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Soft Computation Technique based Fire Evacuation System

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Abstract

Occurrence of fire is an unpredictable activity needing very high attention. Early response for fire may lead to less damage of life and property. In this paper a work is proposed for evacuating the people to a safe point once fire accident occurs. The objective of the proposed work is to process the data acquired from smoke and temperature sensor to indicate the direction for movement of people. Computational technique is used to collect data from sensors and display safest path for people to evacuate from the building. Artificial Neural Network (ANN) is trained using particle swarm optimization to produce evacuation information. To test working of proposed technique it is subjected to several test cases, results obtained proves successful implementation of proposed work.

Keywords: Evacuation, Fire Safety, LabVIEW, Soft Computing

1. Introduction

With the rapid development of economy, science, and technology, more and more large buildings are emerging both at home and abroad, resulting in increasing security and safety risks. A key activity in emergency management is planning and preparation for disaster. If the right safety measures are implemented beforehand, harmful effects can be significantly mitigated. Modern buildings are equipped with various gadgets for sophistication, entertainment, security, etc. They can be assorted into different groups, starting with building safety. There is always a fire detection and alarm system that for example may include smoke detectors as data source. There have been several standard and regulatory bodies ensuring that every structure should implement safe and secure structure. These are some of the reasons which encourage many researchers and manufacturers to design new and improved fire safety and evacuation systems.

Detection of fire is a primary concern and several researchers have also reported works on detection of fire like in[1], an implementation of microwave radiometer for detection of fire is reported. Use of remote sensing satellites for forecasting fire danger is reported in[2,3]. In[4], an electromagnetic device is used for monitoring of forest fire. Image processing techniques are used for detection of fire by the process of spatial temporal analysis in[5]. In [6], a temperature measuring technique is used for detection of forest fire. Cluster of gas sensors are used for detection of fire with the help of embedded microcontroller in[7]. Image sensors are used for detection of fire along with monitoring of other health parameters for security and safety of buildings is reported in[8]. In[9], a fire detection technique using optical, gas, and microwave sensor is discussed. Paper[10], discusses the technique for monitoring of safety and security of building using sensors and communication technologies. Safety management of underground building using wireless sensor network is discussed in[11]. Though many of the researchers have reported techniques for detection of fire, it is seen that most work have concentrated on detection of fire at a particular place of structure. But very little work has been discussed on evacuation of people when any fire accident occurs.

In literature few works have been discussed for evacuation like[12], discusses errors involved when humans are involved in evacuation of buildings during an

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emergency in coal mines. Agent based evacuation model is used for evacuation of people in case of building fire using predictable human analysis model is discussed in[13]. Similar work is proposed for evacuation of crowd during fire disaster in a concert venue using human aid in[14]. In [15], analysis of performance of evacuation model in a college library when fire occurs is discussed. In[16], a model based evacuation model is discussed for evacuation of people from underground coal mines. Most of these reported works have discussed evacuation model based on human interference, but these techniques have human errors involved in it.

In order to overcome the above said drawbacks an intelligent evacuation technique is discussed for movement of people during occurrence of fire. The proposed model uses the output of temperature and smoke sensor for processing of data using neural network computation. Evacuation signals are displayed in accordance to acquired signals from sensor with reference to architecture of building.

The paper is organized as follows: after introduction in Section I, a brief description on diagram of proposed work is given in Section II. Section III discusses the methodology of the proposed work followed by results and analysis in Section IV. Finally conclusion is discussed in Section V.

2. Block Diagram

Evacuation process in case of fire emergency in a building is carried on using proposed technique with the block diagram as shown in Figure 1.

Smoke and temperature sensors are placed at specific positions in the building. Outputs of sensors are connected to the computer with the data acquisition cards. Once the data is acquired it is processed using ANN algorithms to display information for safe evacuation of crowd from the building once fire emergency has occurred.

