Automated Fire Evacuation System with Congestion Control

Sujata Pathak
Assistant Professor
K.J. Somaiya College of Engineering
sujatapathak@somaiya.edu

Shreya Parikh
Student
K.J. Somaiya College of Engineering
shreya.parikh@somaiya.edu

Advait Bhat
Student
K.J. Somaiya College of Engineering
advait.bhat@somaiya.edu

Amandeep Singh Chabada
Student
K.J. Somaiya College of Engineering
amandeepsingh.c@somaiya.edu

Arvind Ganesh
Student
K.J. Somaiya College of Engineering
arvindganesh.a@somaiya.edu

***Abstract*—Most of the traditional fire evacuation systems present today are designed on the assumption that the people present in the building have prior knowledge about the nearest safety exits, but this assumption is not true in many cases and has also resulted in the loss of life in several instances. The Automated Fire Evacuation System is an embedded system which will effectively guide the victims of fire accidents to nearest safety exits. A network of temperature and smoke detector sensors placed strategically collects and delivers accurate information about the surroundings to the system. The Dijkstras algorithm is used to calculate the safest and shortest path to the exits. The evacuation path generated is conveyed to the victims through the use of LED strips which glows in a unidirectional pattern. The system also has an additional congestion control feature which uses image processing to detect congestion of corridors, if any congestion is detected the algorithm dynamically reroutes the people to other available evacuation paths.**

***Index Terms*—Dijkstra, safest route, congestion control, dynamic path,Arduino, raspberry pi**

I. Introduction

There are many public buildings such as malls, government offices, schools where many people are not well acquainted with the architecture, due to this many people fail to find nearest safety exits during a fire accident. The Automated Fire Evacuation System is designed with the aim to solve the above-stated problem by calculating the nearest exit points from each sensor and displaying the evacuation path through the use of LED lights.

This paper is organized as follows. Section 1. related work Section 2. tells about the collection of smoke, temperature, people density using sensors and camera. Section 3. describes reading the blueprint of the building, placement of the sensors and creation of graph data structure. Section 4. elaborates on finding the safest and shortest path. Section 5. describes conveying the safest path to the victims through the use of LED Strips. Section 6. describes rerouting if necessary, by real-time detection of parameters. Section 7. provides a brief conclusion of our work.

II. Literature Survey

Khyrina Airin Fariza Abu Samah, Burairah Hussin and Abd Samad Hasan Basari [1] developed an algorithm for finding the shortest and safest path during emergency evacuation by modifying the existing Dijkstra algorithm for an intelligent autonomous evacuation system. The methodology states the following changes: (1) modification of nodes direction: the nodes direction is restricted to one-way only so that people don't go near the fire affected and to direct them towards the exit nodes only and (2) modification of Dijkstra's algorithm: the blocking of the related nodes affected by the fire thus, rendering those unusable for exit route. This systems results presented that Dijkstras algorithm can be used as an effective navigation solution in emergency situations.

Nor Amalina Mohd Sabri, Abd Samad Hasan Basari,Burairah Husin and Khyrina Airin Fariza Abu Samah [2] details about a simulation method using Dijsktras algorithm for evacuation in high rise buildings. The program was developed on MATLAB and the programs methodology consisted of inputting matrix data, source and destination nodes, removal of affected nodes and the path will be blocked, finally generating a safe exit route.The simulation program attempts to validate the Dijsktra algorithm for generating the safest and shortest path for various different matrix input.

Md Saifudaullah Bin Bahrudin and Rosni Abu Kassim [3] eveloped a fire alarm system with the help of a small single board computer Raspberry Pi and a microcontroller board, the Arduino Uno as a master-slave configuration. The system proposes to alert the user whenever a fire breaks out and ask permission from the user whether to report to the firefighters. The system uses an image captured from the home surveillance camera and sends the image to the user to check the validity of the alert.It was developed on Python and the captured image was displayed on a PHP page.This system demonstrated the use of a cheap and effective solution for detection and alerting users with the help of Raspberry Pi and Arduino Uno.

Yuhong Li, Xiaofan Zhang, Deming Chen [4] developed a

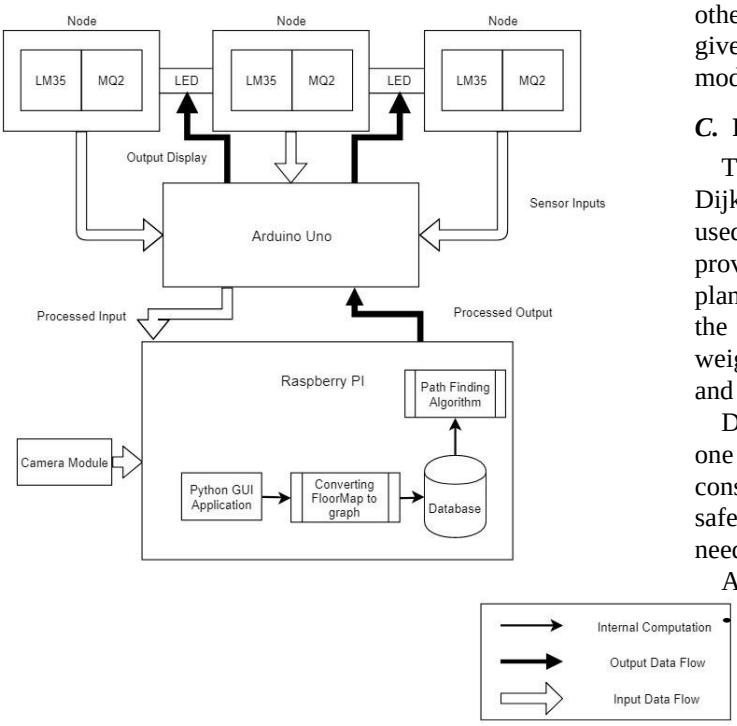

Fig. 1. BLOCK DIAGRAM

neural network for estimated the number of people in a crowd known as Congested Scene Recognition or CSRNet. It is a supervised learning algorithm consisting of a pure convolution structure. This algorithm expounds on the use case of huge crowded public areas but it could be further applied in the detection of congestion in the buildings during the evacuation.

