Intelligent Elevator Systems Using Computer Vision and Human Detection for Enhanced Efficiency

Mitigating Call Button Misuse, Optimizing Energy Consumption, and Improving User Experience

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***Abstract*—This research proposes an intelligent system for elevators leveraging computer vision (CV) and human detection to mitigate misuse of call buttons, reduce energy consumption, and enhance operational efficiency. Elevators often face issues like unnecessary trips caused by prank button presses or misuse, leading to increased energy consumption and reduced system efficiency. To address these challenges, the proposed system uses real-time human presence detection to validate button presses and cancel fake calls. Furthermore, it incorporates an idle mode that powers down lights and fans during periods of inactivity, conserving energy while ensuring rapid responsiveness to legitimate external calls. Experimental validation demonstrates significant improvements in energy efficiency, operational reliability, and user satisfaction, making it an effective solution for integration into modern smart buildings.**

***Index Terms*—Intelligent Elevator Systems, Computer Vision (CV), Human Detection, Call Button Misuse, Energy Efficiency, Operational Reliability, User Satisfaction, Smart Buildings, Real-time Detection, YOLOv11 Algorithm, Idle Mode, Energy Conservation, Privacy in Smart Systems**.

I. Introduction

Elevators are integral to modern infrastructure, particularly in high-rise buildings, providing essential vertical transportation in commercial, residential, and public spaces. However, these systems are frequently plagued by issues that compromise their efficiency and user satisfaction. One such issue is the misuse of call buttons, particularly in public or densely populated buildings where prank button presses, accidental inputs, or unclear user intentions lead to unnecessary trips. This not only wastes energy but also reduces system efficiency, leading to longer wait times for passengers and overall operational delays. The cumulative effect of these inefficiencies can be particularly costly in terms of energy consumption, operational downtime, and user frustration.

The energy inefficiency in traditional elevator systems is another concern, with lights, fans, and other components remaining powered on even when the elevator is not in use. In modern smart building designs, where sustainability and energy conservation are key objectives, this presents an opportunity for optimization. While traditional elevator systems operate based solely on button inputs, often without accounting for the actual presence of passengers, this can result in excessive energy usage and suboptimal performance, particularly during periods of low activity.

In response to these challenges, this paper introduces an innovative solution that leverages computer vision (CV) and human detection technologies to address both the misuse of call buttons and energy inefficiency. By incorporating real-time human presence detection, the system can distinguish between legitimate requests and prank or accidental button presses. This validation process ensures that the elevator only responds to valid requests, minimizing unnecessary trips and reducing energy wastage.

Additionally, the system introduces an idle mode that dynamically adjusts the energy consumption of the elevator based on occupancy and activity levels. When no passengers are present for a predefined period, the system automatically powers down non-essential systems such as lights and fans. This ensures that the elevator is not wasting energy when not in use, while still being able to respond quickly to legitimate external calls.

This paper will first review related literature on elevator optimization, energy efficiency in smart build- ings, and computer vision applications. We will then present the proposed methodology, followed by a dis- cussion of the system's potential impact on energy effi- ciency, user satisfaction, and scalability. Lastly, we will conclude with future directions for research and de- velopment, including the implementation of advanced features like AI-powered predictive maintenance and voice recognition for enhanced user convenience.

II. Literature Survey

A. IoT-Based Smart Elevator Systems

Research in IoT-based smart elevator systems has significantly advanced the optimization of vertical transportation in buildings. The integration of sensors, such as Passive Infrared (PIR) sensors, allows for real- time human detection, reducing unnecessary stops and optimizing energy consumption. For example, the sys- tem proposed by [IoT Smart Elevator Study] focused on minimizing elevator stops at unoccupied floors, re- sulting in reduced energy and time wastage. However, these systems primarily rely on IoT sensors, which may not efficiently handle scenarios involving prank button presses or low-light conditions. The proposed use of computer vision (CV) and YOLO models in intelligent elevator systems extends these concepts by introducing more robust and accurate human detection mechanisms, enhancing operational efficiency and user satisfaction compared to [1] .

B. Advances in Intelligent Elevator Systems

The concept of smart elevator systems has been explored in various research works to optimize op- erational efficiency, reduce energy consumption, and enhance user experiences in modern smart buildings. For instance, a study leveraging RFID, video, and floor sensors demonstrated an efficient elevator scheduling system capable of predicting passenger behavior be- fore call button activation. This system, integrated with building networks, generates reservation calls and optimizes elevator movement direction and timing. Extensive simulations revealed significant reductions in average and maximum waiting times, as well as en- ergy consumption, compared to conventional schedul- ing methods. However, this approach primarily relied on sensor-based mechanisms and focused solely on immediate operational performance metrics, without exploring advanced AI integration or broader smart building frameworks.

