A PROPOSED SYSTEM TO GUIDE THE BEST EXIT PATH DURING FIRE HAZARD IN INDUSTRY ENVIRONMENT

Muhammad Nazrul Islam,[1] Wali Mohammad Abdullah,[2] Sanjida Nasreen Tumpa,[3] Niloy Roy, Md. Imtiaz Abedina
Department of Computer Science and Engineering,
Military Institute and Science and Technology, Mirpur-12, Dhaka-1216, Bangladesh
[1]Email: nazrulturku@gmail.com
[2]Email: shashi.mist@gmail.com
[3]Email: tumpa.sanjida@gmail.com

ABSTRACT

Fire protection is the study where it teaches how to survive during fire hazards and describes the safety measures during construction of the buildings to prevent destructive fire. Ensuring building code and fire code, government can enforce some basic safety measures during the construction of buildings. For smart building and also for already constructed buildings, we need some automated systems to find out the way of nearest exit for the victims, as well as, finding out the shortest path for the fire fighters to reach the target point. In this paper, an efficient algorithm is proposed where it provides immediate and dynamic indication of best possible exit path at the time of fire accidents in industrial environment.

Key Words: Artificial intelligence, Fire hazard, Shortest path finding.

1.0 INTRODUCTION

In this age of rapid, robust industrialization, fire accidents has become a prime concern in any type of working environments. There are some international standards which must be followed to setup working environment. However, industries of developing and underdeveloped countries are not concerned in these standards. As a result, casualties, vulnerability in handling situations (accidents) have become common phenomena in these regions.

Till to date, firefighting robot technology has undergone a long period of efforts whereas systems aiming to ensure safe exits have not been developed in same measure; because most priority should be given to rescue strategy for saving lives. Now-a-days, fire alarm system is common in both corporate and industrial areas. But unfortunately they just initiate the consciousness of endangered workers and don't suffice to present a strategic guidance to the path of rescue. Therefore, during the hazards, people keep panicking and run to and for which creates more casualties. So, calculative and effective alarm system is the urge of time.

Some real-life records can clearly justify the need of a fire exit guidance provider system which we have proposed in this paper in the following sections.

- On May 10, 1993, 188 workers were killed in a fire in Kader Toy Factory fire, Thailand. Moreover, locked exit door and collapsed stairwell increased the damage mostly young women.
- On May 13, 2000, Explosion resulted in 24 deaths and 947 were injured in Enschede at a fireworks department in Netherlands.
- On February 1, 2008, At least 22 people dead and 100 more injured which was caused by accidental explosion of an unlicensed factory of Istanbul, Pakistan.

• On September 11, 2012, Death counts were 289 in a fire at the Ali Enterprises garment factory of Karachi, Pakistan [1].

• On November 24, 2012, a fire accident occurred at Tazreen Fashion factory in Bangladesh and number of causalities was about 100 people.

Therefore, an effective exit guidance provider alarm system is the need of time.

The aim of this paper is to propose a prototype with an efficient sensor based light alarm generating embedded system. Our proposed algorithm follows an intelligent technique and handles time or distance related challenges to ensure minimum life casualties. In other word, this proposed system will guide the affected people to the shortest possible safest path from the point of affected person and exit point.

We have organized rest of the paper as follows. Overview on some related works are described in Section 2. Section 3 illustrates the proposal of the system. Finally, Section 4 concludes the paper.

2.0 RELATED WORK

A limited number of researches has been conducted to develop robotic system to detect and extinguish fire. This section will provide a brief overview of the related work.

Khoon et al. [2] introduced a mobile platform and Dubel et al [3] highlights the logic required and necessary components to successfully locate and extinguish the fire immediately.

A multi sensor based robot was introduced in [4]. This robot identifies the fire by monitoring the temperature and extinguishes fire with water. After identifying the fire, the robot also send message to the people working in that industry and nearby fire station. Another firefighting robot was developed by Miller et al [5] that was capable to sense fire alarm to detect the fire occurring place by following line.

An embedded firefighting robot is proposed in [6] that scan fire using a model floor plan provided with it, while the robot developed by Lin et al [7] locates exact location of fire using infrared flame sensor and least square method.

To handle the dangerous situation, a firefighting robot was proposed by Ahmed et al [8]. This robot was capable to avoid any kind of obstacles during extinguishing fire.

Alsaif & Kim [9] introduced an autonomous firefighting robot that can move from one floor to another climbing stairs; communicate with affected people and other robots while working; consume heat, and provide oxygen masks to the trapped people.

To sum up, the earlier work mainly focuses on different techniques to detect the firing location and extinguishing fire. To the best of our knowledge, no specific research has been conducted yet that focus on safe and shortest exit path considering the person's location and the location of the fire. This paper is aiming to provide conceptual solution to fill this gap to a certain extend.

