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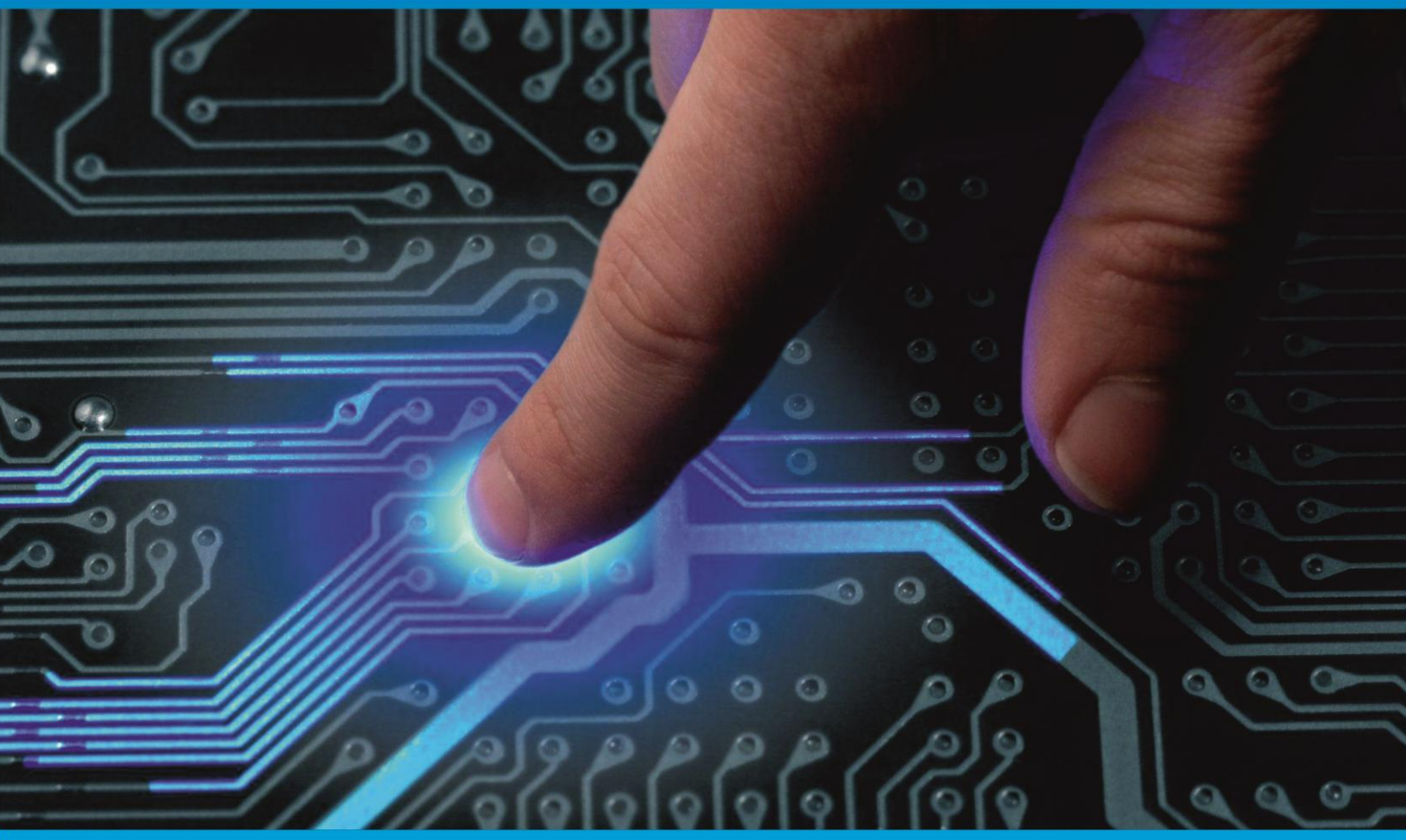

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Fire Evacuation and Safety Navigation System using IOT and Artificial Intelligence

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ABSTRACT: With technological advancements, internet is evolving and so is the development of internet of things. Buildings are getting smarter and this trend is gaining momentum. Wireless sensor networks play a key role in this concept. This idea deals with one of the widely used applications of wireless sensor networks, that is, in the field of navigation. When an emergency occurs, wireless sensors detect the danger and directs the evacuees to areas far from it via cyber physical interaction. Emergency navigation is essential to evacuate users trapped in danger to nearby exit. Our focus is not only to guide users providing short path but also safe path. This helps in avoiding congestion as well as leads to the usage of other sub-optimal paths which are often left unused thereby improving the survival rate of evacuees.