2.1 Smoke Sensors

Proposed system uses ionization type of smoke sensors for detection of smoke. Ionization type smoke sensors are the most common type of sensors because of ruggedness and precision. The principle of ionization type smoke detectors is given as: Alpha radiation from the Americium-241 foil increases the ability of air to conduct electricity and thus ionizes the air through chamber allowing current flow. This current will be proportional to the ionization, and that in turn will be proportional to the amount of smoke detected. This current is converted to voltage and amplified to a range of 0 to 3V[17].

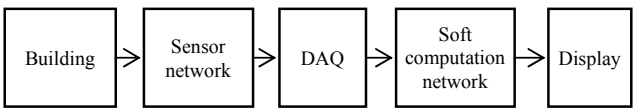

Figure 1. Block diagram of proposed system.

2.2 Temperature Sensors

For the measurement of temperature thermocouple is used. Thermocouple is a temperature measuring transducer working on thermally induced potential. It consists of two dissimilar metal electrode connected, this junction is termed as hot junction/junction where temperature is induced. The other end (cold junction) of the wire are used to measure the potential. The output measured in terms of voltage will be proportional to the change in temperature as compared to cold junction. Output of thermocouple is of the range mV, an instrumentation amplifier is used to scale up to a level of 0 to 5V[18,19].

2.3 DAQ Card

Signals from the sensors need to be acquired on to the system for computation. This is achieved with the data acquisition cards. Here we use a voltage input acquisition card by National Instruments (NI) USB6009. This is used to connect outputs of all sensors for continuous data monitoring on PC[20].

3. Methodology

For computation of proposed fire evacuation system LabVIEW platform is used. LabVIEW is preferred over other platform as it is user friendly with graphical user interface, real time plug and play data acquisition. LabVIEW consists of two panels named as front panel and block diagram. Front panel is the one which is used for visualization/interaction with designed system. Block diagram panel is one where, the actual programming is designed.

To demonstrate working of proposed system, architecture is considered in a way consisting of three floors and three rooms each, having two stairs ways. All rooms and pathway are fitted with gas and temperature sensors. The data from all these sensors are connected to data acquisition devices and acquired on

to LabVIEW platform. Front panel of proposed system is designed consisting of a replicating model of architecture. Indicators are placed on those to monitor the conditions of the building, color of the indicators shows whether any fire incident has occurred. Three strings indicators are used to shows the evacuation message for people to safely move out the building. These string indicators can be considered to be placed on respective floor of the building. A manual override button is also placed to reset the entire process and also to initialize a manual alarm. Figure 2 shows the front panel of proposed system.

Block diagram of proposed system consists of palettes used for programming. Firstly, DAQAssit is used to acquire the data from both the sensors. Once data is acquired, it is used to display the condition of all rooms at any instant of time. Indicators are used for purpose of same, color of these indicators act as indication of its state. This is achieved with the numeric to color palette, the principle of this is variation of RGB intensity to achieve variations in color. Initially blue is made zero, green is kept constant, and red is connected with output of sensors, as it increases with intensity of fire output indicator color also varies towards red.

For the purpose of indication of evacuation signal to the crowd in the building three string indicators are used, these indicators will display path which is safe for movement of crowd. Artificial Neural Network (ANN) algorithm is used for computation of evacuation path. For computation a multi layered perceptron neural network comprising of three hidden layer is trained using particle swarm optimization algorithm[21,22]. Training of neural network is carried on such it checks for nearest neighborhood of each room, for increase or decrease in values of smoke and temperature sensors. The target of neural network block will be the sequence of fire movement. This output of neural network is further used to display the movement of crowd for safe evacuation.