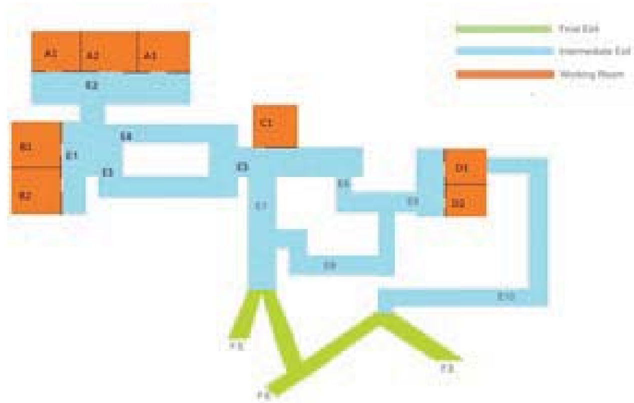

Fig 1: A Sample Office Floor.

3.0 PROPOSED SYSTEM ARCHITECTURE

We have proposed a nobel system for guidance to the emergency exit of a building. As this is extensively close to our day to day life, we have to consider the following major properties to make the system more effective and efficient.

1) Dynamicity:

Dynamicity is one of the biggest challenges for this kind of systems. Most of the emergency exit indicators work in a static way at present. But, during critical fire accidents, any path can become vulnerable at any time. So, if we calculate the exit path statically, the system may lose its significance after few times of the accident. We have designed our system in such a way that, it will come up with the (i+1)-th possible shortest path which is safe instantly if the current i-th optimal path has become vulnerable.

2) Optimization between Safety and Shortest Path:

While finding the emergency exit path, we need to keep two things in our mind: safety and shortest distance. Our proposed system will do the optimization between these two to find out the shortest distant path which is safe.

3) Temperature, Smoke and Gas Forecasting:

Smoke and gas forecasting using sensors can be a useful way to measure the fire condition of a certain place [10]. Temperature sensor will also be used to detect the intensity of heat of that place. Our system will collect readings from these sensors continuously to detect the safest path. If the system receives any reading above certain thresholds, it will consider that place as dangerous. Using these forecast, our system will prepare the (i+1)-th solution while showing the i-th path. If any situation occurs that, the prepared (i+1)-th solution has a tendency to become risky, our system is intelligent enough to come up with the next (i+2)-th solution and so on.

4.0 CROWD DISTRIBUTION:

Another important thing that we should consider is people crowd. In fire accidents, incidents of people getting killed by the crowd are very common. That's why, we need to distribute the people among 2-3 possible safe paths from their rooms to exit to reduce life threats. We can show the best and second best paths alternatively for some particular corners where the crowd can be bigger.

A demonstration of our proposed algorithm has been given below to show how the major properties will be maintained. In Figure 1, a sample office floor has been illustrated. There are eight rooms for the employees colored in Yellow, three final fire exits to the outside from the endangered workplace colored in Green and the others are intermediate places colored in Blue. Let's consider a weighted connected graph to represent the office floor consists of these three colored nodes where, Yellow nodes are the sources and Green nodes are the final destinations. We have to reach from every Yellow node to any of the Green nodes via intermediate Blue nodes. There are edges between nodes to show the connection along with the cost.

In Figure 2, the escape route from source A3 to fire exit 2 has been indicated. Total cost of the route A3 → E2 → E3 → E5 → E7 → FE-2 is (2 + 3 + 2 + 3 + 7) = 17, which is the lowest and also safe for the time being. This route has been calculated using the A* search algorithm.

After a certain time if any intermediate exit becomes endangered, our system will come up with a new route which is

