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Optimization of Elevator Usage by Image Processing for Optimal Energy Conservation

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Abstract - An efficient vertical transit system is a crucial feature of contemporary office buildings. Modern machine learning (ML) algorithms make it simple to optimise lift control strategies. This study proposes a revolutionary way to use Raspberry Pi camera module data for the best possible dispatching of traditional passenger lifts. It is assumed that an image processing system processes a real-time video to ascertain the quantity of people and objects utilising the lifts and waiting for a lift vehicle in the halls. These numbers are assumed to be connected to a specific uncertain probability. The efficiency of our unique lift control algorithm is derived from the need to serve a crowded floor completely, sending as many lifts as possible there and filling them to the maximum weight permitted, in addition to the probabilistic utilisation of the number of people and/or items waiting. The suggested technique introduces the idea of the effective number of persons and items to account for the uncertainty that may arise from the image processing system's imperfection. Reducing wait time, energy conservation and optimization are main the goals of this research. The proposed approach was implemented, and the simulation results showed that the passenger journey time was reduced. A three-story office building was the intended application for the prototype model.

***Key Words*:** Elevator, Raspberry Pi, Machine Learning, Optimization, Image Processing

1.INTRODUCTION

This document shows the suggested format and appearance of a manuscript prepared for SPIE journals. Accepted papers will be professionally typeset. This template is intended to be a tool to improve manuscript clarity for the reviewers. The final layout of the typeset paper will not match this template layout The study uses real-time video processing and machine learning (ML) methods to optimise elevator dispatching in contemporary office buildings. The suggested approach analyses data from cameras positioned throughout the building to dynamically modify lift operations depending on assessments of passenger traffic and demand patterns made in real-time. By taking a proactive approach to lift control, the high-rise building's user experience might be enhanced, productivity could rise, and wait times could be reduced. Operators of lift control systems may now leverage enormous amounts of data to make more flexible and intelligent decisions thanks to the integration of machine learning. To maintain lift operations' flexibility and adaptability in a dynamic environment, the suggested method makes use of probabilistic models for uncertainty control and measurement by expertly managing uncertainty and dynamically altering lift dispatching in response to real passenger demand, the suggested approach demonstrates promise in improving lift operations and increasing building efficiency. Because of its scalability, the suggested approach can be applied to a wide range of building sizes and types, including office skyscrapers and residential complexes.

2. ELEVATOR OPTIMIZATION

A. Optimization Process

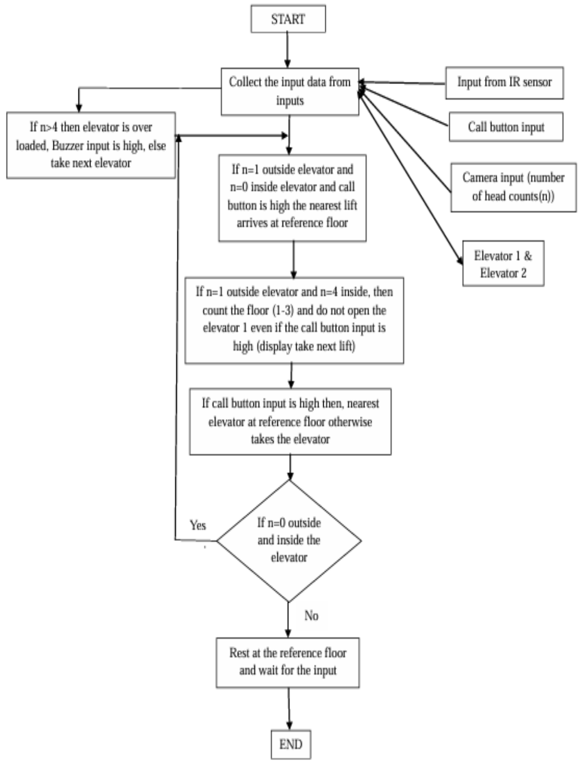

Fig.1-Optimization Algorithm

The initialize parameters for a building layout include defining the number of floors, num_elevators, and elevator_capacity. A matrix is created to depict the presence of people in front of lift doors. Cameras are set up to capture video frames of spaces in front of call buttons and lift doors. A main loop is used to capture video frames continuously. Person detection algorithms are applied to each frame to determine if a person is in front of each lift door. Call button detection is performed by examining recorded frames to see if any lift call buttons are pressed. If a call button is hit and an individual is found in front of the elevator door, the elevator function is activated. The system then checks the lift's capacity, loads up with people, shuts the door behind, informs passengers, and waits for a call button to be hit if neither is recognized. Optional security monitoring is also available. The main loop is repeated. The optimization process algorithm is shown in the Fig.1

