Description of Team "Fusion"

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Abstract. This paper introduces team "Fusion" and its research focuses. We have developed important functions for intelligent mobile robots. We describe a new self-localization method using two landmarks and dead-reckoning for soccer robots.

1 Introduction

Robot soccer is a standard problem for robotics and artificial intelligence. The team "Fusion" is organized by Kyushu University and Fukuoka University. By participating RoboCup Middle-size league, we have developed important functions for intelligent mobile robots such as self-localization[1], collision avoidance of dynamical or static obstacles[2], and communication[3]. This paper describes our new self-localization method in a dynamically changing environment[4].

2 Real-time self-localization

In self-localization in the field of RoboCup Middle-size league, the goal posts and the corner posts can be used as landmarks. If three landmarks are recognized by vision sensor, the pose of the robot can be obtained by triangulation based on the measured direction of them with respect to the robot frame. However, robots often fail to simultaneously recognize three different landmarks during the soccer game: landmarks are easily occluded by other robots. We have developed a new self-localization method using direction of two landmarks and dead reckoning for a robot equipped with an omni-directional camera. The camera reliably provides directions of at least two landmarks in the presence of other robots. Reduction of the number of required landmarks results in robust localization compared with the other technique such as triangulation with three landmarks. Although this method is a variant of Monte Carlo Localization (MCL)[5], amount of computation is effectively reduced.

When a robot detects two landmarks and measures angles of their directions, the robot is positioned at somewhere on a circle which passes these two landmarks while satisfying that the angle at the circumference is the measured angle. Orientation of the robot is determined as a function of its position on the arc and measured direction of the landmarks. To uniquely determine position and orientation of the robot, dead reckoning of the successive motion of the robot is used as followings. Discretizing position on the arc, we obtain a set of candidates of pose of the robot $P(t) = \{p_i(t) | i = 1 \dots N\}$. N is at most 360 in our current implementation. Successively the robot moves for a short period Δt, and then detects plural landmarks and measures angles of direction. Pose displacement of the robot for this short period is also obtained using odometry with measured rotation of wheels. Adding this displacement to each candidate of the pose, we obtain a set of renewed candidates $P(t + \Delta t)$.

Localization error of each renewed pose is evaluated by difference of direction angle to the landmarks: comparison is made between computed direction to each landmark from the renewed pose and actually measured direction by the robot. Error value is accumulated over time.

Accumulated error value is cleared to be 0 at the beginning of the localization process. Then evaluation of all the candidates for the pose of the robot is repeated based on visual measurement of the landmarks and odometry in every short period Δt. Accumulated error value increases gradually. Increase of accumulated error value is slow for those candidates which are closely located near the correct pose, while increase is rapid for those which are far from the correct pose. Finally correct pose is determined uniquely as the one having the smallest error accumulation.

3 Experimental result

An experiment has been made in a half of RoboCup soccer field composed of a goal and a corner post on the green carpet (the left of Fig. 1). Two goal posts (A and B) on both side of a goal and a corner post (C) are used as landmarks. An obstacle (D) is placed. Performance of the proposed method is compared with our conventional method which basically relies on three landmarks and uses dead reckoning with Kalman filter when three landmarks cannot be observed.

A field player robot is initially placed at point O. Then it is manually pushed to follow a given reference test trajectory composed of straight line segments and rectangular corners. In the right of Fig. 1, we show performance of localization for three different cases: 1) localization by conventional method using dead reckoning with Kalman filter alone (data1), 2) localization by the proposed method with three landmarks(A, B, C) (data2), and 3) localization by the method with two landmarks(A, B) (data3).

In the first case, localization by dead reckoning alone suffers large error. In the second case, all three landmarks are correctly recognized and the proposed method is applied. The robot succeeds in self-localization with good accuracy from just after the beginning of motion till end of the trajectory. In the third case, the robot succeeds in localization after traveling for distance of 75 cm, and keep going with good accuracy till the end of the trajectory. The amount of movement required to decide the pose of the robot is small when three landmarks can be observed, compared with the case of observation of two landmarks.

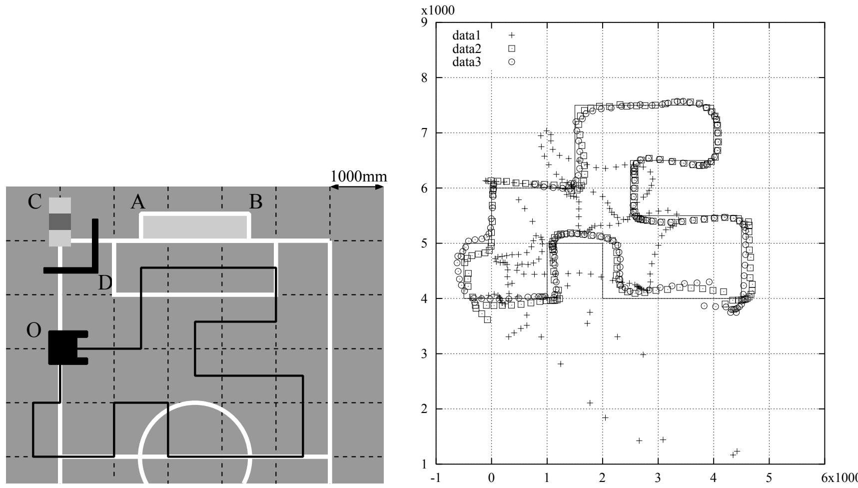

Fig. 1. Experiment of self-localization

4 Conclusions

We have introduced team "Fusion" and described a new self-localization method for autonomous mobile robot. By reduction of the number of landmarks required for localization, the presented method is reliable in robot soccer compared with the other technique using three landmarks.

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