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ỨNG DỤNG CÔNG NGHỆ AI TRONG VIỆC GIÁM SÁT VÀ CẢNH BÁO AN TOÀN LAN CAN TẠI CÁC TRƯỜNG TRUNG HỌC

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TỪ KHÓA

Trí tuệ nhân tạo;
Hệ thống giám sát;
Nhận diện hành vi;
Phân tích dữ liệu;
Hệ thống Iot.

TÓM TẮT

Nghiên cứu "Ứng dụng công nghệ AI trong vệc giám sát và cảnh báo an toàn lan can tại các trường Trung học" nhằm phát triển một hệ thống giám sát và cảnh báo an toàn lan can tại các trường trung học bằng cách ứng dụng công nghệ Trí tuệ nhân tạo (AI) kết hợp với cảm biến IoT. Hệ thống được thiết kế để phát hiện nguy cơ học sinh có thể rơi khỏi lan can và đưa ra cảnh báo kịp thời nhằm giảm thiểu tai nạn. Phương pháp nghiên cứu bao gồm sử dụng camera AI để nhận diện hình ảnh, cảm biến chuyển động để phát hiện di chuyển, cảm biến khoảng cách để đo khoảng cách giữa người và lan can, đồng thời kết hợp loa cảnh báo và gửi tin nhắn đến điện thoại di động trong trường hợp nguy hiểm. Dữ liệu được thu thập và xử lý bằng thuật toán nhận diện hình ảnh với độ chính xác trên 80%, kết hợp với các tín hiệu cảm biến để xác định trạng thái an toàn hoặc không an toàn. Cảm biến chuyển động hoạt động với độ chính xác 92%, trong khi cảm biến khoảng cách có sai số dưới 5%. Kết luận cho thấy hệ thống có khả năng phát hiện nguy cơ và cảnh báo hiệu quả, mở ra hướng nghiên cứu và ứng dụng trong các không gian công cộng nhằm nâng cao an toàn cho người sử dụng.

APPLICATION OF AI TECHNOLOGY IN SAFETY MONITORING AND WARNING AT SECONDARY SCHOOLS

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ABSTRACT

The research "application of ai technology in safety monitoring and warning at secondary schools" aims to develop a system for monitoring and ensuring railing safety in secondary schools by integrating Artificial Intelligence (AI) with IoT sensors. The system is designed to detect potential risks of students falling from railings and provide timely alerts to minimize accidents. The research methodology involves utilizing an AI camera for image recognition, a motion sensor to detect movement, and a distance sensor to measure the gap between individuals and the railing. Additionally, the system integrates a warning speaker and sends alert messages to mobile phones in hazardous situations. Data is collected and processed using an image recognition algorithm with an accuracy of over 80%, combined with sensor signals to determine safe or unsafe conditions. The motion sensor operates with an accuracy of 92%, while the distance sensor has an error margin of less than 5%. Experimental results indicate that the system achieves an image recognition accuracy of 85% in good lighting conditions and 78% in low-light environments. The findings demonstrate that the system effectively detects risks and issues timely warnings, paving the way for further research and applications in public spaces to enhance user safety.

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1. INTRODUCTION

Artificial Intelligence (AI) is one of the most advanced technological fields today, enabling machines and systems to learn, process data, analyze, and make decisions similar to humans. With rapid advancements, AI has been and continues to be widely applied in various fields such as healthcare, transportation, finance, and particularly in security surveillance. The standout feature of AI lies in its ability to quickly and accurately analyze large datasets, thereby providing predictions or responses in real time. As a result, AI is increasingly becoming a valuable tool for solving complex problems in everyday life.

