A Proposal of method for position measurement of Active Landmark Using image processing and Ultrasonic Sensor

Takumi Matoba^{a,*}, Naoyuki Ishijima, Seiichi Serikawa

Kyushu Institute of Technology, 1-1 Sensui-cho Tobata-ku Kitakyushu-shi Fukuoka-ken, 804-8550, Japan

*Corresponding Author: matoba.takumi683@mail.kyutech.jp

Abstract

In recent years, the proportion of Japanese children has been decreasing and that of elderly people has been increasing. Because of them, the working population has been decreasing. We sometimes use a robot to help them. In this situation, the research on autonomous mobile robots is progressing to do more advanced tasks. An autonomous mobile robot is actually working to transport luggage in a warehouse]. Line-trace robots are well used in the room. This type of robot moves along a magnetic tape or white line in a floor. It can move with high precision. This is because that it is easy to recognize white line and magnetic tape. On the other hand, a robot, which scans a room with a laser to create the spatial map and moves based on the map, is often used. This kind of robot can also move with high precision. Robots used for industrial factories are required to move with high accuracy without malfunction. So the above mentioned robots are very useful, but have some problems. Line trace type robot needs to paint the line again to change the route. It takes cost and time. Laser scanning robot needs to scan the entire room again. This takes a lot of time. As the other method, mobile robots using drones have recently been researched. In order for the drones to move autonomously, GPS is generally used. However, we cannot often use GPS. For the reason, it is difficult for the drone to move in a room with high accuracy. Thus, we propose a method using active landmark as a new method that can accurately acquire the position even in an environment where GPS cannot be used. An active landmark means a landmark that can transmit and receive signals by itself. However, with a conventional landmark, although the direction to the landmark can be obtained, the distance from the device to the landmark cannot be obtained.

In this study, we propose a method that can measure the

direction and distance simultaneously. An active landmark that emits ultrasonic wave and a coded light is proposed in this study. The device was actually developed and the experiment was practiced. As a result, the direction to the landmark was correctly detected from the camera image which is attached on the device, and the distance between the device and the landmark was correctly measured using ultrasonic wave. As a result, the three-dimensional position between the landmark and the device can be accurately gotten. For the use of this, a drone will be able to move while always recognizing the 3D position in a room correctly.

1. Introduction

In recent years, with the rapid spread of Internet, the percentage of households using online shopping has increased. This is a very useful system for people who live in the countryside or have a stationary handicap [1]. In order to maintain these convenient systems, it is necessary to manage a huge amount of products. This requires a lot of labor, but the working population has been decreasing in Japan [2]. We sometimes use a robot to help them. In this situation, the research on autonomous mobile robots is progressing to do more advanced tasks. An autonomous mobile robot is actually working to transport luggage in a warehouse. Line-trace robots are well used in the room [3]. This type of robot moves along a magnetic tape or white line in a floor. It can move with high precision. This is because that it is easy to recognize white line and magnetic tape. On the other hand, a robot, which scans a room with a laser to create the spatial map and moves based on the map, is often used [4]. This kind of robot can also move with high precision. Robots used for industrial factories are required to move with high accuracy without malfunction. So the above mentioned robots are very useful, but have some problems.

Line trace type robot needs to paint the line again to change the route. It takes cost and time. Laser scanning robot needs to scan the entire room again. This takes a lot of time. As the other method, mobile robots using drones have recently been researched [5]. In order for the drones to move autonomously, GPS is generally used. However, we cannot often use GPS. For the reason, it is difficult for the drone to move in a room with high accuracy.

Thus, we propose a method using active landmark as a new method that can accurately acquire the position even in an environment where GPS cannot be used. An active landmark means a landmark that can transmit and receive signals by itself. However, with a conventional landmark, although the direction to the landmark can be obtained, the distance from the device to the landmark cannot be obtained [6].

In this study, we propose a method that can measure the direction and distance simultaneously. An active landmark that emits ultrasonic wave and a coded light is proposed in this study. The device was actually developed and the experiment was practiced. As a result, as a result, the three-dimensional position between the landmark and the device can be accurately gotten. Thus, a drone will be able to move while recognizing 3D position in a room.

2. System configuration

2.1 System overview

The model proposed in this study consists of two devices: a landmark and a receiver. The flow of operation of this system will be described as follows.