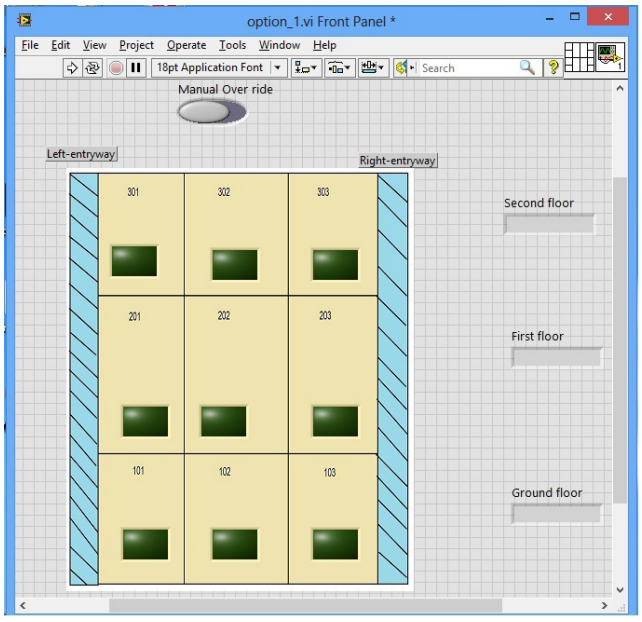

Figure 2. Front panel VI of proposed system.

4. Results and Analysis

For testing of proposed work many sequence of tests are done with igniting fire under different sensor to monitor each room conditions. A set of around 100 cases were done, results shown on the front panel of LabVIEW is shown in Figure 3, Figure 4, Figure 5 and Figure 6 obtained for sample cases. The indication represents both individual condition of each room and also evacuation information for crowd.

In another incident occurrence of fire is in second floor, proposed technique was able to detect the same accurately, colors of the indicators used also indicate the intensity of fire as seen in Figure 5, similar results can also be seen in Figure 6 for occurrence of fire in right side of the building.

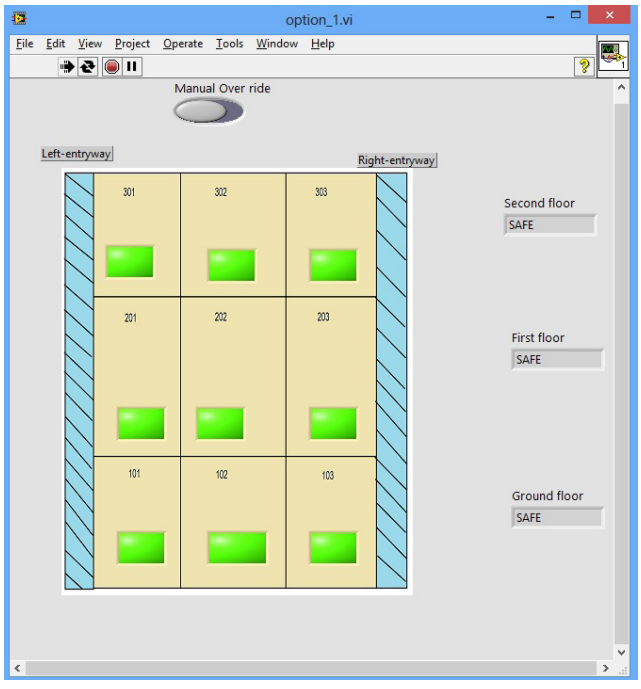

Figure 3. Result on front panel VI when no fire emergency.

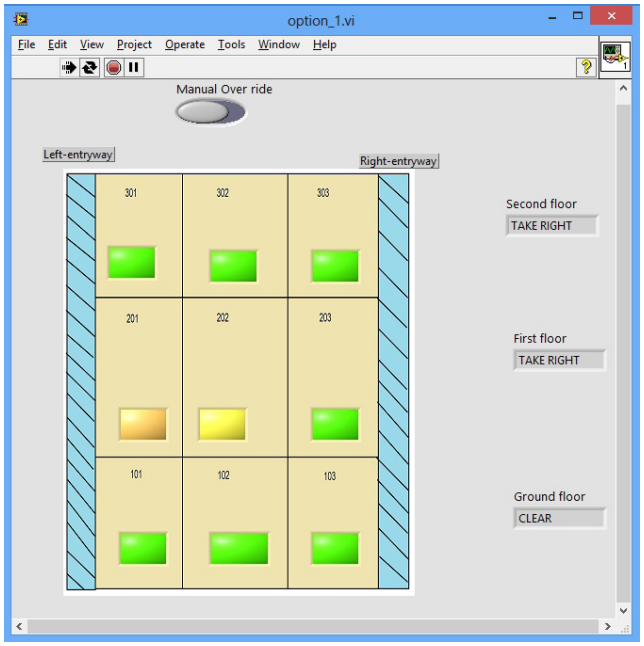

Figure 4. Result on front panel VI with fire emergency.

