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Toward Range-Only SLAM using Ultrasonic Sensors

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ABSTRACT

Recently, simultaneous localization and mapping (SLAM) is applied to challenging environments. Frequently used sensors in SLAM (LiDAR and camera) are not robust in the environments. A result from experiment presents that an ultrasonic sensor shows better performance in that situation despite sparse measurements.

1. INTRODUCTION

Sensors used in a disaster robotics require higher reliability than in a conventional robotics. For example, LiDAR and camera which are commonly used in SLAM, are limited in use within the smoky/foggy environment such as the scene of a fire. The LiDAR detects smoke as obstacles because the light is impossible to penetrate the smoke. The smoke also interferes feature extraction from the camera.

To overcome these problems, many types of research have been made on image restoration by applying dehazing to the camera in a weak smoky/foggy environment (Cho 2016, Shin 2016). However, the intensity of the smoke is much high in the field of fire, and the smoke is barely decreased in the indoor environment. It causes distortion of the sensor signal and the sensor malfunction. (Starr 2013) showed the results of experimenting the characteristics of various sensors in such an environment. Among them, the ultrasonic sensor has the disadvantage that affected by the temperature. It, however, has advantages that it is inexpensive, robust to the smoke, the attenuation of the sensor signal due to temperature is correctable.

Ultrasonic sensor has low data acquisition frequency and sparse measurements compared with LiDAR and the camera. It means that a limitation of measurement sparsity for SLAM has to be checked. For this reason, following concepts are considered in this paper:

- Ultrasonic sensor modeling.
- Checking that mapping is well worked using the extremely sparse ultrasonic

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measurements.

In section 2, we define our sensor model and apply to the occupancy grid map. In section 3, we present experimental results in hallway environment. Finally, we make a conclusion in section 4.

2. ULTRASONIC SENSOR MODELING

The ultrasonic sensor only measures a range of the nearest obstacle in many lobes. The lobes have quite complex shapes. Thus, ultrasonic sensor model is assumed to corn or sector to simplify the model. However, the simplified model also has uncertainty and influence enormously to the mapping failure when the data is too sparse. In this paper, we use a special ultrasonic sensor that the sensor's main lobe is very narrow, so measurement range is considered as a point in Fig. 1 (b). Range uncertainty also better than general ultrasonic sensor.

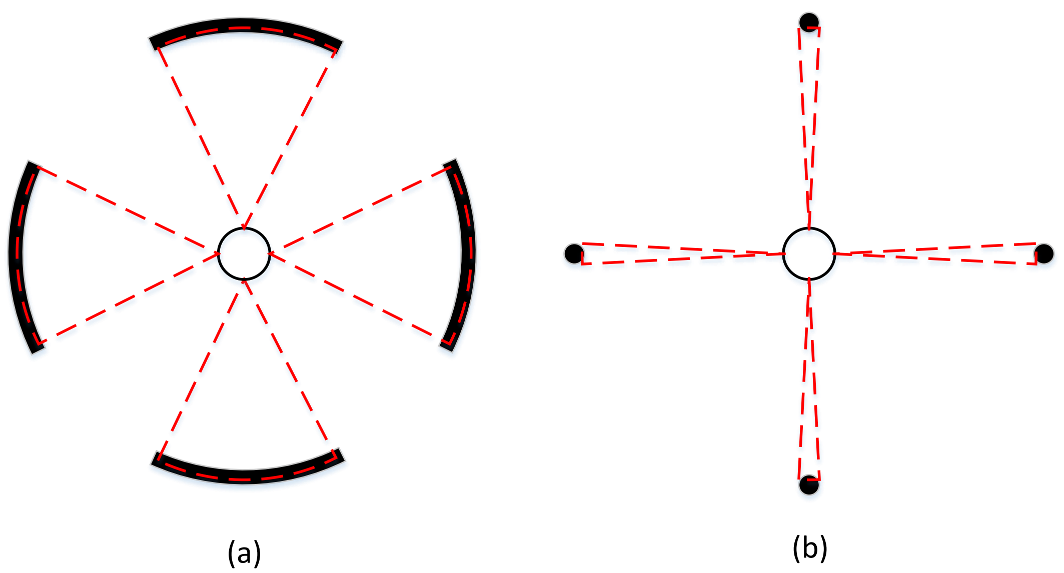
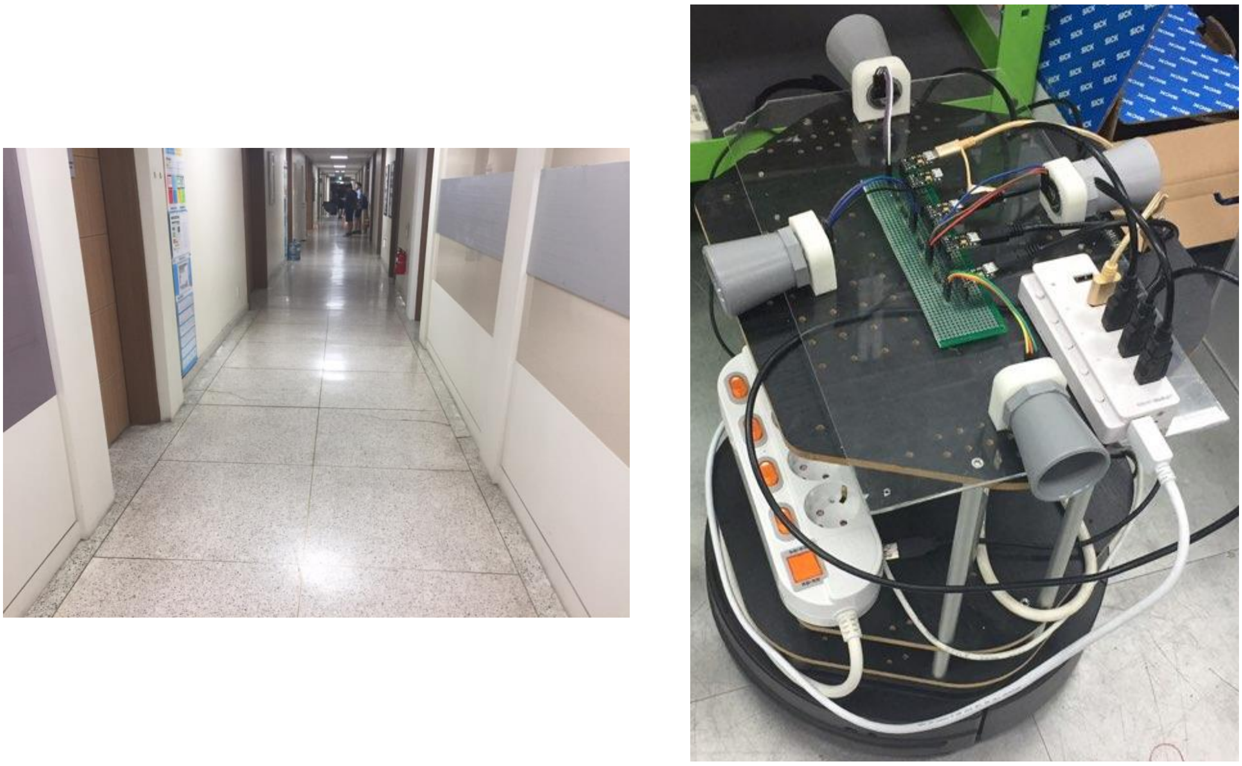


