Fuzzy Logic Based Behavior Fusion for Navigation of an Intelligent Mobile Robot

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Abstract

This paper presents a new method for behavior fusion control of a mobile robot in uncertain environments. Using behavior fusion by fuzzy logic, a mobile robot is able to directly execute its motion according to range information about environments, acquired by ultrasonic sensors, without the need for trajectory planning. Based on low-level behavior control, an efficient strategy for integrating high-level global planning for robot motion can be formulated, since, in most applications, some information on environments is prior knowledge. A global planner, therefore, only needs to generate some subgoal positions rather than exact geometric paths. Because such subgoals can be easily removed from or added into the planner, this strategy reduces computational time for global planning and is flexible for replanning in dynamic environments. Simulation results demonstrate that the proposed strategy can be applied to robot motion in complex and dynamic environments.

Keywords: Behavior based control, fuzzy logic, sensor based motion planning, uncertainty, robotics.

1 Introduction

A key issue in autonomous robot is its navigation in uncertain and complex environments. If a mobile robot wants to move among unknown obstacles to reach a specified target without collisions, sensors must be used to acquire information about real world. Obviously, using such information it is very difficult to build a precise and entire world model in real-time for preplanning a collision-free path. Behavior based control\(^1\)\(^{[1,2]}\) has been proposed for robot navigation in uncertain environments. A key problem in this control strategy is how to coordinate different types of behavior efficiently. In [1], the coordination of multiple types is done by inhibiting those behaviors of lower levels according to their priority. However, this strategy is not unquestionable when a mobile robot executes tasks in complex environments. The example in Fig.1 shows that the robot must efficiently weight different types of behavior, such as avoiding obstacle, following edge, and moving to the target, according to range information, when it reaches a target inside a U-shaped object.

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The usual approach for implementing perception-action behaviors is artificial potential field\cite{[3,4]}. A significant drawback of the approach is that during preprogramming much effort must be made to test and to adjust some thresholds regarding potential field for avoiding obstacle, wandering, moving to target, etc. Besides, these thresholds frequently depend on environments. Fig.2 shows that the robot is unable to get through a narrow channel to reach a given target. The reason is that the robot always activates a single behavior, obstacle avoidance, when it approaches this channel, so that it turns to right to move into a large free space.

This paper presents a new method for behavior fusion control of a mobile robot in uncertain environments\cite{[5,6]}. Fig.3 shows that, by behavior fusion using fuzzy logic, navigation performance is greatly improved so that the robot can go through the narrow channel to reach the given target.

This method also differs from the fuzzy control approaches for obstacle avoidance proposed in [7-9] since perception and decision units in this method are integrated in one module by use of the idea of reactive behavior, and they are directly oriented to a dynamic environment to improve real-time response and reliability.

Based on low-level behavior control, an efficient strategy for connection to high-