Wayne Holmes [1] and collaborators analyzed how AI transforms education, focusing on program design, personalized learning, and assessment. The authors used theoretical analysis methods combined with practical research to explore the role of AI in improving teaching and learning efficiency. The findings show that while AI has the potential to enhance education quality, ethical considerations, privacy concerns, and fairness issues need to be addressed in practical implementations. Author Nguyen Thac Dung [2] application of AI to support health protection warnings during work and study to help students stay focused and minimize health issues related to schooling. Phan Trung Kien and collaborators [3] made recommendations for using AI in learning, teaching, and research, identifying areas for further study such as knowledge base development, transparency and ethics, and digital transformation in organizations and society. They also emphasized the need for educational environments that encourage greater interaction and active engagement in digital transformation within higher education. Authors Vu The Cong and Tran Quy Trong [4] have utilized AI surveillance cameras for public monitoring in crime prevention in Vietnam. Author Trần Đức Hoàn [5] researched the combination of AI cameras and radar sensors for monitoring and rescue operations in warehouses and factories. Nguyen Van Quang [6] demonstrated how AI tools can easily monitor animal activities and locations, collect data on behavior, habitat, and health, identify animals, oversee welfare, determine gender, and assist with vaccine administration. The research team, including Lê Quang Hưng [7] utilized surveillance cameras to automatically determine the position and estimate the distance between people in the frame. If the required distance is not maintained, the system issues a risk warning. The current version operates near real-time and can support monitoring in public areas such as schools, factories, and hospitals. Untung Rahardja [8] applied AI to classify films, making cameras more user-friendly. Md Abdul Baset Sarker [9] and colleagues developed a novel approach by creating camera sensors to detect microparticles (MPs) and measure their size and velocity during motion. This study provided fundamental insights into using AI to detect MPs in various environmental contexts, contributing to more effective strategies for MP management and pollution reduction. Phan Trung Kien [10] and collaborators further explored AI in education, offering recommendations on using AI for learning, teaching, and research while addressing key issues such as knowledge bases, transparency and ethics, and the digital transformation of organizations and society.

Since 2011, the media has recorded seven balcony-related accidents in schools, resulting in serious consequences, with most victims suffering severe injuries and, in some cases, fatalities. In Đồng Nai in 2020, at Lý Tự Trọng Secondary School in Trảng Bom District, a 9th-grade student climbed onto the railing, lost balance, and fell. Despite being rushed to the hospital immediately, the student did not survive due to severe injuries. In response to such tragic incidents, a research team conducted a study titled "Application of AI Technology in Safety Monitoring and Warning at Secondary Schools," focusing on developing an intelligent monitoring system that integrates Artificial Intelligence (AI) to enhance safety in high-risk areas such as railings, balconies, or elevated spaces. The system utilizes motion sensors and AI-powered cameras to detect hazardous behaviors, such as students climbing or attempting to cross railings, as well as other risky situations. The collected data is processed by a specialized AI system, trained to analyze and generate real-time warnings with high accuracy. Depending on the level of danger, the system activates different warning mechanisms, including audio alerts, LED signal indicators, and notifications sent to users' smartphones. With its continuous learning capability, the system improves performance over time, providing a comprehensive safety solution suitable for schools, residential areas, public facilities, and high-rise buildings. This research not only aims to reduce accidents but also highlights the strong potential of AI applications in enhancing safety and quality of life.

2. RESEARCH METHODOLOGY

To solve the problem of monitoring and warning of guardrail safety in high schools, this study applies an integrated approach between artificial intelligence (AI) and the Internet of Things (IoT), which allows for the optimization of data collection, processing, and timely warning. The implementation process begins with requirements analysis through the study of the actual environment, surveying potential risks such as fall risks or dangerous behaviors, and collecting field data to build a suitable system. Next, the system is designed with an architecture including a central processor, AI cameras, motion and distance sensors, warning speakers, and signal LEDs. The implementation and integration phase uses deep learning algorithms for image recognition and risk classification, and integrates hardware and software, and develops a system management interface for monitoring and adjustment during operation. The system was tested in real-world scenarios to evaluate its accuracy, response speed, and stability, and the results were analyzed for improvement. The method outperforms previous studies thanks to its real-time data processing capabilities and high level of automation, which improves the accuracy of risk detection and reduces false alarms.