1. Turn on the red colored landmark.
2. Image acquired with a USB camera of receiver are processed by the Raspberry Pi.
3. Raspberry Pi detects the direction of the landmark and sends a signal to Arduino via wired serial communication.
4. Wirelessly send signals from the Xbee of receiver to the Xbee of landmark.
5. Emit ultrasonic waves from the Arduino of landmark. At the same time, the signal is transmitted from the Xbee of landmark to the Xbee of receiver.
6. Detect the ultrasonic wave and measure the distance between the landmark and the receiver.

Fig.1 System configuration

2.2 Active Landmark

Fig.2 shows Active Landmark's block diagram. The landmark consists of a control unit, a lighting unit, a sensor unit, and a communication unit. Arduino is used for the control unit, red LED (ultra-high brightness 5mm LED) is used for the lighting unit, ultrasonic sensor (UT1612MPR) is used for the sensor, and Xbee is used for the communication unit. The controller turns on the LED, transmits ultrasonic signals, and wirelessly communicates using XBee

Fig.2 Active Landmark's block diagram

2.3 Receiver

Fig. 3 shows receiver's block diagram. The receiver consists of a control unit, a communication unit, a sensor unit, and a detection unit. The sensor unit is composed of an ultrasonic sensor (UR1612MPR) and an inverting amplifier circuit, and the detection unit is composed of a USB camera. The control unit acquires an image from the USB camera and detects the direction to the active landmark using image processing. In addition, the ultrasonic signal received from the active landmark and the distance from the active landmark to the receiver is measured. The communication unit sends and receives signals between the receiver and active landmark.

Fig.3 Receiver's block diagram

3. Experiment

3.1 Preliminary experiment

As a preliminary experiment, the measurable distance of the ultrasonic sensor was examined. The distance was investigated every 0.1 m from 0 m to 2 m. The result is shown in Table 1. In this table, O represents when the measurement was successful and X represents failure.

Here, O means that the signal was correctly detected by the ultrasonic sensor of the receiver. From this table, we can see that the distance cannot be measured above 1.1 m. Therefore, the next experiment will be performed at distances from 0.1 m to 1.1 m.

Table 1 Preliminary experiment results

Measured distance (m)	result
0.1	○
0.2	○
0.3	○
0.4	○
0.5	○
0.6	○
0.7	○
0.8	○
0.9	○
1.0	○
1.1	○
1.2	×
1.3	×
1.4	×
1.5	×
1.6	×
1.7	×
1.8	×
1.9	×

2.0	×
-----	---

3.2 Measurement method

As shown in Fig. 4, the receiver and landmark are placed. First, the landmark direction is detected using the USB camera of the receiver. Next, the distance between the landmark and the receiver was measured.

Fig.4 Image of measurement method

3.3 Measurement results

Fig.5 shows a recognized image of landmark, and Fig.6 shows the measured distance results.

Fig.5 Landmark recognition image

Fig.6 Measurement result

4. Experimental results and the examination

The white squares in Fig.5 show the landmark. As seen from this figure, the receiver recognizes the landmark correctly. Therefore, the direction to the landmark can be easily detected.

In addition, it can be seen from Fig.8 that the actual distance agrees well with the measured value. Therefore, the distance can be accurately measured by this sensor.

However, the measurable distance is 1.1 m, which is insufficient. This is because the power source of ultrasonic waves was 5V, so a large output could not be obtained. Expansion of the measurement distance should be studied in the future.

5. Conclusion

In this study, we propose a method that can measure the direction and distance of active landmark. It uses ultrasonic wave and a LED light. The device was actually developed and the experiment was practiced. As a result, the direction to the landmark was correctly detected from the camera image which is attached on the device, and the distance between the device and the landmark was correctly measured using ultrasonic sensor. As a result, the three-dimensional position between the landmark and the device can be accurately gotten. For the use of this, a drone will be able to move while always recognizing the 3D position in a room where GPS cannot be used. The measured distance is not enough, but it should be modified in the future.

References

- (1) Masao Komatu, "Introduction to Image Processing with OpenCV", 2nd ed, pp1-199(2017)
- (2) Kenzo Nonami, "State of the art and issue of drone technology and business frontier", Journal, vol. 59, no.11, p.755-763