A NOVEL POSITIONING SYSTEM FOR HOME SERVICE ROBOTS

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ABSTRACT

This paper presents a novel positioning system for home service robot. The positioning system uses the difference of flight time between radio frequency and ultrasonic waves to estimate the distance. Especially, the proposed system employs multiple ultrasonic sensors to improve accuracy and position update rate. The experimental result of the proposed system is presented.

1. INTRODUCTION

Knowing its own position is indispensable for a home service robot to execute given tasks and also to be aware of user’s location. The position is measured by two general methods; one is using dead-reckoning sensors attached at the wheels and body to add the displacement to the initial position information, and the other is using a camera, laser, radar and/or ultrasonic sensors to recognize and locate beacons [1]. Although the former scheme is cheap and easy to implement, it is subject to the aggregate error that may result in inaccurate position information. The latter scheme has become popular recently, as it can provide precise location data without error propagation. We have evaluated some location-finding systems of the latter category in our previous work [2]. We have found that the Cricket system [3] is proper positioning system for general location-aware applications but it has a limitation on information update rate, which makes the system hard to be applied to moving objects like home service robots. In this paper, our main focus is to propose an enhanced positioning system with a faster update rate, which can be utilized for home service robots.

2. SYSTEM DESIGN

The basic idea of the proposed system is illustrated in Figure 1. The system consists of transmitter and receiver. Similar with the Cricket location support system [3], the fixed transmitters are spread over a house where the service robot works, and mounted on the known position, e.g. ceiling. In addition, the transmitter broadcasts its location information on RF signal and synchronous ultrasonic pulse. Our specially designed mobile receiver shown in Figure 2 is placed on the top of the service robot to listen to the RF signal and the ultrasonic pulse. The
receiver estimates distance after receiving the RF and the ultrasonic pulse for the corresponding transmitter.

Since the receiver has multiple ultrasonic sensors, it obtains multiple distance estimates at once. The multiple estimates are averaged over space, not over time, which reduce latency caused by sliding window mechanism (Figure 3) in the previous Cricket system aiming to increase positioning accuracy.

Furthermore, the gathered distance information from several transmitters is incorporated at the receiver to estimates its own position using multi lateration [4].

![Figure 3: Sliding Window Mechanism in the Cricket system](image3)

**3. EXPERIMENTAL RESULT AND CONCLUSION**

We have completed distance estimate test with the proposed listener shown in Figure 2. The distance estimate is fundamental in multi lateration positioning technique. We adopt the mode algorithm to obtain valuable distance of eight distance samples to increase the accuracy. If there is no mode value, i.e., the eight samples have all different value, we choose median value instead of the mode value.

The distance estimate error, $\varepsilon = |d - \hat{d}|$ which is the difference between the real distance ($d$) and the estimated distance ($\hat{d}$), is presented in Figure 4 with the standard deviation. The error properties of Cricket system are also shown in figure 4. Each plot indicates errors from original Cricket system without statistical treatment, errors after the use of sliding window mechanism, and errors of the suggested system, respectively. The suggested system is shown to be capable of measuring distance as precise as sliding window mechanism without time-lag in the conventional method thanks to space averaging.

Therefore, multiple receivers can substitute the sliding window. We suggest that the employment of multiple sensors can be a solution to the update rate problem. Hence, the proposed system can be applied to home service robots with relatively high mobility.

![Figure 4: Distance estimation performance comparison between the Cricket system and the proposed system](image4)

The various experimental results will be possibly presented in the full-length paper.

**4. ACKNOWLEDGEMENT**

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**5. REFERENCES**


