November-December 2019
ISSN: 0193-4120 Page No. 227 – 235

Implement and Design an Efficient Structure of the Monitoring System in Disaster Situation

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Abstract

Background/Objectives: Development of architecture is increasing the number of large and complexbuilding. Because the greater number of people who spent time indoors, the more incidents that occurs indoors increases, so these studies are necessary to minimize incident accidents.

Methods/Statistical analysis: The data collected through the robot and nodes. The next step is created Raw map, Topology map from the collected data, after that visualizes and display the status value of the node in real time. In addition, the monitoring system will check the image data that received through the sensor.

Findings: Currently, indoor disaster simulations used at home and abroad have been conducted programs and studies for prevention that do not take into account the actual disaster situation. In this paper, however, it is a simulator made not only for disaster simulation but also for use in the field in preparation for actual disaster situations. This simulator provides a function that provides a path to escape, provides topology map made form raw map and escape path, and provides survivors position, making it easier to rescue the survivors.

Improvements/Applications: It can monitoring the event of fire and building collapse during an indoor disaster, as well as a pathfinding program in large buildings.

Keywords: *Monitoring system, Escape, Disaster, Topology map, Simulator.*

I. Introduction

Due to the development of building technology, the building size and complexity of buildings are increasing day by day. Nowadays the number of incidents that occur indoors also damage on property and human increasing due to people spend more than 80% to 90% of their time with the indoor activities.Since there is no disaster evacuation simulator in Korea, it is dependent on the foreign evacuation simulator and it is widely used for evacuation drills, but it does not consider actual disaster information. [1]In addition, the majority of them are developing and researching simulations to prevent disasters, not simulators used in actual disaster situations. Disaster prevention is very important, but the rescue and escape of the survivors are also one of the most important factors when the disaster actually occurs.Therefore, in this paper, we are going to present the monitoring system that used the human detection technique to recognize people through imaging processing, and used the shortest path algorithm to detect escape routes based on topologymap extracted from

November-December 2019
ISSN: 0193-4120 Page No. 227 – 235

SLAM.Human detection function includes CNN and YOLO, CNN is a network inspired by a human visual cortical mechanism and YOLO function is to look at images and guess the type and location of Objects.

Furthermore, topology map is an important part of monitoring system. To create topology map from the raw map, using the data received by robot and the machine learning method, weclassify the building structure into 3 areas: rooms, doors, corridors and generate the topology map.

The paper is divided into five parts.The first part is the introduction. And second part is about the related research on monitoring system and escape route algorithm.The third part is the indoor disaster monitoring system design. Then, how to create a topology map. Finally is conclusion.

II. Related Work

There has been a lot of research on monitoring systems and many studies including disaster monitoring systems using IoT, social big data or multiple based platforms, infrared image recognition methods for indoor moving robots, research on shortest-path navigation algorithms for efficiency in the event of a disaster, and evacuation systems using indoor location measures.

Monitoring System

A study about Docker-based real-time disaster monitoring system have been developed [2], using collected data from smart sensor based on a Linux container that located in Korea combine with it virtualization technology.There is also a study that provides users with a service to monitor the location and disaster situation in real time with disaster monitoring system-using Node.js [3].Contents of research using IoT-SP (Sensor Platform) and IoT-uSP (Micro Sensor Platform) by utilizing SaaS IoT platform serve as eyes and ears for IoT-uSP to identify accurate information and are sent to IoT-SP periodically [4]. A study about optimizing on the potential of social media also already developed. The report said it monitors the disaster management process at the stage from response to recovery through disaster management or public-participatory disaster management and information integration[5].This research is based on the research that shows the location of fire and the location of users through the application by simultaneously transmitting the location of fire and fire information to the server when it detects fire through the Internet of Things, and BLE Beacon [6].A proposed study applies BIM to the 3D mass model of the construction industry whichintegrates information on fire prevention facilities, Bluetooth sensors, evacuation and rescue route optimization and disaster prevention functions [7]. The picture below is part of the image of the study.