2.1 Research Model

The railing safety monitoring and warning system at high schools is built based on a model (Figure 1) that integrates AI cameras, motion sensors, distance sensors, warning speakers, and LED lights. AI cameras are used to identify and track the presence of people in the railing area through deep learning algorithms, helping to accurately detect when someone is approaching. The motion sensor is responsible for detecting any movement around the railing, thereby assessing whether that movement poses a safety risk, such as students playing around or climbing over the railing. The distance sensor is used to measure the distance from the person to the railing, helping to determine the level of danger. When the system identifies an unsafe situation, the warning speaker will emit an audio signal to warn, while the LED lights change color to reflect the safety status, with green indicating no danger and red when there is a risk. This model ensures effective monitoring and timely warnings, contributing to improving student safety.

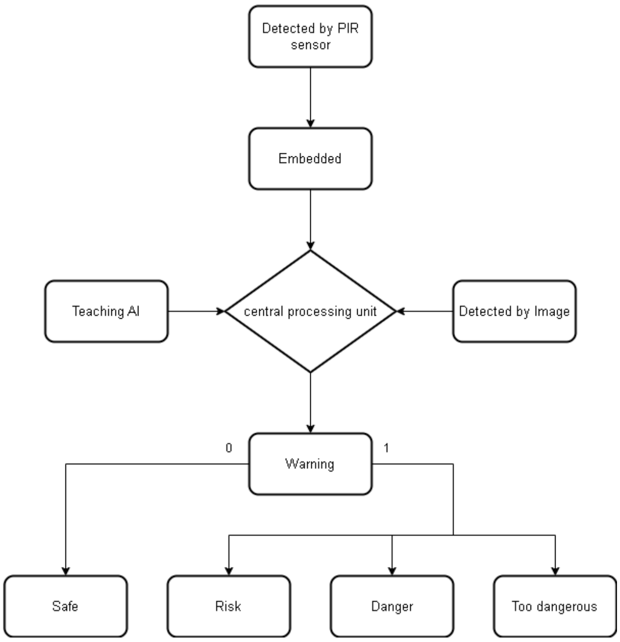

Figure 1: *Diagram of the railing hazard detection and warning solution*

2.2 Experiment Setup

2.2.1 Training the AI camera

At the Safe level, the AI camera recognizes students when they move near the railing or stand near the edge of the railing without performing risky actions. The AI analyzes the student's position (such as standing near the edge of the railing), posture (no signs of loss of balance), or normal movement without dangerous signs. Based on this recognition information, the AI camera only records the student's behavior without issuing a warning, because the situation is not serious enough to require immediate intervention. This level helps the AI recognize potentially dangerous situations without requiring an emergency warning, to monitor the student's behavior when near the railing, but not to issue a warning signal, the teacher monitors the camera and intervenes if the situation becomes more serious. At the Unsafe level, the AI camera will recognize dangerous behaviors that can lead to serious accidents, such as climbing over the railing, standing near the railing and leaning over the railing, showing signs of loss of balance, risk of falling, or unsafe contact with the railing. When the AI camera detects dangerous behavior, the system will sound an emergency warning and send a notification to the teacher for timely intervention. At this level, the AI camera detects dangerous situations and sends an immediate warning, such as turning on the warning lights, sounding a warning speaker, and sending a message to the teacher: “You are in an unsafe area! Avoid contact with the railing!”. The warning requires immediate intervention from the teacher to stop the dangerous behavior and protect the students.

To ensure effective monitoring and warning at the railing area, the system uses PIR sensors fixed at strategic locations to cover the entire area that needs to be monitored. This sensor is capable of detecting movements based on infrared changes in the environment, helping to determine when there is a person or object moving near the railing. The control program integrated with the sensor allows the system to recognize the signal and classify the level of danger into different levels: "Safe" when there is no movement, "Risk" when detecting students approaching the railing area, "Dangerous" when playing at the railing area, and "Very dangerous" when recording students climbing on the railing. When detecting unsafe signs, the system will activate a warning through loudspeakers and LED lights to attract attention, alert people around and prevent potential incidents in time.

2.2.2 Configuring the distance sensor

In the railing safety monitoring and warning system in high schools, the distance sensor is attached to the railing area, facing the location to be monitored to measure the distance between the railing and the approaching person or object. This sensor works by emitting ultrasonic waves and measuring the time it takes for the wave to return to calculate the exact distance. When the distance from the railing to the object is greater than 20 cm, the system will record the "Safe" status. Conversely, if the distance drops below 20 cm, the system will trigger an "Unsafe" level warning, warning of too close approach and potential risk of falling or accident.