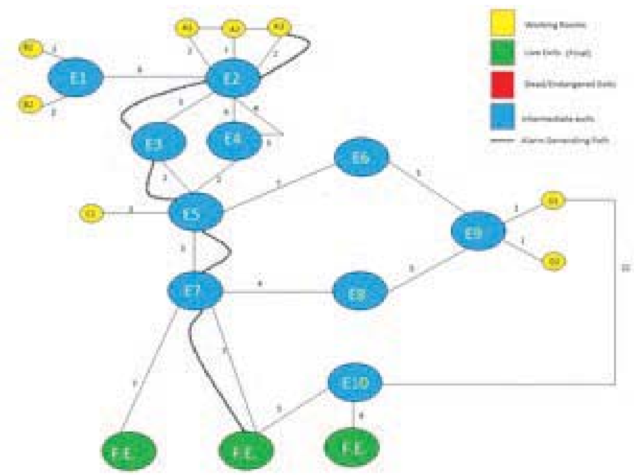

Fig 2: Escape Route from source A3 to Fire Exit-2

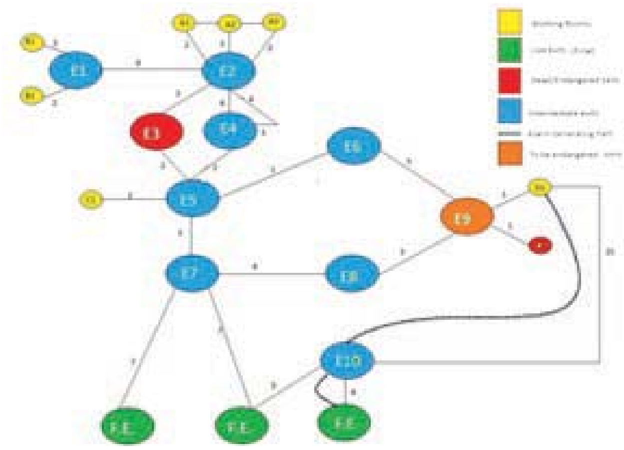

Fig 3: Another Escape Route has been indicated from source A3 to Fire Exit 2 after E3 being endangered

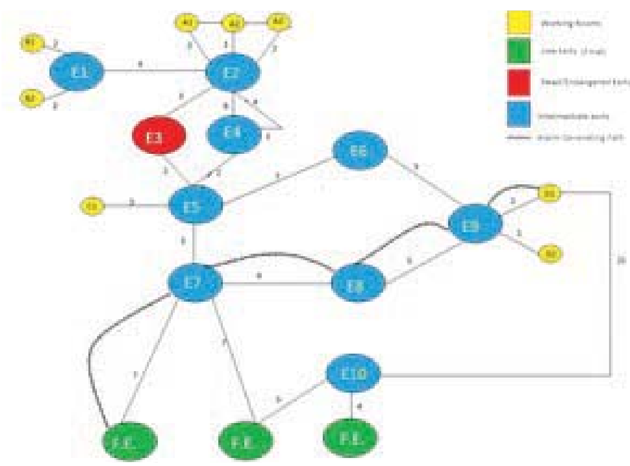

Fig 4: Escape Route from source D1 to Fire Exit

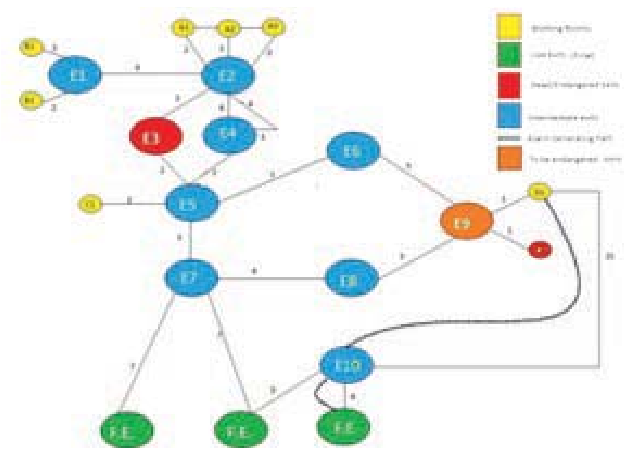

Fig 5: Alternate Escape Route from source D1 to Fire Exit 3.

safe and shortest among the currently available secure routes as our system is calculating routes dynamically. For example, if the intermediate exit E3 becomes endangered, the system will generate another secure escape route from source A3: A3→ E2 → E4 → E5 → E7 → FE-2. The cost of this route is (2 + 4 + 2 + 3 + 7) = 18, which is also the lowest among the currently available secure routes. The dynamic property of our system has been shown in Figure 3.

As we previously mentioned, our system also keep forecasting regarding smoke and gas. By using these two, it can sense if any path is going to be vulnerable after a while. If we have a look on the escape route from source D1 to fire exit 3 which is indicated in Figure 4, we can see both D1 and D2 are connected with the intermediate exit E9. If D2 becomes dead, smoke, Carbon-Mono-Oxide and Carbon-Di-Oxide gases from D2 will gradually filled up the intermediate exit E9. Our system can sense that, E9 will become unusable within a very short period from the forecasting. It will avoid all the routes containing the intermediate exit E9 and start calculating alternative possible escape routes. Though the route from D1 to FE-3: D1 → E9 → E8 → E7 → FE-1 is the shortest, our system start indicating the escape route D1 → E10 → FE-3 having weight (21 + 4) = 25 because the previous one is no longer safe now. Figure 5 shows how the system balances between safety and distance.

A. Algorithm

We can represent an office floor with a weighted connected graph where, weights constitute the distance cost, nodes stand for the employee rooms and intermediate exits, and edges show the paths between nodes. We can use any graph traversing algorithm according to our system demands. The concept of A search algorithm is used to propose our system, because it is an informed search algorithm which is widely used in graph traversing and path finding [11] problems. Algorithm 1 is a sample A* search algorithm, which we have used to build our system architecture.