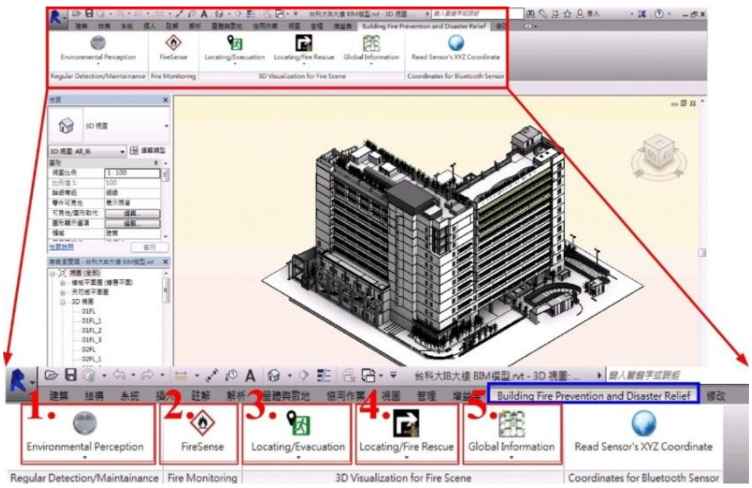

Figure1. Monitoring systems using BIM model.

November-December 2019
ISSN: 0193-4120 Page No. 227 – 235

EscapePath Algorithm

A research about to calculate the optimal evacuation and rescue route in the event of a disaster by using a network model that expresses the space-time database and the indoor spatial structure using spatial information was already developed [8].In the event of a disaster, the study was conducted so that the administrator could control all vehicles by searching for the shortest route and only one route [9].Using the congestion costs and coordinates of the map, the route detection algorithm was studied to control congestion to emergency exits and to support escape by navigating the shortest route [10].

III. Design of Indoor Disaster Monitoring System

There have been many studies previously involving many monitoring systems and their associations.The monitoring system of this paper has been researched as a system to reduce human casualties in the event of a disaster indoors, and it tries to prepare for real situations, not simulated training.In this paper, information suitable for the condition and sensor of each node can be monitored, and the evacuation route will be guided to the survivors in real time. Through autonomous driving of unmanned robots, it plans to reconstruct the map of the disaster situation in real time, detect the evacuated people who have not been evacuated, and transmit the situation to the headquarters.

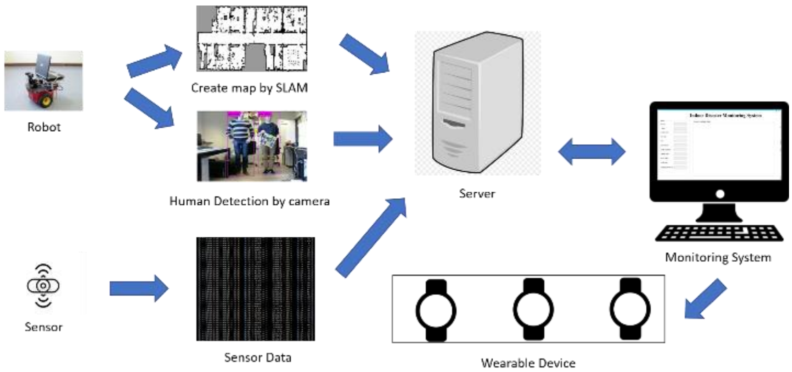

Figure2. Flow chart

Figure 2 above shows a flow chart of this paper's contents.detects people through mapping and imaging through unmanned robots.also collects sensor data through sensor nodes.The collected map data, sensor data, and image processing data can be sent to the server and viewed through the monitoring system.Users can also receive disaster information through the wearable device.