III. Proposed Work

The block diagram for the proposed system is shown in Figure.1 The system consists of the following modules:

A. Collection of surrounding data

Sensors used to collect information are:

- LM 35 Temperature Sensor [5] used for measuring the surrounding temperature.
- MQ2 Gas Sensor [6] used for detection of smoke.
- Camera Module used to collect images of corridors.

Each pair of MQ2 and LM35 sensor is considered as a node in the path finding algorithm. The nodes are further classified into sensor nodes and exit nodes. The exit nodes are the sensors that are placed at the safety exits.

B. Reading blueprint and creation of graph

A web-based graphic user interface (GUI) application is used to input the image of the floor plan. The application then asks the user to add the sensor nodes and the exit nodes and place them on the floor plan according to the real placement of the sensors. The connection between the sensors is then added according to the physical accessibility of one node from the other with the specification of the distance between them. The given input is stored into a database for future reference or modification.

C. Path Finding Algorithm

The algorithm used to find the path is an application of the Dijkstras shortest path finding algorithm [7]. The algorithm used requires a graph data structure as an input, which is provided by the floor plan accepted by the user. In the floor plan, the sensors act as nodes of the graph and the edges are the connection between the nodes with the distance as the weights. An adjacency matrix is used to store the connection and the weights.

Dijkstras Algorithm [8] always finds the shortest path from one node to the other, but in our system, there is a need to consider whether the path is safe.The software focuses on the safety of the evacuees. To calculate the safest path, there is a need to modify the algorithm.

Application of Dijkstras algorithm :

- The algorithm has two sets of labeled nodes, the sensor nodes which act as the start node and the exit nodes as the destination nodes. The shortest path and distance are calculated for each pair of sensors and exit nodes. Further, from all the shortest path calculated from the sensor nodes a path with least distance to an exit node is selected.
- The sensor nodes at which fire is detected are then isolated from the graph and the paths are recalculated by excluding the fire nodes which are labeled as danger nodes.
- The algorithm also detects the congestion at a particular exit by using the image processing algorithm and accordingly redirects the incoming crowd to less crowded exit.

The path finding algorithm is applied repeatedly in a regular time interval so as to adapt to the changes in the surrounding.

Algorithm :

Step 1 : Using User Interface

- Creation of Sensor Nodes and Exit Nodes
- Place Nodes on Strategic Locations
- Select paths present between nodes and initialization weights of each edge
- Creation of a graph and storing it in the database
- Using the graph in the form of adjacency matrix in the algorithm

Step 2 : Detecting Danger Nodes and Congestion

- Read sensor data at regular intervals of 5 seconds
- Check if the sensor data crosses the threshold for detection of fire on the Arduino
- Check for congestion nodes using Camera Shots
- Pass on the danger node data from the Arduino to the Raspberry Pi

Step 3 :

- Execute the modified Djikstra's Algorithm to find the safest paths
- Convey the safest path via the LED strips deployed on all passageways

- If all the people have been evacuated Goto Step 4 else check for new danger nodes Goto Step 2

Step 4 : Stop

D. Congestion Control During The Fire Evacuation

Once the system detects fire, it will display the evacuation path by applying the path finding algorithm. In some cases, there is a probability that a large amount of crowd is diverted to a single safety exit which can lead to overcrowding at an exit and may even result in stamped. To avoid the above-mentioned problem, congestion control is applied by using images from the cameras installed in the corridors. Crowd counting algorithm [9] is applied to the images to count the number of people in the image frame, if the count exceeds the threshold the system will generate an alternative path if available.

Crowd Counting algorithm: A network for Congested Scene Recognition called CSRNet was used to accurately estimate the count of people [9]. There are two major components:

- the front end for 2D feature extraction : convolutional neural network (CNN)
- the back-end : a dilated CNN

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E. Integration of Hardware and Software Implementation

The system that is being developed for this project is based on the concept of an embedded system. A combination of computer hardware and software which is designed for a specific function is known as an embedded system. [10]. In the Automated fire evacuation system, a connection has been made between the hardware and software. The hardware consists of sensors and various communication devices, while the software is programmed to interact with the hardware and provide the user with the safest path in case of an emergency.

List of components:

- Arduino Uno
- Raspberry Pi 3
- LED light strips

Initially, the raw data from the sensors is collected by the Arduino which is then processed. The output from the Arduino is transferred to the Raspberry Pi. Raspberry Pi which is an headless system will run the algorithm using the data provided by the Arduino and the processed output is sent back to the Arduino. Finally, the path is displayed using the LED lights.

IV. Conclusion

In this paper, we presented the framework for calculating safest and shortest path during fire evacuation for occupants in a complex building structure. The system will be focusing on the case of congestion control during fire. The routing algorithm uses data collected by a mesh of sensors and cameras deployed throughout the building for dynamic routing. In this, the wayfinding navigation system during fire evacuation is made more intelligent and automated.

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