B. Image Processing

Image processing is the process of utilizing computer-based techniques and algorithms to manipulate and analyses digital pictures. It includes several different processes, including pattern recognition, segmentation, filtering, and picture enhancement.

Usually, the procedure starts by getting an image from a camera or scanner. The picture is altered after it is taken to enhance its quality, collect data, or examine aspects. These adjustments can be made to the brightness, contrast, or sharpness, noise reduction, edge detection, object identification, and other aspects of the image.

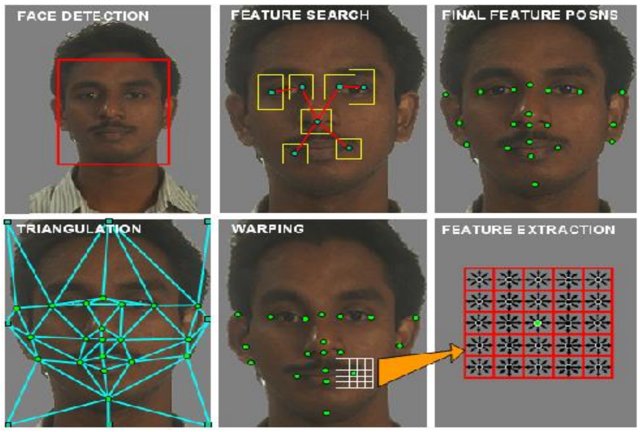

Fig.2-Face Recognition

Improvements in machine learning approaches, hardware capabilities, and algorithms have propelled the field of image processing forward, allowing for more precise and advanced analysis of visual data. Image processing is a computer method that involves modifying digital pictures to extract useful information, improve the quality of the image, or carry out certain studies. The procedure starts with obtaining digital pictures using scanners or cameras and involves many important phases. Preprocessing techniques such as color correction and noise reduction guarantee that the image is ready for further processing. Techniques for enhancing images alter brightness, contrast, and sharpness to raise their general quality. The goal of restoration techniques is to fix distortion or noise-related flaws. While feature extraction separates important components like edges or textures, segmentation divides the picture into meaningful sections. These characteristics are used in object identification and detection to locate and categories things in the picture. Sophisticated methods like deep learning and machine learning are important because they learn patterns directly from pictures to improve accuracy in tasks like segmentation and object categorization.

3. MACHINE LEARNING FOR IMAGE PROCESSING

A potent method for evaluating and deciphering visual data right on the Raspberry Pi module is to use machine learning techniques for image processing. Developers may apply complex machine learning models for tasks like object identification, picture classification, and semantic segmentation by utilising frameworks like TensorFlow.js. TensorFlow.js extends the functionality of the well-known machine learning framework TensorFlow to JavaScript, enabling online apps and embedded devices such as the Raspberry Pi to leverage its capabilities.

For instance, to do image classification tasks, developers can leverage pre-trained convolutional neural networks (CNNs) such as ResNet or MobileNet. In these jobs, the Raspberry Pi recognises objects within images by using patterns it has learned.

Developers may improve the Raspberry Pi's image processing capabilities by utilising machine learning methods, opening a variety of applications in industries including robotics, surveillance, and the Internet of Things.