Fig. 1 (a) General ultrasonic sensor model. (b) Special ultrasonic sensor used in this paper.

3. EXPERIMENTAL RESULTS

The experiment is performed using four MB7380 HRXL-MaxSonar-WRT, a kobuki, and a laptop that has Intel Core i5-3317U 1.70GHz CPU, and 16Gb memory. Visualization is performed using matlab 2017a and vision toolbox (P. Doll´ar). In Fig. 3, the local mapping is well worked despite some multipath artifacts are presented.



(a) (b)

Fig. 2 (a) Experiment environment (hallway). (b) Experiment system (ultrasonic sensors and a kobuki)

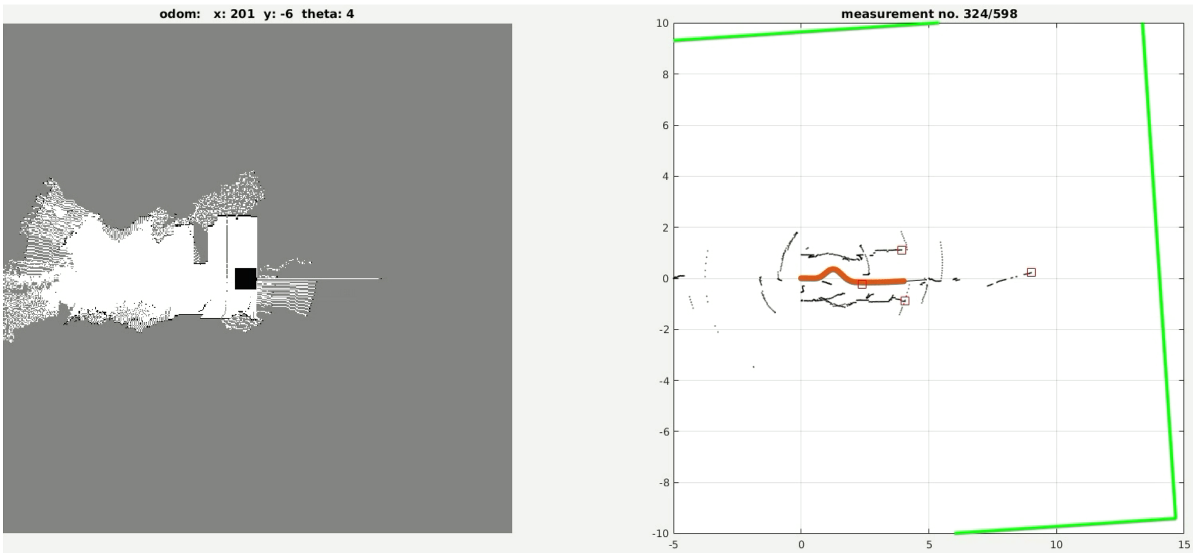


Fig. 3 A mapping result of hallway environment.

4. CONCLUSIONS

In this paper, we presented robust mapping using the sparse ultrasonic measurements. Due to this result, we guaranteed that the ultrasonic sensor applies to SLAM at hazard environments.

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