Building upon these ideas, our research introduces a novel smart elevator system powered by the YOLO model for object detection. By utilizing cutting-edge artificial intelligence and image processing technolo- gies, our system achieves improvement in wait times and reduction in energy consumption compared to the work in [2].

C. Computer Vision Applications

Redmon and Farhadi (2018) introduced YOLOv3, a real-time object detection algorithm that is widely used for human detection in various applications. YOLOv3's efficiency in detecting multiple objects in complex environments makes it suitable for eleva- tor systems, ensuring real-time validation of button presses. However, as YOLOv3 is now outdated, our system implements YOLOv11, which provides higher accuracy and faster inference speed in human detection [3].

Feature	**YOLOv3**	**YOLOv11**
Release Year	2018	2024
Detection Accuracy	Good accuracy for small and medium objects	Higher accuracy, especially for small objects
Speed (FPS)	Moderate real-time performance	Faster with optimized edge-device performance
Architecture	Darknet-53	Enhanced backbone with superior feature extraction
Hardware Requirements	Requires moderate GPU resources	More efficient for edge and resource-limited devices

TABLE I: Comparison of YOLOv3 and YOLOv11 for Intelligent Elevator Systems.

D. Computer Vision-Based Elevator Optimization

Existing research has explored computer vision techniques to optimize elevator operations. Lan et al. (2021) developed a real-time monitoring system that utilizes computer vision to analyze elevator compo- nents and detect abnormal behaviors. Their system focuses on enhancing safety by identifying potential malfunctions, detecting door obstructions, and moni- toring elevator cabin conditions. The primary objective of their work is to improve elevator maintenance and operational reliability, reducing the risk of mechanical failures and ensuring a safer user experience.

However, while their system effectively identifies hardware faults and unusual passenger behavior, it does not address energy consumption or call button misuse. Their approach primarily benefits maintenance teams by enabling early fault detection but does not optimize elevator movement based on real-time user demand. Our work extends this research by integrating human detection and button validation mechanisms to actively prevent unnecessary elevator trips, thereby improving both energy efficiency and operational per- formance [4] .

E. Privacy in Smart Systems

Herwanto (2021) discussed privacy-preserving tech- niques for IoT systems, emphasizing the importance of local data processing and anonymization. Given that the proposed system relies on computer vision, privacy concerns are addressed by processing video feeds locally and ensuring that no personal data is stored or transmitted externally. This approach aligns with ethical standards and data protection regulations, ensuring that the system is both functional and compliant [5].

III. Proposed Methodology

A. System Overview

The system presented in the paper integrates computer vision (CV) and human detection technologies to enhance elevator operations. The solution is aimed at two main problems:

1) Misuse of Call Buttons: People often press elevator call buttons unnecessarily (either by accident or as pranks), causing the elevator to make unnecessary trips. This not only wastes time but also consumes extra energy and reduces system efficiency.

2) Energy Inefficiency: Elevators often keep their lights and fans running even when not in use, contributing to unnecessary energy consumption. The proposed system addresses this by dynamically managing power based on cabin occupancy and activity.

B. Software Architecture

1) Human Detection Algorithm: YOLOv11 (You Only Look Once version 11) is the primary algorithm used for human detection in this system. YOLOv11 is a deep learning-based real-time object detection algorithm that is known for its speed and accuracy. YOLOv11 works by scanning the elevator's camera feed and classifying objects within the frame. If a human is detected, it marks the bounding box around the individual and updates the system in real-time. One of the key advantages of YOLOv11 is its ability to work effectively even in low-light or cluttered environments, which is important in an elevator that may not always be well-lit or could have multiple passengers.

Fig. 1: Detection using YOLOv11

2) Button Validation Logic: After human presence is detected, the system cross-checks whether the button press is valid. If the cabin is empty (no human detected), any button press is deemed a fake or unnecessary call and is canceled. If the camera and sensor data validate the presence of passengers, only then the system processes the button input and moves the elevator accordingly. This ensures that the elevator doesn't make unnecessary trips due to prank button presses or accidental button presses by passengers outside the cabin.