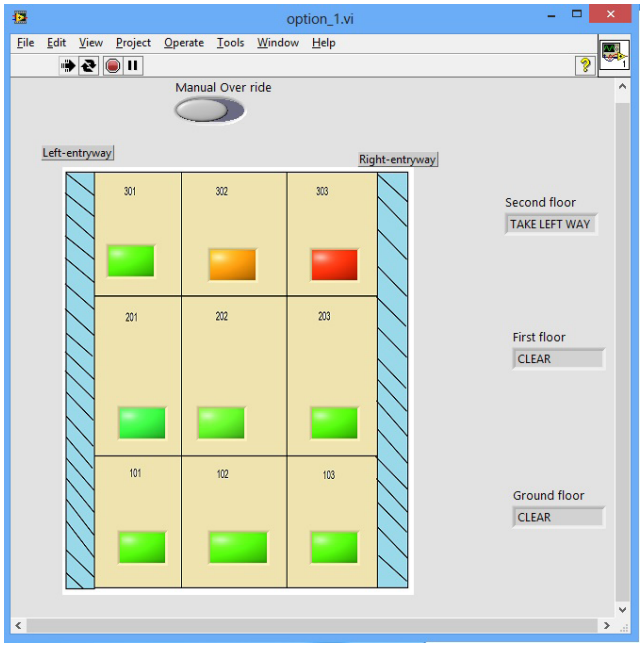

Figure 5. Result on front panel VI with fire emergency.

For testing, a condition is also created with no fire emergencies. Output for the same can be seen in Figure 3. Similarly a condition is created where occurrence of fire is in first floor, and spreading. Since the area is not safe a string data displays information for crowd to take the right stair way path, as shown in Figure 4.

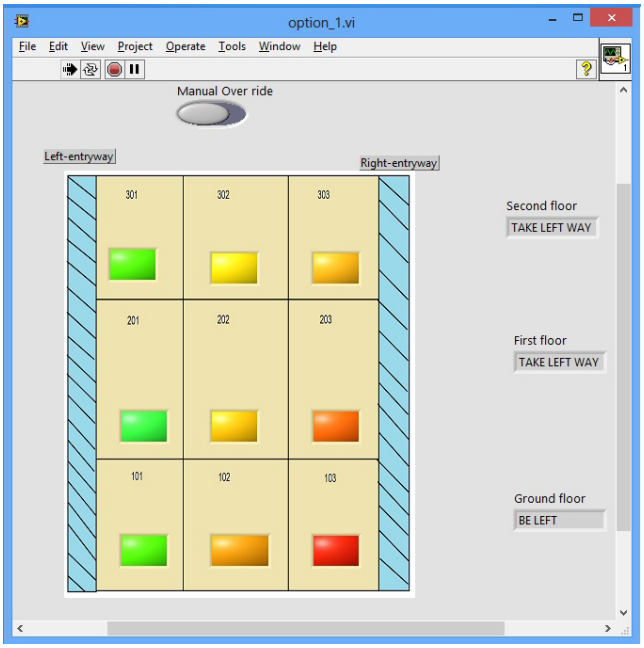

Figure 6. Result on front panel VI with fire emergency.

5. Conclusions

Population of people is increasing rapidly in cities, to accommodate the population it has become a necessity for any structure let be a housing complex, shopping complex, industry, hospital, etc. to expand vertically. Scenarios like fire accidents if not attended in a proper way would lead to high loss of life. It becomes very important to have a proper crowd management system in place, when such unforeseen events occur. Dependence on human's always would not be a better solution, so a technique is proposed using technology of sensors and computation languages for safe evacuation of crowd on occurrence of fire.

Proposed technique used ionization gas sensors and temperature sensor to monitor occurrence of fire, and soft computation tool like ANN is used to find the safe evacuation model.

Proposed system was tested with more than hundred test case, results produced were actually matching with real results to an accuracy of greater than 95%, few results obtained are also shown in Figure 3 to Figure 6. The performance obtained is satisfactory and can be implemented to real life application.

