Chapter 18
Mobile/Wireless Robot Navigation

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ABSTRACT

Sensor-based localization has been found to be one of the most preliminary issues in the world of Mobile/Wireless Robotics. One can easily track a mobile robot using a Kalman Filter, which uses a Phase Locked Loop for tracing via averaging the values. Tracking has now become very easy, but one wants to proceed to navigation. The reason behind this is that tracking does not help one determine where one is going. One would like to use a more precise "Navigation" like Monte Carlo Localization. It is a more efficient and precise way than a feedback loop because the feedback loops are more sensitive to noise, making one modify the external loop filter according to the variation in the processing. In this case, the robot updates its belief in the form of a probability density function (pdf). The supposition is considered to be one meter square. This probability density function expands over the entire supposition. A door in a wall can be identified as peak/rise in the probability function or the belief of the robot. The mobile updates a window of 1 meter square (area depends on the sensors) as its belief. One starts with a uniform probability density function, and then the sensors update it. The authors use Monte Carlo Localization for updating the belief, which is an efficient method and requires less space. It is an efficient method because it can be applied to continuous data input, unlike the feedback loop. It requires less space. The robot does not need to store the map and, hence, can delete the previous belief without any hesitation.

INTRODUCTION TO NAVIGATION

Mobile Robotics is a vast topic and covers various strategies, and people have been working on it for a long time. It has some ancient as well as some modern techniques. Although a lot of work has been done in this field, robots cannot accept oral instructions by humans.

Navigation is the process of directing and monitoring a robot (as in our case) from one point to another. In addition, the extent or the range to which a mobile can navigate is called its

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resolution. An independent device should know its original position within its range (of sensors). For this purpose we have:

- Global Navigation;
- Local Navigation;
- Personal Navigation.

In Global Navigation, the robot itself determines its position relative to the environment and with the help of this location, it moves to the desired location. In Local Navigation, the robot determines its position relative to the objects in the environment and hence makes decisions to move after communication with them. In Personal Navigation, the robot is aware of the positioning. This case involves the monitoring of the individual robot and anything in contact with it.

Two technologies are used for Mobile Robot Navigation:

- Satellite-Based Global Positioning System

The first satellite-based navigation system was created in 1973 by the American Defense Department as a joint service between US Navy and Air Force. Limited access was given to non-military users. Presently, we have 24 space segmented satellites around the world. Each position on the earth requires 3 satellites to secure it. GPS provides accuracy 95% of the time. However, it may not work indoors because of some reasons like signal blockage and multipath interference.

- Image-Based Positioning System

This system works exclusively using optical sensors and the range is usually found by laser-based range finder, while the photometric cameras use CCD arrays. Extraction of the required information from these range finders and photometric cameras is extracted as follows:

- Environment representation.
- Sensing the environment.
- Applying Localization algorithm.

Techniques used for vision-based positioning are:

- Landmark-based positioning.
- Model-based approaches (3-D model or digital map).
- Feature-based positioning.

We can use vision-based techniques combined with other techniques like ultrasonic and laser-based sensors.

AIM OF THE CHAPTER

The main emphasis of this chapter will be to introduce mobile robot navigation rather than its tracking. Tracking is simple and can easily be implemented using a feedback loop (Phase locked loop). Kalman filter is one such example, which uses the phase locked loop and takes the average of the real and estimated positions of the robot to give the final position of the robot. Kalman Filter, however, is less accurate because it applies a weighted average methodology on the observed outcome of the next measurement. In addition, the weights are calculated with the help of covariance resulting in less accuracy. Kalman Filter basically tries to estimate a random state **'x'** of a discrete-time controlled process which can be represented by the following equation:

$$X_t = F_t x_{t-1} + B_t u_t + w_t \quad (1)$$

where 'F' is the transition model, 'B' is the control input model and 'w' is the process noise.

In this chapter, we will try to solve this problem of less precise tracking occurring because of the

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