3) Idle Mode Controller: The idle mode feature is key to optimizing energy usage. When no passengers are detected in the cabin for a predetermined period, the system switches the lights and fans off to conserve energy. The system uses real-time data to monitor the cabin's occupancy status, turning the energy-saving mode on or off depending on the number of passengers and overall activity in the elevator. This controller ensures that the elevator is responsive to legitimate requests (external calls) while minimizing power usage when idle.

C. Workflow

The workflow is designed to seamlessly handle real-time detection, decision-making, and power management:

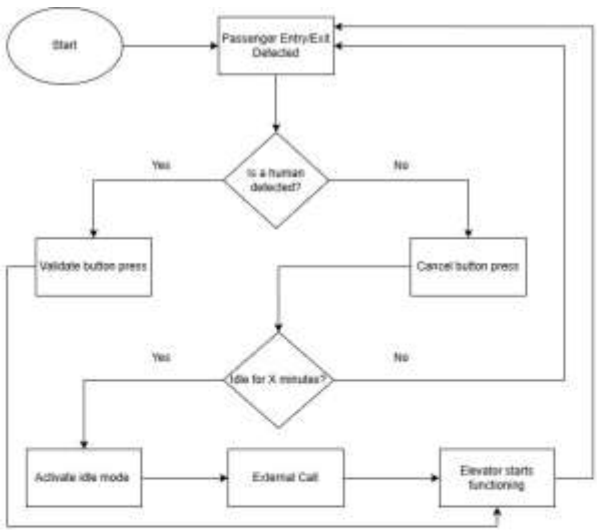

Fig. 2: Workflow

1) Passenger Entry/Exit Detection: When a person enters or exits the elevator, the system continuously checks the data from the camera to detect and confirm the presence of passengers.

2) Button Press Validation: The system checks whether there are any passengers in the cabin before validating button presses. If passengers are present, the system proceeds with the button press and moves the elevator. If no passengers are detected, the system cancels the button press to avoid unnecessary trips.

3) Canceling Fake Calls: If a button is pressed by someone outside the cabin but no passengers are detected, the system cancels the call to prevent the elevator from wasting energy by making an unnecessary trip.

4) Idle Mode Activation: After a period of inactivity, the system automatically turns off non-essential systems like lights and fans in the cabin. The idle mode is activated when no passengers are detected for a predefined period. This saves energy when the elevator is not in use, and helps in reducing the overall energy consumption.

5) Override Idle Mode for External Calls: If an external call is made (someone presses the button outside the cabin), the system overrides the idle mode and restores power to the lights and fans. The elevator responds quickly to the external call, ensuring minimal waiting time for users.

IV. Discussion

A. Energy Efficiency & User Satisfaction

1) Efficiency: The system helps reduce energy consumption by preventing unnecessary trips and optimizing idle times. For instance, reducing trips caused by prank button presses directly contributes to energy savings. Furthermore, the system's ability to deactivate lights and fans during inactivity results in energy savings.

2) User Experience: The system ensures a smoother user experience by preventing frustration caused by prank button presses. It eliminates unnecessary interruptions, making sure that only legitimate requests are processed. The elevator's quick response to external calls, even after entering idle mode, enhances user convenience.

3) Scalability: The modular design of the system means that it can be easily integrated into existing elevator infrastructures. The approach allows building management systems to implement this system without requiring major hardware or software overhauls. This scalability ensures that the solution is a cost-effective upgrade for smart buildings, as it can be adapted to different elevator models.

B. Challenges

1) Privacy Concerns: Since the system relies on cameras to detect human presence, there are inherent privacy concerns regarding video surveillance. To address these, the system employs local processing of data (on the edge device like Jetson Nano), ensuring that no video data is sent externally. Additionally, data anonymization techniques can be implemented to further protect users' privacy, ensuring that no personal data is stored or transmitted.

2) False Positives/Negatives: Although the detection algorithms are designed to minimize false positives (incorrectly detecting non-human objects as people) and false negatives (failing to detect a human), challenges still exist in complex environments. To minimize these errors, the system can use multi-sensor data fusion. By combining the inputs from the camera, PIR(Passive Infrared), and ultrasonic sensors, the system can reduce the likelihood of detection errors, ensuring more reliable operation.

V. Conclusion

The research proposes a novel solution to enhance elevator operations by addressing common issues of misuse and energy inefficiency. The integration of computer vision and human detection algorithms leads to significant improvements in operational reliability and energy savings. The system not only enhances user satisfaction but also supports the goals of smart building design. Future enhancements will include prototype testing, AI-powered predictive maintenance, and the exploration of contactless interfaces such as voice recognition for greater user convenience.

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