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An Examination on the Location of the Victims in a Disaster Situation and How to Construct a Dynamic Map

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Abstract

With the development of architectural technology, buildings are becoming larger and more complex. In a building, there are many disasters which can occur such as fire and deconstructing disaster. In case of disaster happening, evacuate the victim is burden task for firefighter. Therefore, in this paper, we study on the location of the victim during a disaster situation and constructing a dynamic map. In this paper, disaster situation and researches are being conducted to find out the victims using unmanned robots in Korea and overseas, and to dynamically reconfigure the changed maps due to the collapse of the buildings In this paper, we are going to study how to detect victims while moving an unmanned robot in a disaster situation such as a fire or a building collapse, and dynamically reconstruct the map at the same time. detect the victim and reconstruct the map, the position of the movable corridor must be determined from the design of the target building. Then, the existing map data is input to the unmanned robot, and the robot needs to form the position and graph by connecting the positions of the corridors based on the data. In addition, the unmanned robot must reconfigure the changed map by overwriting the existing map while moving the map.

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I. Introduction

In the field of national disaster and safety, there is a limit to the timely crisis management and response to human accidents caused by high number of death rate and insufficient safety compared to the speed of rapid economic development. In the meantime, Building infrastructure, linking and utilizing private data, and exchanging and expanding information for citizen participation services is extremely important (1). In Korea, many researches have been conducted since 1980s to prevent in many disaster situations and reduce the damage (2). With the increasing in population and the development of technology, the living space is expanding vertically and the building of large complex structure is increasing.

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This affects the scale of the damage caused by many disasters such as earthquakes, explosions, and terrorism, which are increasing in frequency in recent years. As the damage caused by spatial structure rather than simple disasters is increasing, interest in disaster prevention services has been increased in the field of spatial information, and many researches related to disaster prevention algorithms and real time prevention systems are under way.

In addition, disasters occur repeatedly every year, and the scale of damage tends to increase with the change of social structure and the complexity of facilities. As be seen in the FerrySewol case, in the event of a disaster, rapid rescuing and responding are important, but the size of the disaster and identification of the victim are becoming important issues.

In this study, we propose a reconfiguration method of a modified map to detect a victim who has not yet escaped using a disaster robot and to facilitate the rescue operation.

II. Detecting Human in Indoor Disaster Situation

When an indoor disaster occurs, most people escape before they are damaged. However, there are many cases where people are not able to evacuate after a disaster occurs. Normally rescuers are mobilized to rescue the victims, but if people cannot pass because of gas leaks or collapses, it is not enough for rescue operations. Therefore, it is necessary to use an unmanned robot to search for isolated survivors by attaching various cameras and sensors.

Thermal imaging camera

A thermal camera is a technology that senses the infrared rays emitted by an object by a special sensor and images the temperature value, so that the complete information on the thermal state of the object or the facility can be obtained. Their detection capabilities also make them to be a valuable tool, for example, in search and rescue operations (3). A VUE PRO 640 thermal camera from FLIR (Wilsonville, OR, USA), a camera that can be attached to the drones, has been selected. The size of this device is 58 x 45 mm and 40 640 x 512 pixels. It also stores data on aerial imaging deterioration.A 10-pin mini-USB connector provides a simple power / video output interface and sets the image optimized for droneoperation. It also has camera control via PWM connection with flexible and powerful camera control and configuration options. This is a function that allows you to adjust the image color palette and start and stop recording (4).

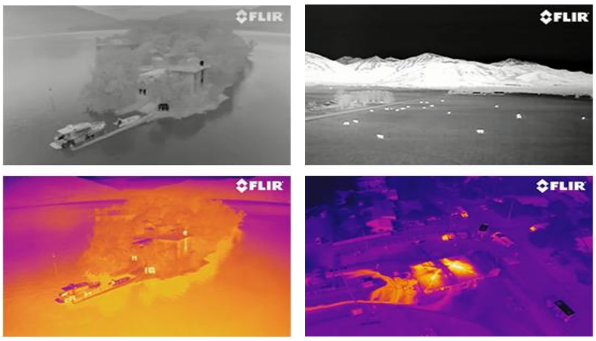

Figure 1: Image taken with FLIR VUE PRO thermal camera

In Figure 1 is a thermal image taken using FLIR's VUE PRO equipment. Designed for professional usage, FLIR Vue Pro is more than a thermal camera, it is a thermal measurement instrument and data recorder that adds tremendous value to your sUAS operations and services. Still with the same industry-leading thermal imaging quality and affordability as the best-selling FLIR Vue, the Vue Pro adds full data recording of thermal video and 14-bit still imagery. When connected to compatible flight control systems, it will automatically insert full aircraft geo-location and flight data information into each captured image for the easy image

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stitching required for mapping, survey, and precision agriculture applications.