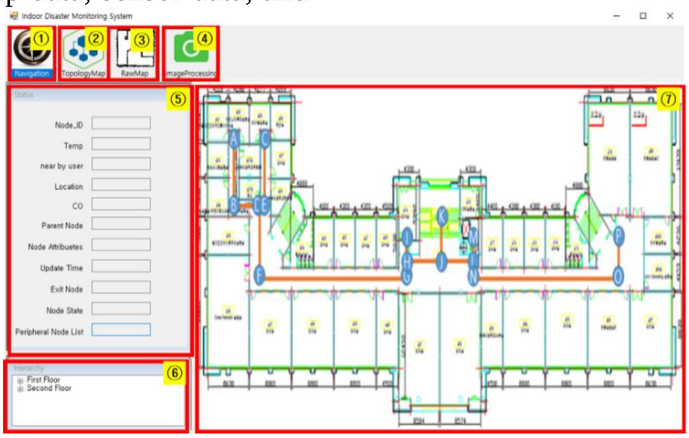

Figure3. navigation map frame

TEST Engineering & Management

November-December 2019
ISSN: 0193-4120 Page No. 227 – 235

Figure 3 above illustrates the indoor disaster monitoring system. The functions of the indoor disaster monitoring system are as follows.
1. Navigation: The route from the origin to the destination is provided on the main screen.
2. Topology Map: Topology Map based on raw map is provided on the main screen.
3. Raw Map: Raw map created through SLAM is provided on the main screen.
4. Image Processing: Provides the image processing contents in the main screen.
5. Node Status: Shows the measured sensor values and information for each node.
6. Hierarchy: Interlayer node sensors are shown in hierarchical form.
7. Main Screen: Provide a suitable screen for the button.

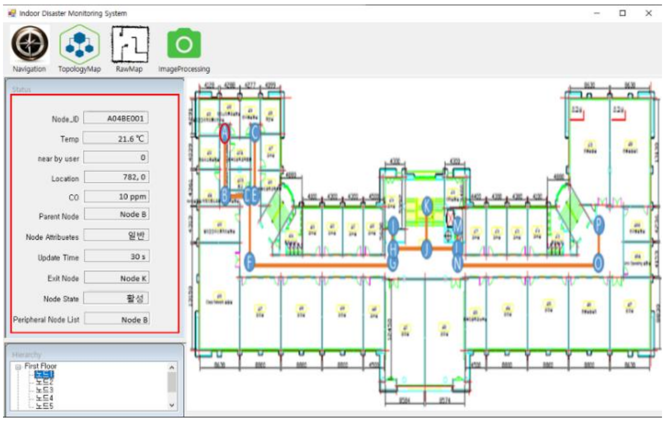

Figure4. Node status frame

Figure 4 above describes the status window of the node. The attributes and information of a node are as follows:

1. Node_ID: Display the ID of the node
2. Temp: Display temperature through temperature sensor mounted on node
3. Nearby user: Displaying nearby users who are communicating with the node
4. Location: Displaying the coordinates of the node in question
5. CO: Show CO concentration through gas sensor mounted on node
6. Parent_Node: Display the parent node associated with the node
7. Node_Attributes: Showing the properties of a node (exclusive, warning)
8. Update Time: Display the updated status information of the node
9. EXIT_Node: Exhibit Node at Exit
10. Peripheral_NodeList: Displaying the information of the nodes around you

When selecting the node shown on the map as shown in Figure 4 above, the sensor data of the node is visually displayed in the node status window.

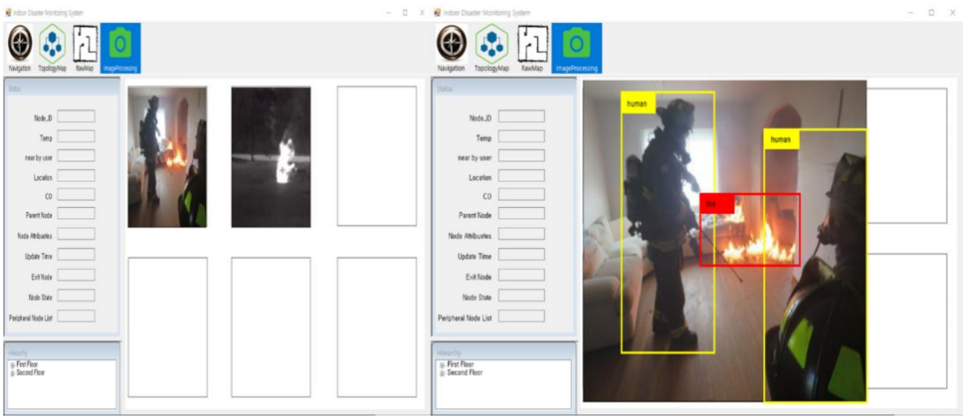
Figure5. (a)Image Processing frame and (b) Magnified image of Image Processing

November-December 2019
ISSN: 0193-4120 Page No. 227 – 235

Figure 5 above shows the image processing page.Detect victims and surroundings using human detection algorithm to detect people in situations where fire and smoke cannot be visually identified.(a) is a basic frame of image processing that collects images taken by multiple cameras for easy viewing.Among the multiple cameras, users can click on the image they want to view, making it easier to see the image as it expands.As shown in (b)to make the image easier to see and to check the detected person and surroundings through the detection algorithm.

