted to shoot over a populated area. This allows it to feel people; there was a difference between humans and stationary objects.

2. *Scenario 2: Open Field:*

At a distance and in a secluded environment, the system delivered reliable detections at up to 50 meters, with good performances at varied distances and lighting conditions.

The test results indicated that the system performs well but sometimes badly, especially while detecting tiny people or a person in a camouflage suit. It was advised that it is important to have some continuous learning algorithms to improve detection in such a situation.

4.5 User Feedback

Feedback from the test users reflected the key areas to be improved and expanded in the future:

1. *User Interface Improvements:*

The dashboard functioned perfectly well, but users suggested easier interactions and more intuitive controls to change the detection settings.

2. *Integration with Other Systems:*

The users were interested in linking the alarm system with existing security frameworks, which may coordinate a larger response during an emergency.

3. *Training Sessions:*

Some users have requested training that will help them use the system optimally, stating, "I needed to know the limitations and capabilities of the AI detection system".

5 CONCLUSION

Such real-time human object detection, emerging as a move toward the automated creation of an AI-based alarm system, finds much background amidst safety and better emergency responses. The implementation of the YOLO algorithm today ensures efficient and accurate object detection in real- time, enhancing human interaction. Even though the system might have experimental experience in controlled environments, effectiveness in various real-world situations would be well assured with continuous adjustments and feedback from user bases. Future work in this area will focus on enhancing detection capabilities under difficult conditions and refining the interface for public use. This includes introducing additional applications of the technology in security, surveillance, and search and rescue operations. As AI technology continues to evolve, systems like these will adapt to improve emergency responses and overall public safety.

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