I. INTRODUCTION

Cities with heavy populations escalate burden on energy, water, buildings, public places, transportation and many other things. Therefore, we need to find out solutions that are “smart” which means they are efficient and feasible for economic growth of the city and society as well [1]. With the development of science and technology, the design of modern architecture is becoming more and more complicated and large-scale, and the large-scale public buildings such as shopping malls, office buildings, and science and education centers are increasing dramatically [2]. From a building resident’s perspective, the process of fire evacuation comprises of three main phases: awareness, response, and movement [3]. We propose Smart Escape, a real-time, dynamic, intelligent and user-specific evacuation system with a mobile interface for emergency cases such as fire. Unlike past work, we explore dynamically changing conditions and calculate a personal route for an evacuee by considering his/her individual features. Smart Escape, which is fast, low-cost, low resource-consuming and mobile supported, collects various environmental sensory data and takes evacuees' individual features into account, uses an artificial neural network (ANN) to calculate personal usage risk of each link in the building, eliminates the risky ones, and calculates an optimum escape route under existing circumstances. Then, our system guides the evacuee to the exit through the calculated route with vocal and visual instructions on the smartphone.

1.1 ARTIFICIAL INTELLIGENCE

The field of artificial intelligence (AI) has shown an upward trend of growth in the 21st century. The evolution in AI has advanced the development of human society in our own time, with dramatic revolutions shaped by both theories and techniques [4]. AI has been utilized into several major subjects including computer vision, natural language processing, the science of cognition and reasoning, robotics, game theory, and machine learning since the 1980s [5], [6]. In simple terms, AI aims to extend and augment the capacity and efficiency of mankind in tasks of remaking nature and governing the society through intelligent machines, with the final goal of realizing a society where people and machines coexist harmoniously together [7]. IMPORTANT GOAL of artificial intelligence research is to devise machines to perform various tasks normally requiring human intelligence. Proving mathematical theorems, learning to translate languages, playing good games of chess, and learning to improve its own performance are a few of the kinds of things such a machine is expected to perform [8].

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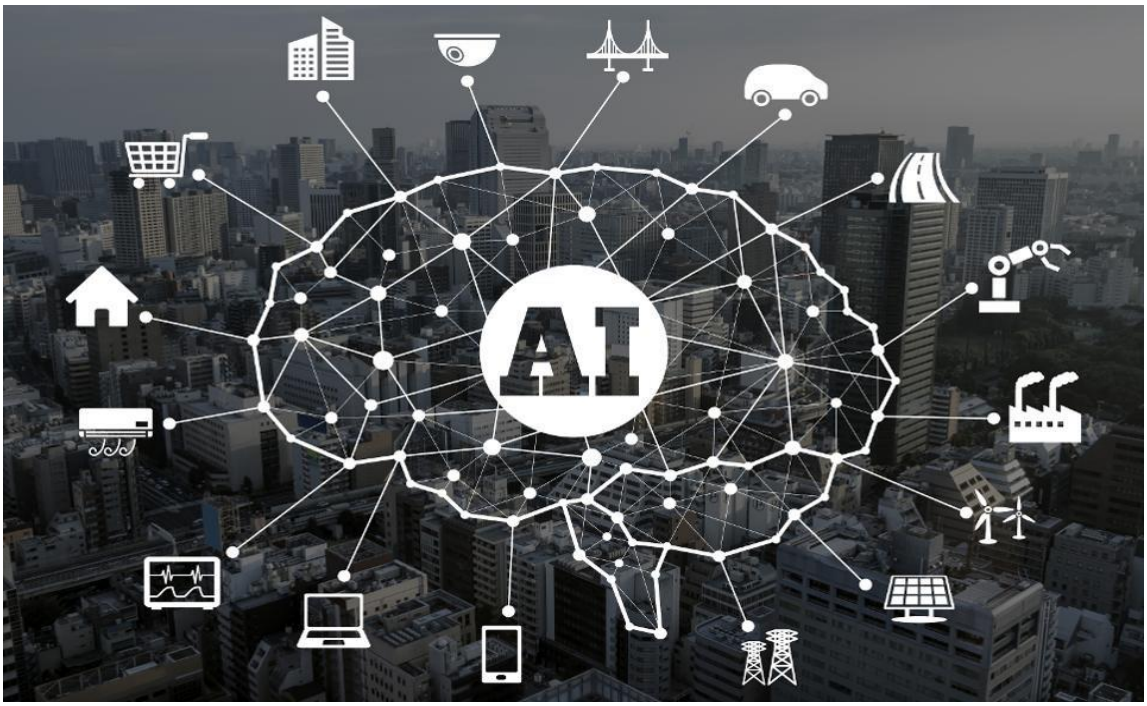

1.2 INTERNET OF THINGS (IOT)

Internet of Things is a new paradigm that has changed the traditional way of living into a high-tech life style. Smart city, smart homes, pollution control, energy saving, smart transportation, smart industries are such transformations due to IOT. The Internet of Things (IOT) is an emerging paradigm that enables the communication between electronic devices and sensors through the internet in order to facilitate our lives [9]. IOT use smart devices and internet to provide innovative solutions to various challenges and issues related to various business, governmental and public/private industries across the world [6]. Internet of Things has changed the way we use consumer electronics products in our daily life. The true power of IOT comes in when a sensor network combines its data intelligently for a meaningful result instead of simply collecting data for the sake of displaying it [10]. The concept of IOT is integration of elements like sensors, actuators, RFID (Radio Frequency Identification) involving a communicating interface and a computing capability into the Internet. Elements which we use in daily life such as (e.g., fridge, window, heater, switch, washing-machine, etc.) could be easily accessible, manageable and communicate through the Internet via Internet-based protocols (IPv6, UDP/TCP, HTTP) [11]. IOT is essentially a platform where embedded devices are connected to the internet, so they can collect and exchange data with each other. It enables devices to interact, collaborate and, learn from each other's experiences just like humans do.