There are several processes involved in utilising machine learning to implement face recognition on a Raspberry Pi. First, a collection of labelled face photos with a variety of changes in stance, expression, lighting, and backdrop must be gathered into a dataset. The photos are then standardised using preprocessing methods including scaling and grayscale conversion to guarantee uniformity and improve quality. Subsequently, the pretrained images are subjected to meaningful feature extraction via techniques such as Principal Component Analysis (PCA) or Convolutional Neural Networks (CNNs). This allows the model to identify distinct attributes of every face. The labelled dataset is then used to train the machine learning model, teaching it to correlate extracted attributes with matching IDs. To evaluate the model's performance using metrics like accuracy and F1-score on a different validation dataset, evaluation is essential. The model is installed on the Raspberry Pi after it has been trained and assessed. It integrates with OpenCV and Dlib libraries to do image processing and face identification tasks. Detecting faces with a pre-trained model, passing the face regions through the trained identification model, and recording video frames from the Raspberry Pi camera are the steps involved in real time face recognition. This makes it possible for the system to link identified faces to their corresponding identities and offer real-time feedback, which makes applications like security systems and customised interfaces possible.

4. RASPBERRY PI CAMERA MODULE

The Raspberry Pi Foundation in the UK is the creator of the Raspberry Pi line of tiny single-board computers. It was developed to support computer science education in elementary schools and in underdeveloped nations. But because of its affordability, small size, and adaptability, it has become more and more popular in several other domains, including hobby projects, Internet of Things (IoT) applications, and prototyping.

Via a special camera interface, the Raspberry Pi Camera Module is a tiny add-on that joins the Raspberry Pi board. The Raspberry Pi can now directly record photos and video, which makes it a useful tool for a variety of applications like computer vision projects, security systems, photography, and videography.

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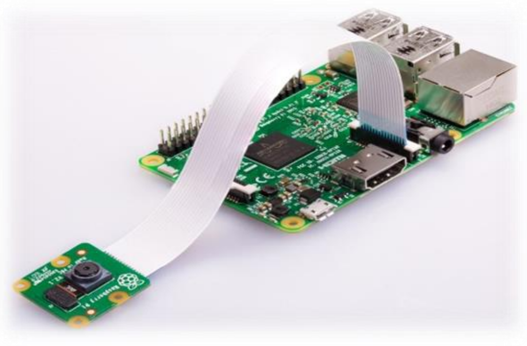

Fig.3- Raspberry pi camera Module

Utilising software techniques, image processing on a Raspberry Pi entail modifying digital images for a range of uses. The Raspberry Pi, a small and reasonably priced computer, offers an appropriate platform for image processing jobs because of its computational power and the programming languages and libraries that are available for it. To begin with, photos can be taken by reading image files from storage or by utilising the Raspberry Pi Camera Module. After that, developers can carry out a variety of image processing tasks by using libraries like scikit-image, OpenCV, or PIL. Feature extraction and detection, object detection and recognition, colour space conversion, image segmentation, morphological operations, and filtering to improve or preprocess images are some of these tasks. On the Raspberry Pi, image processing methods are usually implemented using C/C++ or Python programming languages. Because of its ease of use and the availability of modules like OpenCV, Python is especially well-liked. With the Raspberry Pi's limited processing power and memory, developers can enhance performance by optimising algorithms and leveraging hardware acceleration. Applications for image processing on Raspberry Pies are used in medical imaging, surveillance systems, automated inspection systems, object tracking, face detection, and augmented reality. All things considered, Raspberry Pi provides an adaptable platform for carrying out image processing tasks, opening a variety of applications in various fields.

The early warning benefit is the primary advantage of the image processing-based fire detection system. This system can be deployed almost anywhere for the purpose of detecting fires in commercial buildings, shopping centres, and many other public areas. This technology detects fires by using a camera. Therefore, additional sensors are not required to detect fire. To detect fires, the system processes the camera input and then the processor processes it. To identify whether there is a fire and take appropriate action, photos are analysed for heat signatures and fire illumination patterns. The device sounds an alarm and enters emergency mode upon sensing fire. also shows the system's state on the LCD display providing information.

5. METHODOLOGY

The methodology analysis offers a critical look at the research techniques used in the suggested solution, which include real-time video processing and the application of Machine Learning algorithms with Raspberry Pi for lift optimisation in office and residential buildings.