Algorithm 1: A* Search

Result: Escape Route from sourceRoom to fireExit
Function Escape Route (sourceRoom, fireExit)
Initialization;

closedSet := { };
openSet := sourceRoom;
cameFrom := the empty map;
gScore := map with default value of Infinity;
gScore[sourceRoom] := 0 ;
fScore := map with default value of Infinity;
fScore[sourceRoom] :=
Heuristic Cost Estimate (sourceRoom, fireExit);
while openSet is not empty **do**
current := the node in openSet having the lowest fScore[] value;
if current = goal **then**
return Reconstruct Path(cameFrom, current);
openSet.Remove(current);
closedSet.Add(current);
for each neighbor of current **do**
if neighbor in closedSet **then**
continue;
tentative gScore := gScore[current] +
Dist Between(current, neighbor);
if neighbor not in openSet **then**
openSet.Add(neighbor);
else if tentative gScore _ gScore[neighbor] **then**
continue;
cameFrom[neighbor] := current;
gScore[neighbor] := tentative gScore;
fScore[neighbor] := gScore[neighbor] +
Heuristic Cost Estimate (neighbor, Fire Exit);
return failure;
Function Reconstruct Path(cameFrom, current)
total path := [current];
while current in cameFrom.Keys **do**
current := cameFrom[current];
total path.append(current);
return total path ;

4.0 CONCLUSION

In this paper, we proposed an efficient algorithm which would work as a guidance provider component during fire hazard. Implementation of this proposed system can save people from death by alarming them in a smarter and quicker way. Existing alarm system informs people of danger but our algorithm will also keep them a little bit ahead of time as the efficient path to exit is shown.

At present, we have worked on only three properties. We have a strong desire to integrate the fourth property of distributing human crowd over the escape routes into our system as well as we shall incorporate graphical simulation system with our existing proposed system. Any real time efficient traffic management algorithm can be implemented here to reduce life risks.

ACKNOWLEDGEMENT

The authors would like to thank Prof Dr. Md. Mahbubur Rahman of Military Institute of Science and Technology for his valuable suggestion and useful comments.

References

[1] Wikipedia, "List of industrial disasters — Wikipedia, the free encyclopedia." http://en.wikipedia.org/w/index.php?title=List%20of%20industrial%20disasters&oldid=758267333, 2017. [Online; accessed 05-January-2017].
[2] T. N. Khoon, P. Sebastian, and A. B. S. Saman, "Autonomous fire fighting mobile platform," Procedia Engineering, vol. 41, pp. 1145– 1153, 2012.
[3] W. Dubel, H. Gongora, K. Bechtold, and D. Diaz, "An autonomous firefighting robot," in IEEE SOUTHEASTCON, 2003.
[4] M. Nithiya, E. Muthamizh, and I. Yr-ECE, "Fire fighting robot," Recu-perado a partir de http://www. ifet. ac. in/pages/intsymp14/TechnoVision, vol. 20, p. 2714.
[5] L. Miller, D. Rodriguez, K. Allen, M. Makeev, J. Plew, and M. M. E. Schwartz,
[6] "Firebot: Design of an autonomous fire fighting robot," Ma-chine Intelligence Laboratory, Department of Electrical and Computer Engineering, University of Florida, Gainesville, FL, USA, 2003.
[7] S. S. Shah, V. K. Shah, P. Mamtora, and M. Hapani, "Fire fighting robot," Int. J. Emerg. Trends Technol. Comp. Appl, vol. 2, no. 4, pp. 232–234, 2013.
[8] F.-q. LIN, Y. ZHANG, and W.-x. YANG, "Fire-fighting robot based on infrared flame sensor and least-square method," Transducer and Microsystem Technologies, vol. 1, p. 033, 2015.
[9] A. Hassanein, M. Elhawary, N. Jaber, and M. El-Abd, "An autonomous firefighting robot," in Advanced Robotics (ICAR), 2015 International Conference on, pp. 530–535, IEEE, 2015.
[10] K. A. Alsaif and B. S. Kim, "Smart compact indoor firefighting robot for extinguishing a fire at an early stage," Mar. 10 2015. US Patent 8,973,671.
[11] S.-J. Chen, D. C. Hovde, K. A. Peterson, and A. W. Marshall, "Fire detection using smoke and gas sensors," Fire Safety Journal, vol. 42, no. 8, pp. 507–515, 2007.
[12] Wikipedia, "A* search algorithm — Wikipedia, the free en-cyclopedia." http://en.wikipedia.org/w/index.php?title=A*%20search% 20algorithm&oldid=747268230, 2016. [Online; accessed 11-November-2016