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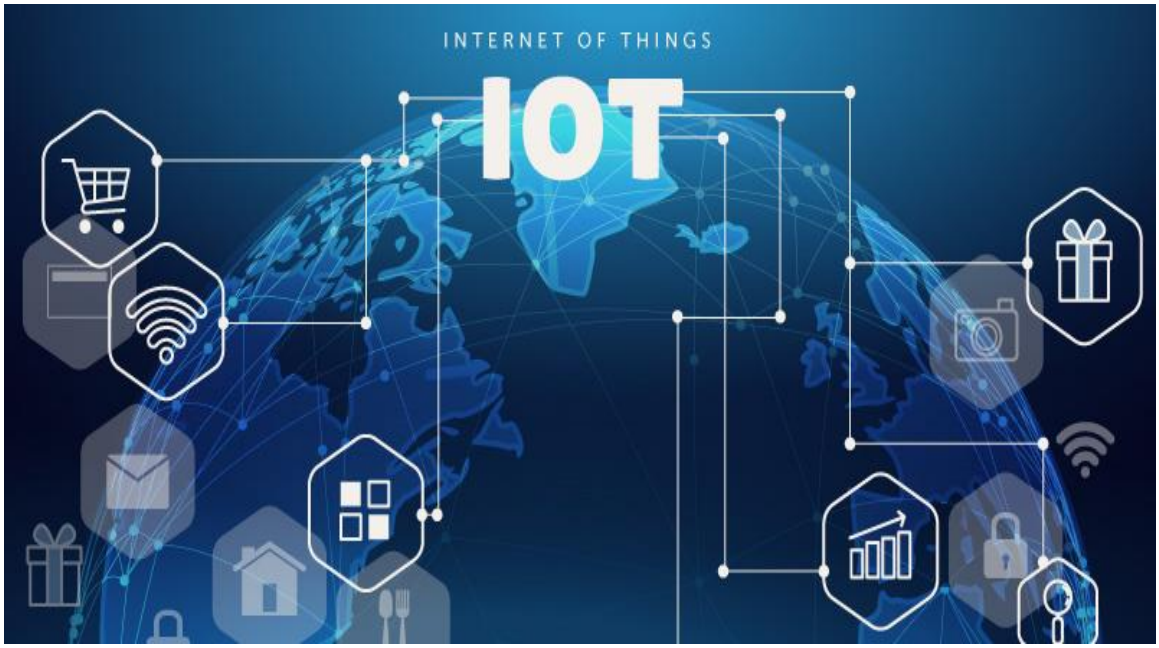

Picture courtesy-Google

1.3 PROBLEM DEFINITION

There is the route coordination problem in emergency expulsion of large smart buildings. The building expulsion time is crucial in saving lives in emergency situations caused by immediate natural or man-made threats and disasters. Conventional approaches to expulsion route coordination are fixed and predefined.

1.4 METHODOLOGY

Smart systems that are deployed in buildings increase user comfort and management of building resources becomes more efficient. These systems are referred to as building automation systems (BAS). Automated management of functions like heating, ventilation, lighting, security, and energy management is provided with BAS by using hardware and software-based techniques.Emergency Evacuation Service model is proposed as part of the BaaS project and details of this model are explained. At emergency situations, especially in densely populated buildings, evacuation of people to safe places is a very challenging task because of complexity of the building floor plans. An emergency service is targeted in this study in order to solve this issue.

1.5 MODULE DESCRIPTION

User login: For login to the system, user will enter the Username and password, if entered details are correct then the system will redirect him to home page otherwise it will show an error message.

Registration: The user will register to the system with normal information. At the time of registration, password will be auto generated and it will be provided to user's mail.

Prediction system: It will predict the path based on the indoor positioning system. It will help if any of the path is block.

Hardware: In this part ame sensor will check if any of the threshold level is crossed. If crossed buzzer will start.

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II. LITERATURE SURVEY

Title: Mobile Fire Evacuation System for Large Public Buildings Based on Artificial Intelligence and IoT.

In this, the artificial intelligence technology is used to construct an efficient and intelligent dynamic evacuation path solving model, and an intelligent mobile terminal re-evacuation system was built for large public buildings based on artificial intelligence technology. A grid environment model has been established, and the best evacuation route has been planned by analyzing three different stages of fire with improved ant colony algorithm. At last, the intelligent evacuation indicator is dynamically displayed.