IV. How to Create Topology Map

To build our topology map from grid map, total 5 steps need to be processed: map preprocessing, skeletonization, feature extraction, topology map, and map labeling.

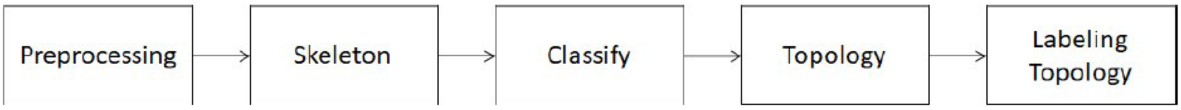

Figure 6.Generate topology map process

Generally, the given map from 2D laser sensor as well occupancy grid map is ambiguous and includes many the noise cells due to the unreliable of laser sensor. In this situation, the map segmentation becomes more complexity and tends to be false classification. Therefore, the preprocessing step is necessary to make the occupancy grid map similar to floor plan. First, the map is refined in order to remove all ambiguous obstacles from raw map and makes the map more similar the floor plan. For example, the raw map contains a lot of small obstacles corresponding to indoor stuff, and these stuffs generate some nodes which will be labeled in the final step. The generated nodes tend to be the classification failure. A narrow passage is formed from two the tables that can acquire the observation data which look like a doorway in the feature extraction step because extracted feature is based on the free space surrounding the node. Moreover, the ambiguous obstacle is able to yield some outlier observation data that significantly have impact on the segmentation map.

The second step is skeletonization.This is the process of removing as many pixels as possible from grid map without altering the general structure of the map, after the pixels are removed, the shape of grid map should still be recognizable. The Voronoi graphs is one of the most famous strategies that use to compute skeleton of map. A graph determines the set of nodes or vertices which lay on the orthographical line with the connected line between two obstacles on 2D map, this implication of all points on the edges of graph is always equidistant from two or more obstacles in 2D map. Moreover, all polygons are created from the graph and constructed by the vertices and the arcs of the graph.

The feature extraction is main component of classifying step. We assume that we have observation data at each cell of grid map is acquired from a laser range finder sensor. The observation describes the free space area around an observation node, the observation data is a beam of lights which emit 360 degrees around a point to obtain the distance between an emitted point and an obstacle. However, the raw data cannot use directly to classify for node because these data is not generalized and undistinguishable among the class of areas. Therefore, before feeding data into a classification algorithm, the feature extraction processing is performed to achieve useful information which is sufficient enough to be generalized and distinguishable. Additionally, the feature is extracted from the observation data having two taxonomies. The first category is the set of features from laser range data which is a bunch of estimated distance from skeleton to closet obstacle. The second category is the features from the spatial property of free space surrounding that pixel.