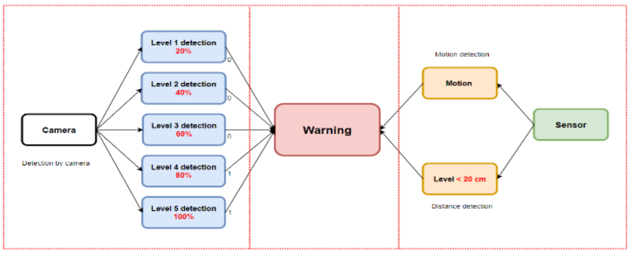

Figure 2: *Warning levels*

2.3 Conducting the experiment

During the deployment of the railing safety monitoring and warning system in high schools, the research team utilized OhStem devices, including ESP32, an AI camera, a PIR sensor, a distance sensor, and a sound player. The system operates based on four scenarios: "Safe," "At Risk," "Dangerous," and "Highly Dangerous."

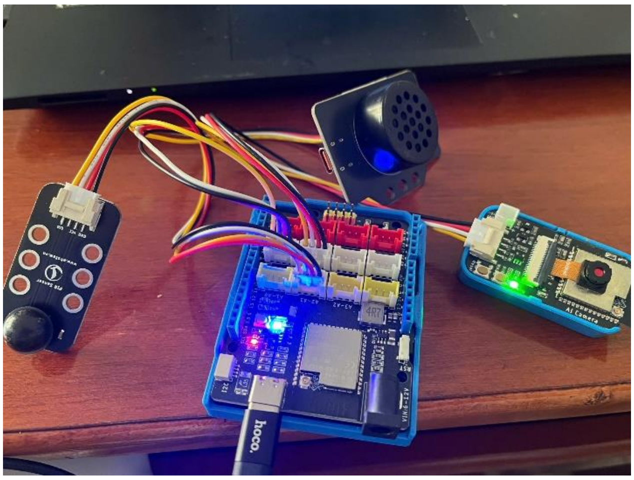

Figure 3: *Devices used in monitoring*

2.3.1 "Safe" Scenario

The system is configured not to trigger any alerts when the AI camera does not detect the presence of a person in the railing area. Additionally, the motion sensor does not register any movement, and the distance sensor measures the distance between the railing and a person or object as greater than 20 cm. When all these conditions are met, the system's LED light displays green, indicating that the area is safe and no risks need to be addressed.

2.3.2 "At Risk", "Dangerous," and "Highly Dangerous" Scenarios

The system is tested in situations where a person is near the railing, with the AI camera accurately recognizing their presence with over 80% confidence. The motion sensor detects activities such as rapid or sudden movements within the monitored area, and the distance sensor measures the distance between the railing and the person as less than or equal to 20 cm. When these conditions occur, the system immediately changes the LED light to red to indicate danger. Simultaneously, the warning speaker is activated to emit an alert sound, drawing the attention of people nearby, and an emergency notification is sent to the mobile phone of the administrator or security personnel for timely intervention.

3. RESULTS

3.1 Image Analysis Results

The AI camera system in the study of guardrail safety monitoring and warning showed reliable image recognition performance, with an average accuracy of 85% in daylight conditions and 80% in low-light conditions. These results met safety standards, allowing the system to accurately classify between safe and unsafe situations. The average processing time of the system was 0.8 seconds per situation, fast enough to detect and issue timely warnings. This result confirms the feasibility and effectiveness of applying AI technology in safety monitoring and warning in school environments.