First off, the approach deviates from conventional static scheduling techniques by integrating AI&ML algorithms into lift control systems. This integration represents a move towards more flexible and dynamic approaches that can react to fluctuations in passenger demand in real time. The decision to use ML reflects the knowledge of the intricacy of lift operations and the requirement for intelligent systems that can continuously learn and adapt.

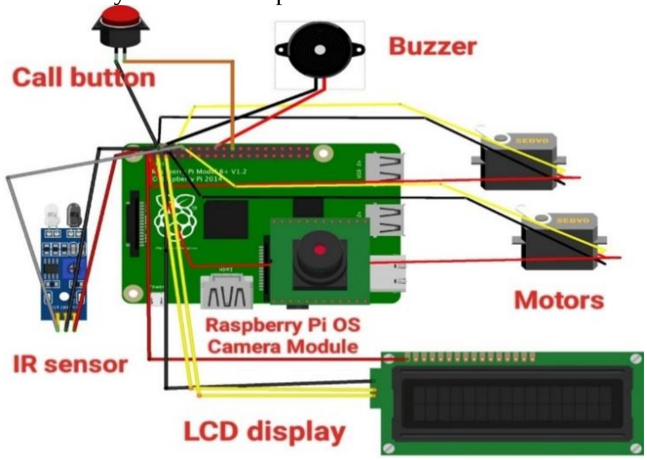

Fig.4-Circuit Diagram

Second, real-time data from camera module is placed throughout the facility is incorporated into the technique. This method of data collecting is essential for gathering precise and current data on demand and passenger traffic patterns. The research team can monitor lift utilisation in real time and pinpoint areas for optimisation by employing a camera module with raspberry pi to optimize direction and working of motor.

Thirdly, the approach entails creating and putting into practice image processing algorithms to examine the information gathered from Raspberry Pi camera module. These algorithms are essential for deriving valuable information from unprocessed video footage, including floor-level demand, movement patterns, and passenger counts. The research team can efficiently translate visual information into useful data for lift dispatching by using image processing techniques.

Fourthly, to handle the uncertainties included in the information gathered from camera data, the methodology incorporates probabilistic models. This part of the strategy aims to measure and control uncertainty in the decision-making process while acknowledging the limitations of image processing techniques. The research team can take into consideration differences in data accuracy and create more resilient decisions in response to changing situations by utilising probabilistic models.

Fifthly, the approach dynamically modifies lift dispatching in response to passenger demand in real time, giving priority to the efficient service of packed floors. By minimising traffic and cutting down on passenger wait times, this proactive strategy hopes to improve the lift system's overall effectiveness and user experience. Through the emphasis on providing effective service to busy floors, the research team makes sure that the suggested method is in line with the main objective of maximising lift operations and energy conservation.

Finally, many simulations are used in the methodology to assess how effective the suggested strategy is. These simulations offer quantifiable proof of the method's effectiveness in contrast to conventional lift control schemes. The study team shows how the suggested approach may be scaled and applied to different building types through simulations utilising a prototype model based on a three-story office structure.

The methodological study demonstrates the creative application of machine learning (ML) algorithms, real-time Raspberry Pi camera data, image processing methods, probabilistic modelling, and simulation-based evaluation to maximise office building lift operations using Raspberry Pi. The suggested strategy provides a thorough answer for resolving lift optimisation issues, enhancing building efficiency, user experience overall and energy conservation by integrating several research techniques.

6. CONCLUSION

A probabilistic technique based on optimisation theory and the closest automobile lift is presented in this study. The programme optimises the lift passenger journey time by using data from cameras via Raspberry Pies in hallways and lift cars. To ensure maximum collection from busy levels, the control system uses this information to identify the closest lift car. Every person's size is considered by the algorithm. For lift optimisation, a camera uses an image processing algorithm to detect the effective number of passengers. Reducing average travel, journey, and waiting time is another objective. In up peak traffic conditions with high traffic intensity and a big number of people, the algorithm operates poorly. It performs best in scenarios with small traffic size. Future research will concentrate on combining fixed and dynamic sectoring lift control techniques with a camera-driven probabilistic BN-based algorithm. The elevator optimization has been achieved by the Raspberry pi camera module through pretrained Machine Learning Algorithm for recognizing the human face(passengers).

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