Using improved ant colony algorithm, traditional geometric paths are replaced by effective lengths, and the optimal dynamic fire evacuation path is obtained. The advantage of this paper is that when a fire breaks out, the system can help guide people to evacuate from the building in real time and reach the safe exit quickly, so as to reduce casualties and economic losses. This paper has made a significant contribution in the field of fire protection.

Mobile terminal should be configured with ArcGIS Android SDK 10.1. rather than what is used in the paper.

Title: Building Smart Cities Applications using IoT and Cloud-based Architectures.

This paper focuses on the characteristics of a cloud platform for smart cities deployment with validation of platform's ability tailored to IoT functionalities using cloud middleware.Smart homes, smart buildings, airports, hospitals, universities or communities equipped with mobile terminals and embedded devices with sensors or actuators are interconnected. The importance of this research derives from the fact that it studied the ways through which the Cloud and Internet of Things concepts can be used in the context of smart cities.

This approach holds immense promise of reducing capital and infrastructure costs while improving efficiencies of service provision within the Smart City Framework.

The overall challenge is interoperability to enhance the interoperability among various providers and users in the IoT domain: Providing alignment between different systems and using ontology matching solutions, using coordinated efforts to design common specifications and core schema/reference models, providing metrics, tools and interfaces for annotations, test and validation and integration.

Title: An IoT Based Intelligent Fire Evacuation System.

In this paper, an IoT based intelligent fire evacuation system is developed that effectively guide people along an evacuation path in case of fire accidents. The A* search algorithm has been used to
control the central module of the proposed model. This help people navigate out of danger by guiding through the shortest safe path possible.

This system will play a potent role in saving the lives of the people in such circumstances. The implementation can bring a tremendous change in the fire accident handling procedure.

The disadvantage is that the use of A* search algorithm is that the speed of execution of A8 search is highly dependent on the accuracy of the heuristic algorithm.

Title: Smart Apparatus for Fire Evacuation - An IoT based fire emergency monitoring and evacuation system.

In this paper, a novel IoT based fire defense system is designed where the focus is on localizing fire instead of localizing people. Meshed Sensor Network is used in order to direct people away from fire we first had to realize a physical system that could locate a fire. Central Hub and Path Planning was to implement a server workstation that will receive all the sensor data from various nodes, process the data to identify the location of fire, learn about dynamic
fire spreading pattern and using the building structure map, generate exit strategies. User Interface is designed in order to display the evacuation maps generated by the central hub, a simple and user-friendly interface needed to be developed.

The advantage is that this problem does not require technologies like indoor localization that are complicated, expensive, and underdeveloped.

Currently, the whole system takes between 25 and 40 seconds from when the fire is sensed to when the website is updated correctly. This could be significantly improved by using a dedicated server for hub processing and an

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optimized path planning algorithm. Another essential improvement is to develop a fully performing actuator circuit. This would mean that people wouldn't need their phone for the best evacuation path. Guided LEDs can be used for that reason.

Title: Building Fire Emergency Detection and Response using Wireless Sensor Networks.

In this paper, there is an overview of work in two areas: protocol design for robust network operation, and sensor driven Evacuation. Also Routing and MAC Layer Design for Building Fire is designed. The framework of communication protocol design for building fire, and the main schemes to use WSNs in fire evacuation/guidance, as well as the multi-agent emergency simulation is presented in this paper. Considering scenarios where the network is damaged for this opportunistic Routing with Mobile Sinks are used. ER-MAC has been designed, a hybrid MAC protocol for fire emergency. This protocol adopts TDMA approach to schedule collision free transmission toward the sink.For evacuation path planning dynamic model is represented. The dynamic model provides estimated information about the dynamicity of the fire hazard over time in the building environment. A Multi-Agent Emergency Simulation has been proposed where a real-time simulator for detecting and handling building fire emergency scenarios is designed.

One of the advantages is that, dynamic sensor network management methodologies for building environment where wireless sensor network technology providing low-cost data acquisition which also provides a means of detecting the environment and the combine wireless sensing and actuating capabilities to provide some response capability for sensed events has been designed.

The future work includes the complementary of existing protocols and mechanisms, as well as implementing simulations under different network scenarios and fire models. One of the drawbacks of this paper is that in WSN, nodes need to be chargedat regular intervals. Battery life of the nodes is very low.

Title: Indoor Positioning Algorithm Based onthe Improved RSSI Distance Model.

This paper has proposed an RSSI real-time correction method based on Bluetooth gateway which is used to detect the RSSI fluctuations of surrounding Bluetooth nodes and upload them to the cloud server. The Global Navigation Satellite System (GNSS) cannot achieve accurate positioning and navigation in the indoor environment. Therefore, the back propagation neural network enhanced by particle swarm optimization (PSO-BPNN) is used to educate the RSSI distance model to scale down the positioning error. The experiment shows that the proposed method has better positioning accuracy than the traditional method. The least squares algorithm has been used in order to estimate the terminal position.