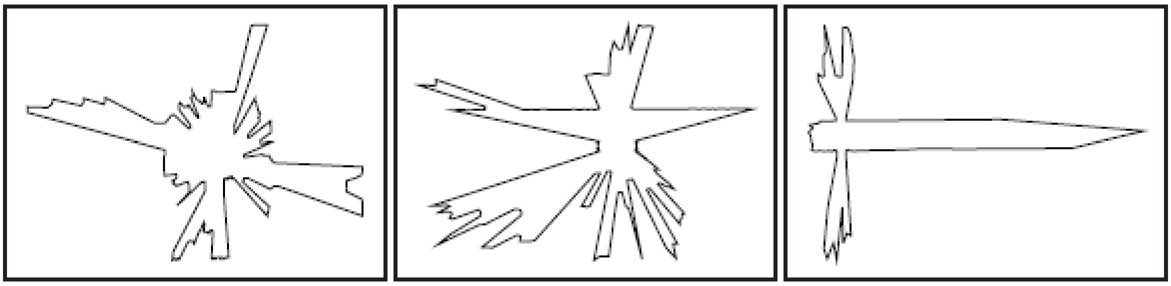

Figure7. Data visualization of room, door and hallway

After extracting the feature of all Voronoi nodes inside the map, we proceed to label for these nodes a label such as room, hallway, or doorway. Intuitively, the observation data possess different labels which are significantly distinctive (see Fig. 2). For instance, the shape of observation data of hallway point looks like a narrow rectangle at the top and wide at the bottom. The shape of the doorway has a narrow part in the middle like two parallel lines which corresponds to two doorposts, and the shape of the room is wide at center. However, sometimes the shape of observation data is able to be ambiguous due to noise data which are not eliminated at preprocessing phase, because a few obstacles still are remaining by the given threshold. For example, a node between two obstacles is like a narrow passage as a doorway, but technically it is in the room. In this case, the classification algorithm needs to adopt with that issue, and our approach uses the SVM (Support Vector Machine) to label the pixel in the skeleton. According to that property of each pixel in skeleton, the skeleton is divided and labeled by three labels: room, hallway, and doorway with red color represent room, blue are hallway and yellows are doorway.

To make topology map from skeleton, we treat skeleton diagram as an image and apply connected component labeling (CCL) method. CCL scans image and groups its pixels into components based on pixel connectivity. For example, all pixels in a connected component share similar pixel color and are in some way connected with each other. The center pixel of each group will become delegate note of that groups, pixel connectivity remains and turns into connection between groups.

Finally, it is labeling topology map. Color channel segmentation was used to labeling our topology map. Due to the speed of the algorithm, it is a good starting point to develop a fast algorithm for color segmentation, also each node of topology map has different colors. We scan topology map, pixel-by-pixel (from top to bottom and left to right) in order to identify the node’s group. Then, the rooms and the doors are separately enumerated with regard to the map, from left to right and from top to bottom.

