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ROBOT LOCALIZATION AND MAP CONSTRUCTION USING SENSOR DATA

Summary: This work describes the problem of map contraction and a robot localization using sensor data and data from a group of other robots. This methodology is called SLAM or CML, Simultaneous Localization and Mapping or Concurrent Mapping and Localization, respectively.

SLAM solves problems connected with building a map of an unknown environment by a mobile robot while at the same time navigating the environment using the map.

SLAM comprises of multiple parts: landmark extraction, data association, state estimation, state update and landmark update. Each part can be performed in different ways. As the robot has sensors on one height from the ground, we will get 2D map [1].

Key words: SLAM, computer simulation, robot.

Introduction

Modern science pays great attention to the development of artificial intelligence systems. The issue has important practical significance. Autonomous agents controlled by artificial intelligence are able to replace man in dangerous enterprises, high-risk conditions for life and rescue operations.

The problem of navigation of the service mobile robot consists in his positioning in space at the movement in the dynamic nondeterministic environment. In a general view the task of navigation indoors can be set as follows. There is some the room in which the mobile robot equipped with a sensor, for instance, laser. The target point which the robot has to reach for performance is set some task. It is necessary to define the law of control of the mobile robot which will transfer him from initial situation to a target point. At first sight, the task seems idle time, however, there are a number of problems, conditions and restrictions.

Problem statement

There is a distorted surface. On the surface there can be barriers preventing free movement on it. In arbitrary locations on the ground there are sources of radiation or radioactive contamination. The area is dangerous for a long staying. There is a need to eliminate sources of pollution as soon as possible. In such circumstances the search can be done only by remote-controlled or autonomous robots. The search is carried out by robots that communicate using radio waves or deprived of opportunities for long-distance communication.

In order to make search of radioactive source faster we need high efficiency of every robot. One of the possible solutions is to make robot share information that it has already observed. Other robots may use this information and do not follow explored path or find possible shortest path to a target.

Mathematical Model Description

In this paper we use ready Edmonton dataset [2] and Extended Kalman Filter(EKF) SLAM.

Odometry. In Edmonton dataset you will be give two text files. One of them contains robot pose increments as measured by the odometry.

Each line contains 3 values:

- Δx : Increment in "x", in meters.
- Δy : Increment in "y", in meters.
- $\Delta \varphi$: Increment in "phi", in radians. Phi is an angle of rotation of the robot. Phi=0 is in the direction of "+x" axis.

In order to calculate current position (x_i, y_i, φ_i) of robot, we will use following formulas:

$$\varphi_i = \varphi_{i-1} + \Delta \varphi_i \quad (1)$$

$$x_i = x_{i-1} + (\sqrt{\Delta x_i^2 + \Delta y_i^2}) * \cos(\varphi_i) \quad (2)$$

$$y_i = y_{i-1} + (\sqrt{\Delta x_i^2 + \Delta y_i^2}) * \sin(\varphi_i) \quad (3),$$

where $\varphi_0 = 0, x_0 = 0, y_0 = 0, i = 0 \dots n$, n is number of lines in the file (number of movements).

In figure 1a, a real map is presented. In figure 1b you can see calculated path of the robot. It can be compared with figure 1a.