The experimental results show that the algorithm can improve the positioning accuracy and meet the requirements of the indoor positioning system.

The proposed method can be further improved by fusion positioning with multiple sensors which could be investigated in the future, including the positioning in some special cases.The disadvantages of particle swarm optimization (PSO)

algorithm is that it is easy to fall into local optimum in high-dimensional space and has a low convergence rate in the iterative process. In this paper, some special positions were not considered, like indoor corners and other complex electromagnetic regions.

Title: IoT-Based Intelligent Modeling of Smart Home Environment for Fire Prevention and Safety.

In this paper, a wireless sensor network using multiple sensors for early detection of house fires is designed and evaluated. In addition, the Global System for Mobile Communications (GSM) is used to avoid false alarms.Some analysis has been done by using different fire datasets. The work is divided into four parts. The first unit describes the sensor which collects the information from the environment and transmits it to the second unit, i.e., the processing unit, by using the ZigBee protocol. The third unit is the GSM communication unit, which alerts the users about the event. The fourth unit triggers the alarm.

The system designed in this paper is more efficient as compared to other related systems.Two major flaws of the currently used systems are: (a) the fire prevention systems mostly use a single sensor for event detection but problems arise if the target sensor does not detect the event; (b) false alarms can be generated. Overall, the proposed method in this paper provides a solution to these problems. The paper has introduced an efficient technique to overcome these problems. They have used multi-sensors for each region in smart homes.

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In the future, as they have used multi-sensors for the detection of fire and the amount of data generated by the sensors during a fire was high, so further work will be to find a method that deals with this high amount of data efficiently. One of the drawbacks is that for communication they have used Zig Bee protocol. As ZigBee has low transmission rate. Moreover, it does not have many end devices available yet.

Title: Virtual Reality for Fire Evacuation Research.

This paper discusses about human behavior in fire. In this we get info about how we can test our system from virtual reality to real world. VR experiments allow the convenient recording of behavioral and physiological data with a very high resolution as well as the collection of subjective data. Case studies refer to the descriptive, exploratory or explanatory analysis of a real fire emergency.

The biggest strength of VR is surely its ability to create highly immersive, externally valid, highly controlled, and safe experimental set-ups.

The biggest weakness is the reduced ecological validity in comparison with field and case studies, as well as the lack of validation studies. Visual input as well as well as interaction methods are still limited. Especially the simulation of behaviorally realistic virtual humans is still challenging. The paper has proposed Smart Escape, a real-time, dynamic, intelligent and user-specific evacuation system with a mobile interface for emergency cases such as fire.

Title: An IOT-based Emergency Evacuation System.

The system utilizes BLE beacons, mobile application, and smart exit signs to create a context aware system that dynamically routes occupants to the safest exit. BLE beacon has a built-in temperature sensor ESP32 microcontroller is interfaced with an MQ-2 gas sensor. Multiple edge devices including smart signs based ESP32 microcontroller and supporting Wi-Fi and the Digi Mesh network were deployed.

This technique to be effective large room only required two BLE beacons for effective localization and path finding. The system is robust as the Digi Mesh network takes over in case of a failure of the Wi-Fi system.

In our system users are equipped with mobile phones or PDAs interact with the sensors through Wi-Fi. We are also using indoor positing Algorithm to find shortest path.

Title: Building Fire Rescue with Evacuation Management Information System and its application.

In this paper,the framework of Building Fire Rescue with Evacuation Management Information System (BFREMIS) is built according to the relevant theory of Management Information System and the characteristics of building fire rescue and evacuation system. First, a suitable evacuation algorithm has chosen, establishing the evacuation model. Then a management information system was built by using GIS platform functions of data integration, information query, spatial analysis, data updating and expansion. A comprehensive optimization program was developed by systems analysis and the emergency evacuation plan.

With the basic information of the building transmitting to the fire safety systems, the fire safety systems can provide fast, efficient rescue measures when the fire breaks out.

Network model was adopted in this paper for establishment of evacuation model but network model is quite complicated and so one as to understand it well in order to implement it or modify it.