Human Voice Detection

The voice activity detection (Voice Activity Detection) algorithm is applied to various speech processing systems such as speech recognition noise canceller and it isrecognized as a key part that has a major influence on system performance (5)

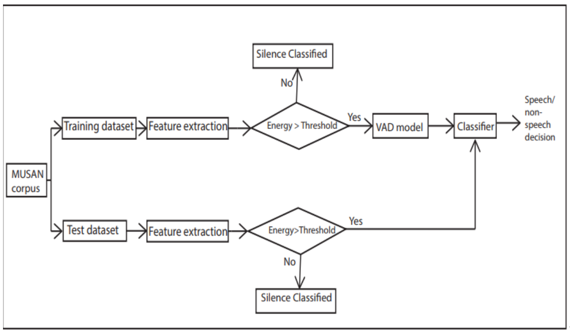

Figure 2: General system model for the proposed voice activity detection

A general overview of the VAD system is shown in Figure 2. First, if a speech signal mixed with noises is input, the entropy of the input signal is calculated, and the initial speech interval is detected using the calculated entropy. Entropy refers to statistical disorder in terms of inverse statistics and is used as a measure of the amount of information inherent in data in the field of information communication and signal processing.

The input speech signal is subjected to an initial process using entropy as described above. In the initial result, the region judged as the voice is determined as the voice, and the clustering method is applied to the region determined as the noise. First, in the initial result, the fuzzy membership degree of the interval judged as the voice is transited, and the voice interval and the non-voice interval are detected by classifying into two clusters by the fuzzy clustering method. The result of the detected speech interval is smoothed and the final speech interval is detected.

The temporal resolution of speech detection is limited and much lower than the sampling rate of the audio signal. Therefore, the decision is typically not performed for each sample n of the signal x(n).

$$x(\ell) = [x(\ell L - N + 1), \dots, x(\ell L - 1), x(\ell L)]^T (1)$$

that buffer N samples of the noisy signal. In addition, the frame rate is reduced by an integer factor L compared to the sampling rate.

The goal of VAD is to determine whether the frame $x(\ell)$ contains speech or not. Therefore, the two hypotheses

$$H1: x(\ell) = b(\ell) + s(\ell)$$

$$H0: x(\ell) = b(\ell) (2)$$

which are formulated where the noisy frame is either assumed to be a superposition of speech components $s(\ell)$ and noise $b(\ell)$ or to be purely noise. The decision for one of the hypotheses

$$VADftr(\eta, \ell) = \begin{cases} 1, & when\ H_1\ is\ accepted, \\ 0, & when\ H_0\ is\ accepted, \end{cases} (3)$$

Can be applied to detect speech. When the feature exceeds a threshold $\eta \in R$, H_1 is accepted and speech is detected;

In addition, there are also methods to determine whether a Gaussian statistical model for speech is detected by means of a determinative method that measures the likelihood ratio (LR) of the presence and absence of speech used to estimate optimal voice detection parameters.

III. Dynamically generate maps in Indoor Disaster Situation

Locating the people in a dynamic indoor environment is necessary. A fire broke out in

Jangseong-gun Hospital in Jeollanam-do in 2014, killing 21 people. In the same year, at the Pangyo Techno Valley Festival, 16 people were killed and 11 injured when ventilation holes connected to the underground parking lot of nearby buildings collapsed.

In China in 2013, 388,000 building fires caused 1637 casualties and a total loss of $0.71 billion in property damage (6). In the event of an internal disaster, there may be an environment where people cannot pass because of fire, gas leakage, or building collapse. However, since the robot can pass through, it is necessary to redraw the changed map due to the disaster situation when the fire, gas leakage, or collapse of the building occurs. In recent years, intelligent autonomous navigation devices have been selected as a growth engine industry and applied to a wide range of fields. Among the technologies of intelligent autonomous navigation devices, researches on autonomous navigation technology have been actively conducted (7,8).