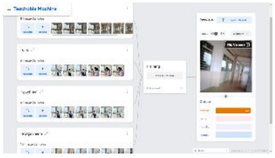

Figure 4: *Training the AI camera to recognize Level 1 - Safe*

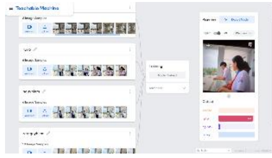

Figure 5: *Training the AI camera to recognize Level 2 - Unsafe*

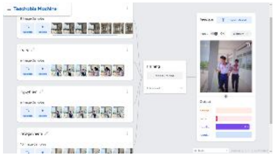

Figure 6: *Training the AI camera to recognize Level 3 - Dangerous*

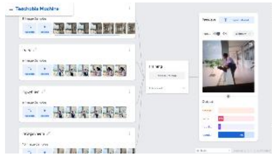

Figure 7: *Training the AI camera to recognize Level 4 - Very Dangerous*

3.2 Motion Sensor Results

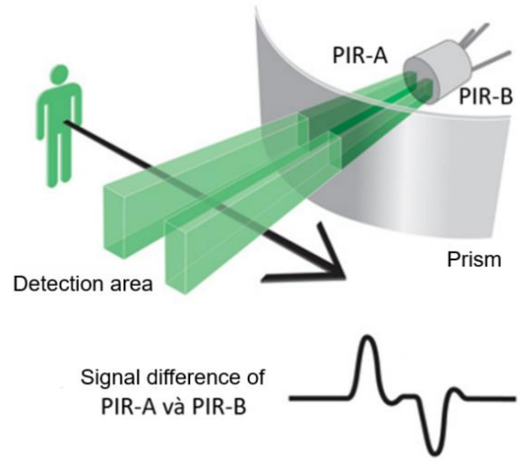

Figure 8: *The operating principle of the PIR sensor*

The motion sensor integrated in the railing safety monitoring and warning system demonstrated stable performance with a 360-degree cone detection range and a maximum distance of 3 meters around the railing area. The system recorded high detection sensitivity, with an accuracy rate of up to 97% for movements in the test area. The response time from when the sensor detected movement to when the signal was transmitted to the processing center was an average of 0.5 seconds, fast enough for the system to issue timely warnings.

3.3 Distance Sensor Results

The distance sensor in the railing safety monitoring system shows high accuracy, reaching a reliability of up to 95% in measuring the distance between people and railings. The device operates stably within the activation range of 20 cm ± 1 cm, ensuring quick and accurate response in situations requiring safety monitoring. In particular, the sensor is designed to minimize errors below 5%, even in complex environments with many obstacles. This is achieved thanks to the application of data correction algorithms and the ability to separate noise signals, helping to optimize performance under real conditions. This result affirms the important role of distance sensors in improving the effectiveness of monitoring and warning, ensuring the safety of students in high schools.

3.4 Results of the warning system

The integrated warning system has demonstrated high performance in detecting and promptly warning dangerous situations. Specifically, when detecting a risk near the railing, the system immediately activates the warning speaker with an average delay of 0.5 seconds, emitting a clear warning sound, helping students and school staff to quickly recognize it. At the same time, the system sends notifications to the administrator's mobile phone with an accuracy of 98% in transmitting information, ensuring that dangerous situations are handled promptly and effectively. Feedback from actual tests shows that the system operates stably, is capable of minimizing response time and preventing potential accidents in the railing area.

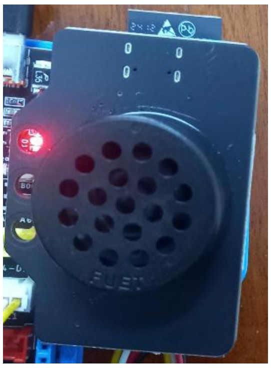

Figure 9: *Activate speaker warning, LED turns red*

Figure 10: *Enable SMS alerts on your phone via the Telegram App*

Figure 12 illustrates the system's recognition and non-recognition percentages at different sensitivity levels from 20% to 100%. The results show that at 20% sensitivity, the system achieved 92% correct recognition and 8% non-recognition. When the sensitivity level was gradually increased to 40% and 60%, the correct recognition rate decreased to 83% and 61%, respectively, while the non-recognition rate increased to 17% and 39%. At 80% sensitivity, the correct recognition rate increased to 77%, and the non-recognition rate decreased to 23%. At the maximum sensitivity level of 100%, the system achieved the highest recognition performance with 98% and only 2% non-recognition. The distance recognition boundary was set at 20 cm, showing the high efficiency of the system in detecting objects at dangerous distances near the railing. This result confirms the necessity of sensitivity tuning to optimize recognition performance and minimize non-recognition rate in real-world scenarios.