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III. LITERATURE SUMMARY

Sr. No.	Title	Advantages	Drawbacks
1.	Mobile Fire Evacuation System for Large Public Buildings Based on Artificial Intelligence and IoT.	Using improved ant colony algorithm, traditional geometric paths are replaced by effective lengths, and the optimal dynamic fire evacuation path is obtained. When a fire breaks out, the system can help guide people to evacuate from the building in real time and reach the safe exit quickly, so as to reduce casualties and economic losses.	Mobile terminal should be configured with ArcGIS Android SDK 10.1. rather than what is used in the paper.
2.	Building Smart Cities Applications using IoT and Cloud-based Architectures.	This approach holds immense promise of reducing capital and infrastructure costs while improving efficiencies of service provision within the Smart City Framework.	The overall challenge is interoperability to enhance the interoperability among various providers and users in the IoT domain.
3.	An IoT Based Intelligent Fire Evacuation System.	This system will play a potent role in saving the lives of the people in such circumstances. The implementation can bring a tremendous change in the fire accident handling procedure.	The disadvantage is that the use of A* search algorithm is that the speed of execution of A8 search is highly dependent on the accuracy of the heuristic algorithm.
4.	Smart Apparatus for Fire Evacuation - An IoT based fire emergency monitoring and evacuation system.	The advantage is that this problem does not require technologies like indoor localization that are complicated, expensive, and underdeveloped.	Currently, the whole system takes between 25 and 40 seconds from when the fire is sensed to when the website is updated correctly. This could be significantly improved by using a dedicated server for hub processing and an optimized path planning algorithm.
5.	Building Fire Emergency Detection and Response using Wireless Sensor Networks.	One of the advantages is that, dynamic sensor network management methodologies for building environment where wireless sensor network technology providing low-cost data acquisition which also provides a means of detecting the environment and the combine wireless sensing and actuating capabilities to provide some response capability for sensed events has been designed.	One of the drawbacks of this paper is that in WSN, nodes need to be charged at regular intervals. Battery life of the nodes is very low.

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6.	Indoor Positioning Algorithm Based on the Improved RSSI Distance Model.	The experimental results show that the algorithm can improve the positioning accuracy and meet the requirements of the indoor positioning system.	The disadvantages of particle swarm optimization (PSO) algorithm are that it is easy to fall into local optimum in high-dimensional space and has a low convergence rate in the iterative process. In this paper, some special positions were not considered, like indoor corners and other complex electromagnetic regions.
7.	IoT-Based Intelligent Modeling of Smart Home Environment for Fire Prevention and Safety.	The system designed in this paper is more efficient as compared to other related systems.Two major flaws of the currently used systems are: (a) the fire prevention systems mostly use a single sensor for event detection but problems arise if the target sensor does not detect the event; (b) false alarms can be generated. Overall, the proposed method in this paper provides a solution to these problems.	One of the drawbacks is that for communication they have used Zig Bee protocol. As ZigBee has low transmission rate. Moreover, it does not have many end devices available yet.
8.	Virtual Reality for Fire Evacuation Research.	The biggest strength of VR is surely its ability to create highly immersive, externally valid, highly controlled, and safe experimental set-ups.	The biggest weakness is the reduced ecological validity in comparison with field and case studies, as well as the lack of validation studies.
9.	An IOT-based Emergency Evacuation System.	The technique used is to be effective large room only required two BLE beacons for effective localization and path finding. The system is robust as the Digi Mesh network takes over in case of a failure of the Wi-Fi system.	The ESP32 microcontroller used is pricey. Moreover, mesh topology used can increase the complexity.
10.	Building Fire Rescue with Evacuation Management Information System and its application.	A comprehensive optimization program was developed by systems analysis and the emergency evacuation plan.With the basic information of the building transmitting to the fire safety systems, the fire safety systems can provide fast, efficient rescue measures when the fire breaks out.	Network model was adopted in this paper for establishment of evacuation model but network model is quite complicated and so one as to understand it well in order to implement it or modify it.

IV. PROPOSED SYSTEM

The proposed system is especially for densely populated buildings, in emergency conditions where evacuation of people to safe places is a very challenging job because of the complexity of the building floor plans. In the proposed system, the emergency evacuation of large smart buildings is taken into account.

Here we aimed to design a Smart Escape, a real-time, dynamic, intelligent, and user-specific evacuation system with a mobile interface for emergency cases such as fire. Our system calculates a personal route for an evacuee by considering his/her features. Our system collects various environmental sensory data and takes evacuees' features into account, uses an artificial neural network (ANN) to calculate the personal usage risk of each link in the building, eliminates the risky

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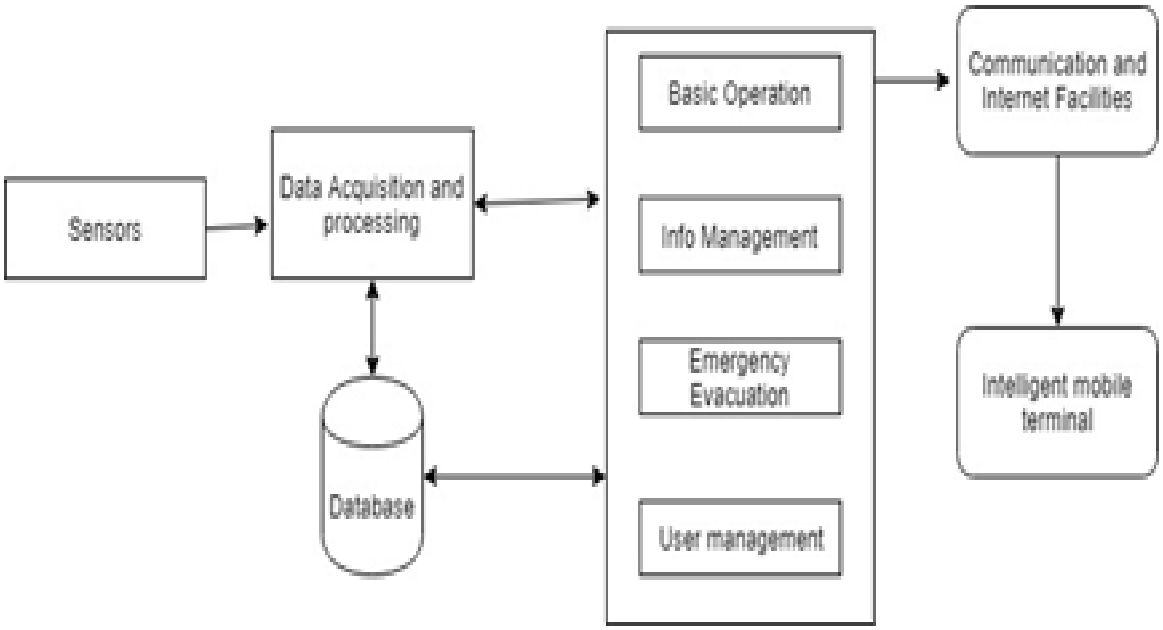
ones, and calculates an optimum escape route under existing circumstances. Then, our system guides the evacuee to the exit through the calculated
route with vocal and visual instructions on the smartphone.
Our System includes the following 4 stages:

1. Initially, the user should get registered to the mobile phone application. The user will register to the system with normal information. At the time of registration, the password will be auto-generated and it will be provided to the user's mail.
2. On the occurrence of hazardous accidents like fire or gas leakage, the sensor value set goes beyond the threshold, and an emergency is triggered. In this part, the AME sensor will check if any of the threshold levels are crossed. If crossed buzzer will start.
3. Wi-Fi is a technique used for location tracking of the evacuee with wireless access points(AP's). It will predict the path based on the indoor positioning system. It will help if any of the paths is block. The centralized control/sever has the location details of the building (for path navigation and also mapping details to exit).
4. Using an ant colony optimization algorithm (ACO), the system guides the evacuee to the short path but also safe exit through the calculated route with vocal and visual instructions on the smartphone.

4.1. ARCHITECTURE



4.2 .ALGORITHMS

A) INDOOR POSITIONING ALGORITHM

Like a GPS for indoor environments, IPS refers to the technology that helps locate people and objects indoors. That location information is then fed into some type of application software to make the information useful. For instance, IPS technologies enable a number of location-based indoor tracking solutions, including real-time location systems (RTLS), wayfinding, inventory management, and first responder location systems.
Just about everyone is familiar with the Global Positioning System or GPS, which can determine the precise position of any person or object on earth based on satellite signals. But what about indoor location tracking? GPS doesn't work well inside buildings—that's where an indoor positioning system (IPS), or indoor location tracking, comes in.To find location of user indoor if in case GPS didn't work in indoor. It also shows your exact position so that the person can easily navigate to the room. Location based services (LBS) require a reliable, accurate and continuous position

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determination of mobile users. This is particularly true in indoor environments where thewidely used Global Positioning System (GPS) is not available due to its signal outages. This is useful tofind exact position of user.

The below given figure (a.1) tells us the current position of the evacuee will be trackedusing indoor positioning with the help of a WIFI signal and leads to the short and safe exit.

Fig (a.1)

B) ANT COLONY ALGORITHM

It is an optimization algorithm which will give shortest path. It was inspired by the behaviour of ants that provides to find shortest distance between their nest and food resource. This algorithm is based on the traditional fingerprinting algorithm and consists of two stages, the offline acquisition process and the online positioning process.

- The offline acquisition process consists of three phases:

Phase 1: Collecting Indoor Wi-Fi signal.

Phase 2: Error handling of Indoor Wi-Fi signal collecting.

Phase3:Constructing the database of location fingerprints.

- The online positioning process consists of four phases:

Phase 1: Pre-matching location fingerprints.

Phase2: Improved Euclidean distance positioning.

Phase 3: Improved joint probability positioning.

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Phase 4: Weighted fusion positioning.

The figures (b.1) and (b.2) given below tells us about the ant colony optimization algorithm whichprovides the users'short path butalso a safepath. This helps in avoiding congestion as well as leads to the usage ofother sub-optimal paths which areoftenleft unused thereby improving the survival rate of evacuees.