Improvement of the present technique can be achieved by incorporation of system to detect the presence of humans, take actions for evacuation. Ascertain the severity within the constraint of time.

6. References

1. Dvorak P, Zvanovec S. On the sensitivity of fire detection by a microwave radiometer. Proceedings of International Conference on Geoscience and Remote Sensing; Melborne, Australia. 2013 Jul.
2. Chowdhury EH, Hassan QK. Operational perspective of remote sensing-based forest fire danger forecasting system. ISPRS Journal of Photogrammetry and Remote Sensing. 2015; 104:224–36.
3. Sirimongkonlertkul N, Phonekeo V. Remote sensing and GIS application analysis of active fire, aerosol optical thickness and estimated PM_{10} in the north of Thailand and Chiang Rai Province. Proceedings of International Conference on Environmental Science and Development; Hongkong. 2012.
4. Wu X, Lee D-W. An electromagnetic energy harvesting device based on high efficiency windmill structure for wireless forest fire monitoring application. Journal of Sensor and Actuators A: Physical. 2014; 219:73–9.
5. Chen L-H, Huang W-C. Fire detection using spatial-temporal analysis. Proceedings of the World Congress on Engineering; London, UK. 2013.
6. Makela HM, Laapas M, Venalainen A. Long-term temporal changes in the occurance of a high forest fire danger in Finland. Journal of Natural Hazards and Earth System Sciences. 2012; 12:2591–601.
7. Bashyal S, Venayagamoorthy GK. Paudel B. Embedded neural network for fire classification using an array of gas sensors. Proceedings of International Conference on Sensor Applications; Atlanta GA, USA. 2008 Feb.
8. Horch C, Schafer F. A combined sensor data management system for sturctural health monitoring and building safety and security. Proceedings of International Conference on Sensoren und Messysteme; Numberg, Germany. 2014.
9. Krull W, Tobera R, Willms I, Essen H, Wahl N. Early forest fire detection and verification using optical smoke, gas, and microwave sensors. Proceedings of International Symposium on Safety Science and Technology; Germany. 2012.
10. Novak T, Gerstinger A. Safety and security-critical services in building automation and control systems. IEEE Transacations in Industrial Electronics. 2010; 57(11):3614–21.
11. Tan Z-L, Zhang C-L. Construction of the safety management system for urban underground business district with application of IOT. Proceedings of International Conference on Service Systems and Sercie Management; Hong Kong. 2013.
12. Wang L, Wang Y, Cao Q, Li X, Li J, Wu X. A framework for human error risk analysis of coal mine emergency evacuation in China. Journal of Loss Preventaion in the Process Industires. 2014; 30113–23.
13. Tan L, Hu M, Lin H. Agent-based simulation of building evacuation: Combining human behavior with predictable spatial accessibility in a fire emergency. Journal of Information Sciences. 2013; 295:53–66.
14. Wagner N, Agarwal V. An agent-based simulation for concert venue crowd evacuation modeling in the presence of fire disaster. Journal of Expert Systems with Applications. 2014; 41:2807–15.
15. Chixiang M, Baotie S, Shimei S, Hui L. Analysis of performance-based fire safety evacuation in a college library. Proceedings of International Symposium on Safety Science and Engineering; China. 2012.
16. Jingwei J, Jingyao Z, Jinlin C, Shuang W. Computer simulation of evacuation in underground coal mines. Journal of Mining Sience and Technology. 2010; 20:0677–81.
17. Bakhoum EG. High sensitivity miniature smoke detector. Journal of Sensors. 2012; 12(10):3031–5.
18. Liptak BG. Instrument engineers handbook-process measurement and analysis. 4th ed. CRC Press; 2003.
19. Murty DVS. Transducers and instrumentation. PHI Publication India; 2003.
20. Travis J. LabVIEW for everyone. 3rd ed. Prentice Hall; 2006.
21. Russell S, Norvig P. Artificial intelligence a modern approach. 3rd ed. Prentice Hall New York; 2009.
22. Clerc M. Particle swarm optimization. Wiley Publisher; 2006.