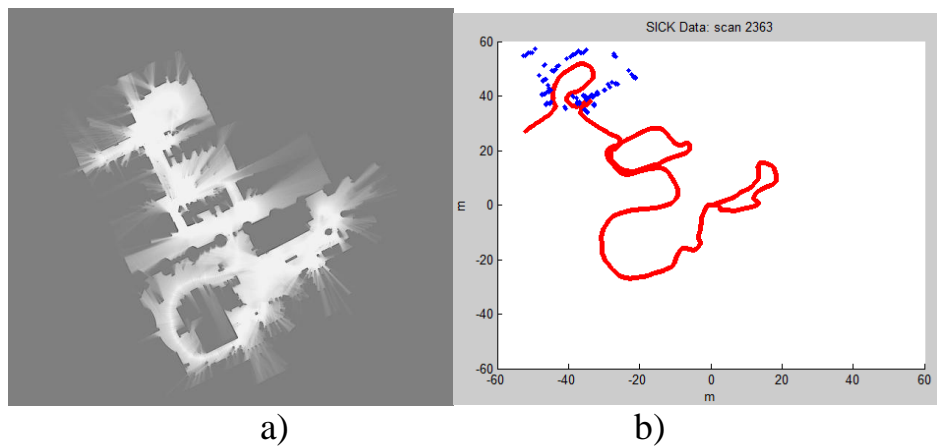


Figure 1. a - real map, b - calculated path and one of the scans.

Scanned surface. The second file of Edmonton dataset contains one scan range per line ($0^\circ - 180^\circ$). Values are in meters.

In order to calculate $(x_{li}, y_{li}, \varphi_{li})$ coordinates of scanned point we use these formulas:

$$\varphi_{li} = \varphi_{ri} + \varphi_i \quad (4)$$

$$x_{li} = x_{ri} + d_i * \cos(\varphi_{li}) \quad (5)$$

$$y_{li} = y_{ri} + d_i * \sin(\varphi_{li}) \quad (6),$$

Where φ_{ri} - current angle of a robot, φ_i - current angle of a laser beam ($-90^\circ \dots 90^\circ$), (x_{ri}, y_{ri}) – current position of a robot, (x_{li}, y_{li}) – current position of scanned point, d_i - distance from robot to a scanned point at angle φ_{li} .

When the odometry changes on the grounds that the robot moves the instability relating to the robots new position is updated in the EKF utilizing odometry update. Landmarks are then removed from the surroundings from the robots new position. The robot then tries to relate these landmarks to perceptions of landmarks it has seen beforehand. Re-watched landmarks are then used to update the robots position in the EKF. Landmarks which have not been seen beforehand are added to the EKF as new perceptions so they can be re-watched later. It ought to be noticed that anytime in these stages the EKF will have an estimate of the robots current position.

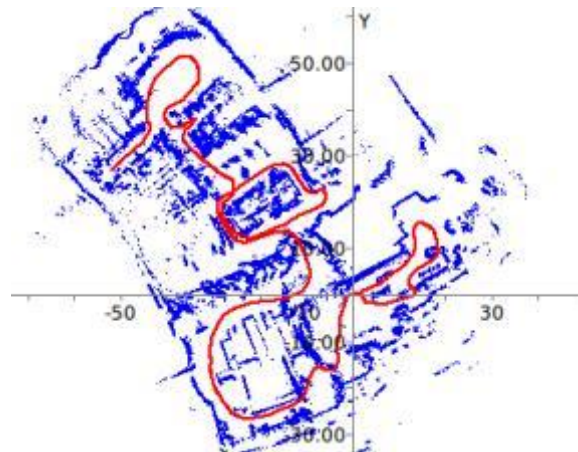


Figure 2. Constructed map

Results and Discussion

Approach discussed in this paper is used only for 2D map building. We will use robots based on Arduino open-source electronic prototyping platform. Data is received through ultrasonic sensors. Robot sends observed information through Wi-Fi to computer where we handle it and build a map of a room. A program that will show us building map in MATLAB.

In future work we suppose to use approved methods for 3D map building. Question to be solved:

1. Accuracy. Because map should be more accurate. We decided to use Extended Kalman Filter. Although EKF is slow in high dimensional maps, it handles uncertainty very well [3]. As we use a small room this algorithm is suitable for our purposes.

2. Speed. It should happen in real time. So we have to minimize it. MATLAB program will be used in order to see map in real time. Each robot will send information about observed territory and its location inside.

3. Communication between robots in system. We supposed to have one server, where overall map will be stored and each robot can send or take information from it.

References

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