In order for the autonomous navigation device go to the target position at an arbitrary position, it should know the absolute position on the map where the autonomous navigation device is located. This is possible by applying SLAM. The SLAM and the preprocessing algorithm for obtaining the absolute position of the autonomous navigation device on the map at any position are shown in Figure 3 (9).

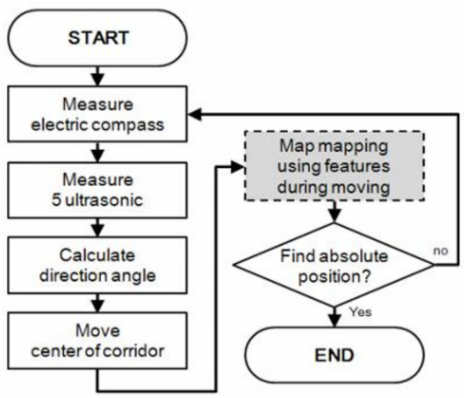

Figure 3: SLAM and preprocess algorithm

For route planning of actual self-driving devices other than simulations, quick check of obstacles and easy deletion and addition of obstacles should be possible.While certain short-term and small-scale dynamic changes can be considered as noise, truly long-term SLAM requires a filter that explicitly takes dynamic changes into account in the environment (10).

SLAM technology, the autonomous vehicles and various mobile robots market are expanding. However, the conventional technology has a limitation of the location recognition technology in a dynamic environment. Also, in the environment where the minutiae are lacking, there is a large error in the location recognition, and robust location recognition and mapping technology is needed in various environments.

So the quality of the map is improved by using LiDAR sensor and RGB-D sensor together. Using LiDAR sensor, the person and low dynamic object are recognized in real time, and SLAM based on graph structure through 3D feature point detection and LRF scan matching is used. In addition, based on MCL (Monte-Carlo Localization), it performs location awareness and plans real-time paths that can avoid collisions with dynamic objects (11).

NDT scan matching (12), which is a technique to match maps using the statistical properties of point clouds scanned by LiDAR, finds the mean and variance of the point clouds in each grid of the map, and uses the current scanned LiDAR point clouds to normalize do.

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$$\mu = \frac{1}{n}\sum_{k=1}^{n} m_k \quad P = \frac{1}{n-1}\sum_{k=1}^{n}(m_k-\mu)(m_k-\mu)^T$$

$$p(x) = \frac{1}{2\pi^{D}/_{2}\sqrt{P}} \exp\left(-\frac{(x-\mu)^T P^{-1}(x-\mu)}{2}\right) (4)$$

In Equation (4), μ and P are the mean and variance within the map grid, respectively, and p(x) are PDFs normally distributed using the mean and variance within the current scan data x and map gridwhere D is the Dimension value of the x vector. Multiply all PDFs of each grid obtained to create a likelihood function.

NDT scan matching is a plane representation using the mean and variance of LiDAR's point clouds.Therefore, even if the resolution of the grating becomes large, the deterioration of the matching property is small as long as the shape of the plane does not largely change.Therefore, the performance is not much lower than the catching using the conventional occupancy grid map without generating a map with a precise resolution.In addition, for ICP (Interactive Closest Point), which is mainly used as a scan match for LiDAR Point Cloud, the number of reference points is slower as the size of the map increases, whereas NDT scan matching does not affect the speed of the matching, as only the average and variance are stored on the map (12).

IV. Conclusion

In this paper, we propose a method to detect a person while autonomously driving along with a camera and a microphone sensor being attached to an unmanned robot in order to find the location of a disaster victim in the event of an internal disaster, and using a SLAM and LiDARsensornot only locating the victim but also developing a method of dynamically reconfiguring the map when the robot changes its map due to gas leakage, fire and building collapse.

In this study, there is no separate result because we have studied the method, not the method of showing the result by experiment separately. Afterwards Based on the methods described in this study, we will then conduct a simulation to compare and analyze the contents and other methods described above to conduct an experiment on which methods are better performance and quality.

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