An Embedded Localization Sensor Based on IR Landmark for Indoor Mobile Robot

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Abstract – The localization for mobile robot in indoor environment is one of the most important issues in robot research area. This paper describes an embedded localization image sensor which computes its location by using the pixel positions of infrared sources on IR landmark. The proposed localization sensor can operate robustly on the change of illumination in common indoor environment. The components of embedded localization sensor and its performance will be mainly depicted.

Keywords – localization, navigation, artificial landmark, mobile robot.

1. Introduction

To make the robot navigate by itself and plan paths on its way to a goal, the robot should have information about its location. The localization technique in mobile robot is to find out the 2-D position and heading angle of robot in a certain space that is built for robot localization. Localization technology in the field of mobile robotics has been well studied and a multitude of methods have been proposed so far; a good overview on the robot localization technology can be found in [2].

Sensor for the robot localization has the following properties: accuracy, repeatability, real-time computation, scalability, robustness, and economic efficiency. Our localization sensor suite meets those needs above.

2. Architecture of Sensor Suite

Localization sensor (Fig. 2. (a)) is composed of microprocessor, image sensor, RF (radio frequency) communication chip, and SDRAM memory. Microprocessor includes embedded software to control the image sensor, RF chip, UART and SDRAM memory. It also has the algorithm detecting IR landmarks: the sensor computes its location in real-time by tracking the IR source.

The 3rd International Conference on Ubiquitous Robots and Ambient Intelligence (URAI 2006)

3. Localization

The localization sensor is configured such that infrared landmark modules are attached on the ceiling of a space and the sensor is mounted on top of a mobile robot as shown in Fig. 3. The CMOS camera in the sensor detects IR landmark through an infrared bandpass filter. It is oriented to look upward so that its optical axis is perpendicular to the ground. In order to obtain maximal field of view, a wide-angle camera lens is utilized.

The location information of the sensor can be obtained when at least two IR LEDs are detected within the field of view of the camera.

The localization is performed in two steps. In the first step, the image coordinates of the IR LED are computed and landmark IDs are identified by the sensor. In the
second step 2-D location and heading angle of the sensor are computed from the relationship between the image coordinate and world coordinate of the detected LEDs. The location update rate of the sensor is 30Hz.

The details about the localization algorithm can be found in [7].

4. Experimental Results

We have done the experiments to focus on the accuracy and repeatability of the estimated position with the sensor discussed above. The height of the ceiling is 2.6m and each distance between infrared landmark is 1.20m. The location information was computed for every grid points which are spaced regularly with 60cm distance.

![Image 1](image1.png)

Fig. 3. Sensor configuration of the localization system

![Image 2](image2.png)

Fig. 4. Static localization results of the fixed points

Table 1 Repeatability result

<table>
<thead>
<tr>
<th>Position</th>
<th>Mean</th>
<th>Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0,0)</td>
<td>(-1.34, 1.997)</td>
<td>0.0317</td>
</tr>
<tr>
<td>(-200, 200)</td>
<td>(-196.47, 203.42)</td>
<td>0.1289</td>
</tr>
</tbody>
</table>

with standard deviation of 2.9cm. We have the maximum position error of 17.1 cm at (180, 60) because of uneven ground condition. The experimental result shows that the sensor suite gives acceptable localization performance in indoor environment. The field of view of the sensor when the ceiling height is 2.5m is 5x5(m).

Table 1 shows the result of the repeatability (10 times) of localization when a robot stayed at the same position of (0,0) and (200, 200).

On the heading angle experiment, we turn the sensor on the same position by 10 degree from 0 degree to 350 degree. The angular mean error is 0.21 degree and its deviation is 0.31.

From the above experiment results, we can conclude that our embedded sensor is very effective as a robot localization sensor.

5. Conclusion

In this paper, we have proposed a localization sensor for mobile robots. Important factors for localization sensor are accuracy, scalability, robustness, and economic efficiency. Experimental results show that the proposed sensor satisfies the factors mentioned above.

Acknowledgements

This work was supported by Ministry of Information and Communication, Korea.

References