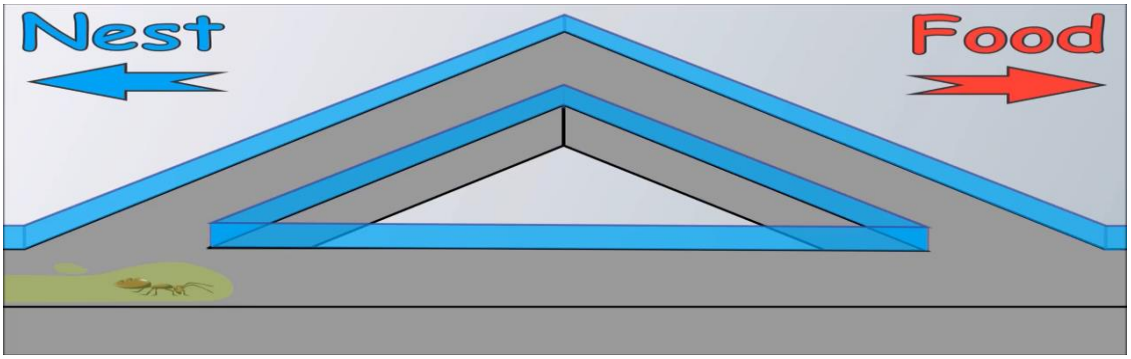

Fig (b.1)

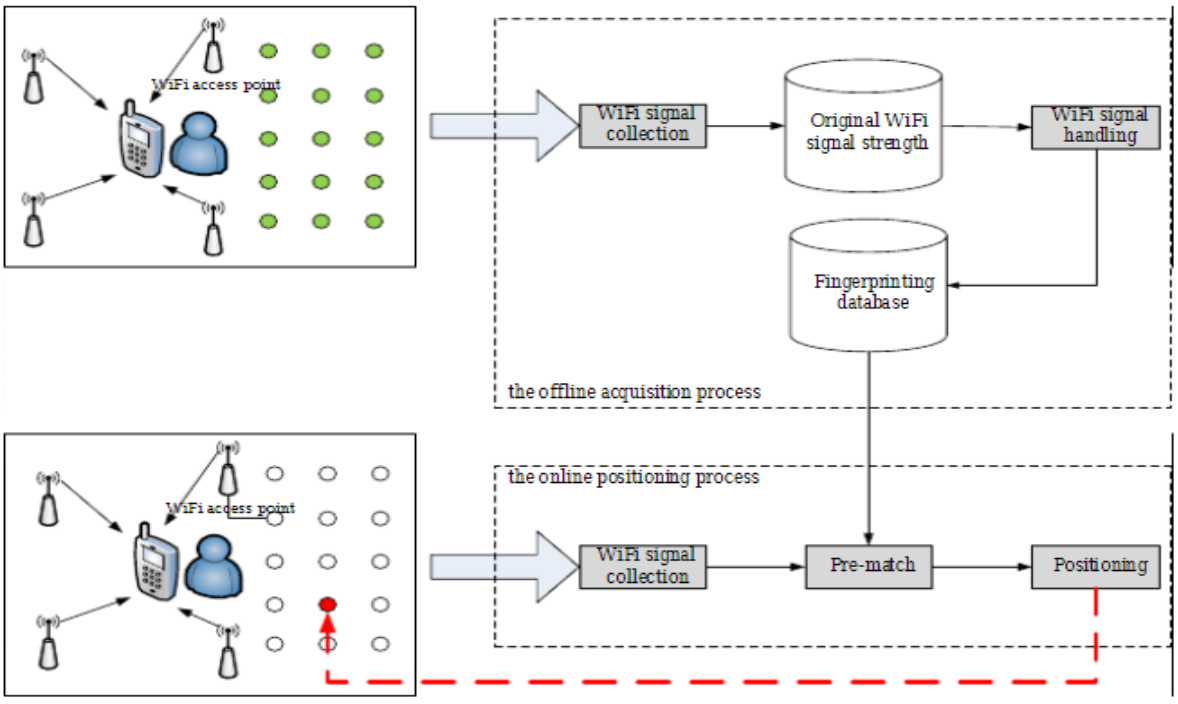

Fig (b.2)

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V. RESULT DISCUSSION

The overall design of the system is quite user-friendly. Module one which comprises of smoke sensor MQ2 which will be used to detect smoke in fire emergencies. Module two is designed for user login and registration where person will register into the app so that the person's location information is stored into the server. Module three is designed for map creation where as soon as there is any fire related emergency then the smoke sensor will detect fire andArduino will send the location of the room where there is fire. Then map will be created to help safely navigate people who are in the building towards the exit of the building. Module four has emergency calling where if a person finds difficult to make an exit then that person can quickly call on that emergency number. This whole system is designed to detect fire and help people navigate safely outside the building.

VI. CONCLUSION

The users equipped with mobile phones or PDAs interact with the sensors through Wi-Fi.GPS is in adequate for indoor location positioning. Wi-Fi is a technique used for location tracking with the wireless access points (AP's). Base on the range of Wi-Fi we can predict the current location of user in the indoor. Based on the current location we can show the exit location using the ant colony algorithm which will tell shortage and safest route to exit. This project helps in the exit of the user from the flat or company etc. Hardware will be used to detect the fire.

The complications and actuations in the internal environment of public buildings helps to think about how to protect people in there and instantly reach the secure area. On the compatible re emergency expulsion policies and ideas at home and abroad, this study uses artificial intelligence technology to the smart dynamic evacuation path solving model, and then it constructs an intelligent mobile terminal navigation system for large public buildings based on artificial intelligence technology.

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