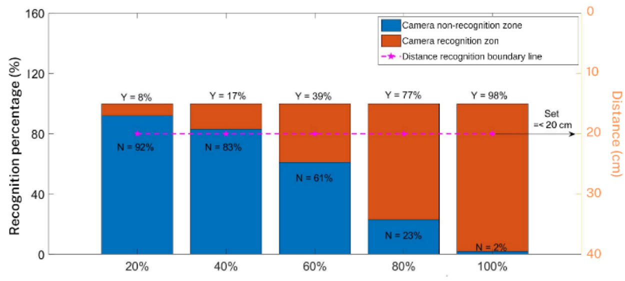

Figure 11: *Levels of system detection and non-detection*

4. DISCUSSION

Traditional railing safety monitoring methods primarily rely on direct observation by teachers or security staff, leading to limitations in surveillance coverage and slow response times in case of an incident. Additionally, measures such as installing warning signs or barriers are merely passive precautions and cannot immediately detect or alert potential dangers.

In contrast, the application of AI technology in this study offers a more effective approach by enabling continuous monitoring, accurately identifying hazardous situations, and providing rapid responses through an automated warning system. By integrating AI-powered cameras, sensors, and alert notifications, the system can promptly detect risks, minimize accidents, and enhance safety for students in school railing areas.

Table 1: *Comments on traditional methods and scientific and technological methods*

Method	Traditional	Science and technology
Describe	Teachers teach the theory of railing safety, using images, simulation videos and discussions, promote railing safety during flag-raising ceremonies or flag-raising activities.	Use cameras and image recognition software systems to monitor student behavior near railings and warn of danger.
Advantage	Help students understand the theory and importance of railing safety. Provide opportunities for students to discuss, share experiences and knowledge.	Automatically detect dangerous behavior and alert immediately, regardless of teacher supervision. Provide data, can analyze and evaluate dangerous

	Reach a large student audience and easily convey the message. Provide opportunities for periodic reminders of railing accident risks. Help students practice skills and know how to handle real-life situations. Increase students' awareness and attention to real-life risks.	behavior in real time. Reduce costs and resources for manual supervision. Educate students by educational message features sent to them, can change the message.
Disadvantages	Cannot check actual student behavior. Students may not pay attention if the teaching method is not engaging. Messages may not be deeply absorbed by students. Cannot organize discussions or direct practice. Requires space and time for practice, which can be expensive. Close supervision is required to ensure safety during training.	
Novelty, creativity		Data analysis and early warning features. Timely and diverse warnings. Integrated sensors and technology. User-friendly and easy to use.
Uniqueness of the solution		Applying IoT (Internet of Things) technology. Automatic update and quick response features

From table 1 it can be seen that both traditional monitoring methods and technology-based methods aim at the common goal of improving student safety. Traditional methods often rely on manual monitoring, which may be limited in terms of timely detection and accurate handling. In contrast, technology-based methods allow the system to operate continuously, automate the monitoring process, minimize human intervention, and significantly improve the accuracy and speed of response in risky situations, contributing to better protecting students in the school environment.

5. CONCLUSION

The research results have demonstrated the effectiveness of the railing safety monitoring and warning system in secondary schools. The system, utilizing AI and sensors, achieves outstanding accuracy (over 80% under all conditions), ensuring efficient detection and classification of safe or unsafe situations. With an average processing time of less than 1 second, the system provides timely warnings to prevent risks. This research successfully developed and tested a railing safety monitoring and warning system based on the integration of Artificial Intelligence (AI) and the Internet of Things (IoT).

In the future, the research will continue to focus on improving algorithms to enhance recognition performance and reduce false alarm rates while optimizing deployment costs to expand the scope of applications in more complex environments. The contributions of this research go beyond technical aspects, holding significant importance in improving safety and quality of life in modern society.

6. ACKNOWLEDGMENTS

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