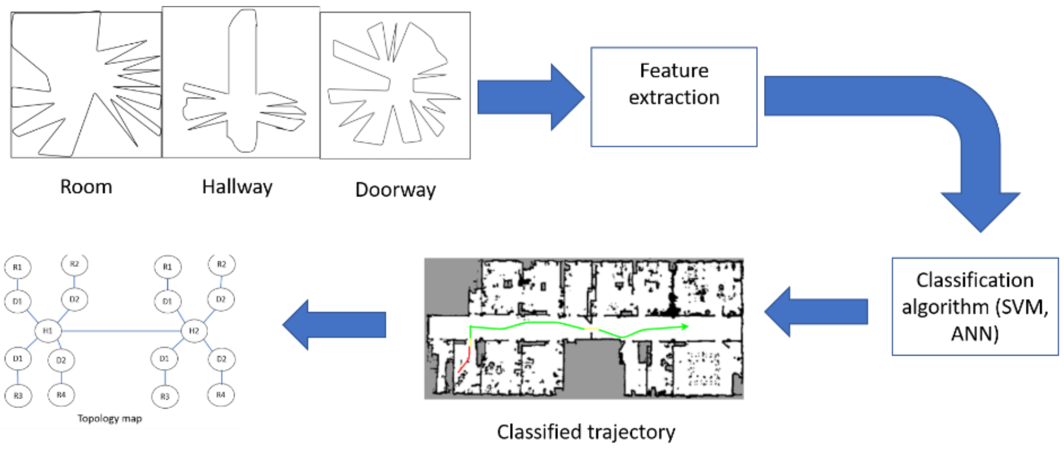

Figure8. Flow Diagram for Topology Map Generation

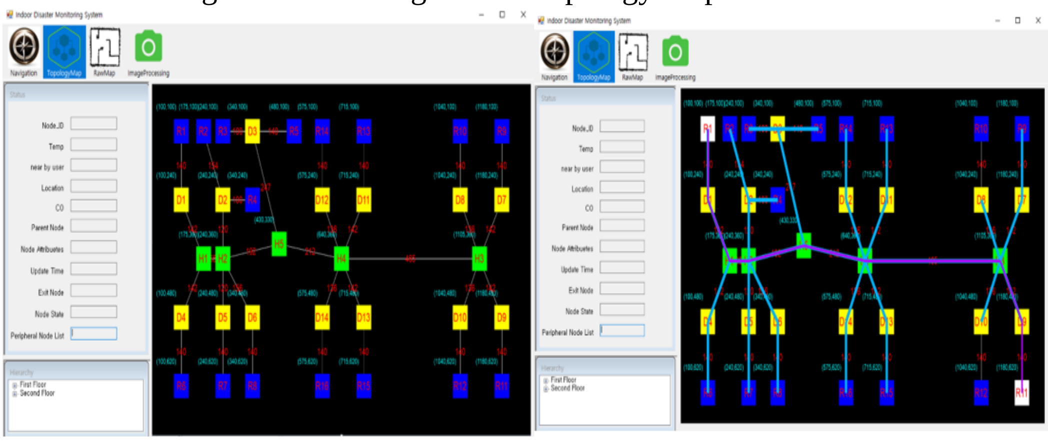

Figure9. (a) Topology Map Frame, (b) Topology map route

Above figure 9 creates a raw map through Robot in figure8 and infers and extracts features of room, hallway, and doorway data from the generated map data to generate topology map through classification algorithm.The generated Topology Map will look like Figure9 and can show the route as shown in (b) by selecting the starting point and ending point.

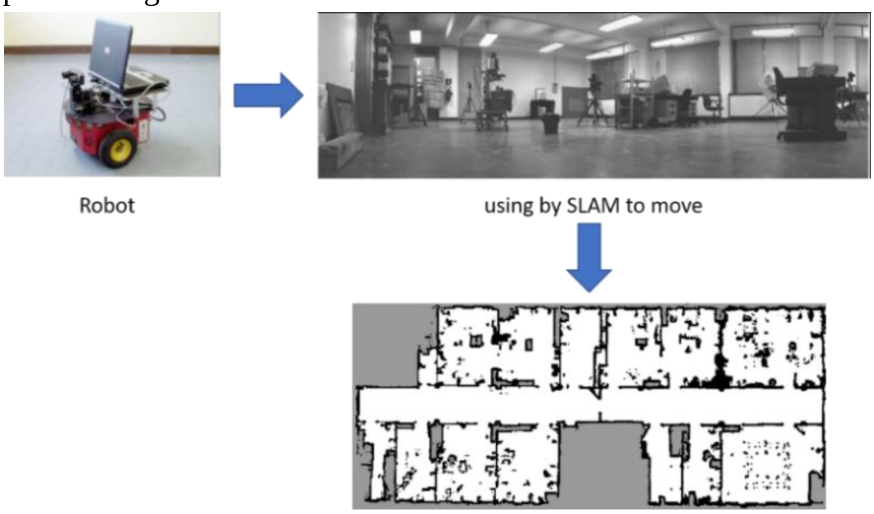

Figure10. Flowchart for creating Slam map

Above figure 10 is a flow chart to create Raw Map through Robot.Reconstruct the map in

November-December 2019
ISSN: 0193-4120 Page No. 227 – 235

real time through the sensor of the robot.

Figure11. Raw map frame

In Figure 11 above, click the RawMap button at the top to see the map created by Robot.In the map shown that you can identify the location of the survivors and mark the location of the survivors on the map.The WiFi fingerprinttechniqueis used to locate survivors.The indoor space wasdividedinto small cell units, then we collect radio signal strength (RSS) come fromaccess points (APs) ineach cell, and makes a database. It is called Radio Map.The accuracy is much higher than the Triangulation method.When comparing RSSvalues of radio map, the location is measuredby the closest cell's value.

V. Conclusion

Based on the explanation above, this paper proposed to make an indoor disaster monitoring system, and as a further work, we proposed to improve on the image processing section. An addition, when the temperature or gas level rises abnormally in the node status window, an alarm will be issued to the monitoring system user to show the warning. This monitoring system reconstructs maps through sensors where human beings cannot be identified through video processing through robot or drone when the victims are isolated due to an indoor fire or when it is difficult to identify them due to the collapse of a building. Therefore, it is expected that it can be used in certain situations not only indoors but also outdoors.

VI. Acknowledgment

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