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Genetic Algorithm Based Approach for Autonomous Mobile Robot Path Planning

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Abstract

In this study, an improved crossover operator is suggested, for solving path planning problems using genetic algorithms (GA) in static environment. GA has been widely applied in path optimization problem which consists in finding a valid and feasible path between two positions while avoiding obstacles and optimizing some criteria such as distance (length of the path), safety (the path must be as far as possible from the obstacles) ...etc. Several researches have provided new approaches used GA to produce an optimal path. Crossover operators existing in the literature can generate infeasible paths, most of these methods dont take into account the variable length chromosomes. The proposed crossover operator avoids premature convergence and offers feasible paths with better fitness value than its parents, thus the algorithm converges more rapidly. A new fitness function which takes into account the distance, the safety and the energy, is also suggested. In order to prove the validity of the proposed method, it is applied to many different environments and compared with three studies in the literature. The simulation results show that using GA with the improved crossover operators and the fitness function helps to find optimal solutions compared to other methods.

Keywords: Genetic algorithm; path planning; crossover operator; navigation; mobile robot;

1. Introduction

An autonomous mobile agent is an intelligent vehicle which is able to perceive the workspace, extract and interpret the significant data coming from its sensors,locate its position in the environment, recognize and plan. The agent must be able to produce a feasible path from a starting point to a target position, and decide how to act to reach that path, and finally the movement control; the agent must has a means of control to regulate its movement in order to complete the planned trajectory [1]. Autonomous mobile agents have become an indispensable asset in industry, transport, agriculture and even in everyday life. For example they are widely used in transportation, cleaning and maintenance, assisting a person with limited mobility...[2]. Thus, to achieve the above cited tasks, the mobile agents must operate in

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an intelligent and autonomous way, and must be armed with perception, location, planning and navigation capabilities, which allows the mobile agent to make decisions autonomously based on the information extracted by the perception of its environment. In this study we focus on motion planning which is an important task in robotics, that aims at perceiving the environment via sensors, extracting information (obstacle positions , starting position, arrival position) that will help the agent to build its map , locate its position in its environment, then the agent executes a planning method to find the optimal path between the two positions and finally navigate from a starting point to a target point while avoiding obstacles [3]. Path planning involves finding a path between two configurations by optimizing a number of criteria such as distance, energy, safety, and time. The generated path must be efficient (the agent gets to the point quickly) and secure (obstacle avoidance) [2]. Path planning can be either global or local planning. Global path planning consists in finding a reference path. It is determined before the agent begins its navigation by considering the environment as static. The second level (local planning) is based on the global path and data of the environment detected by the sensors in order to form a dynamic occupancy grid. The reference path is chosen in the first time, but it will be changed according to the changes happening in the environment so as to ensure a fast and secure navigation while avoiding fixed and mobile obstacles. Global planning is a very important step in mobile agent navigation, as it is difficult to ensure the convergence toward the target in dynamic environments. Indeed, local planning may be trapped in local minima where it can be difficult to get out without having the global path (reference path) to reach the goal. There are several methods and tools in the literature for the autonomous mobile agents to solve this problem. These methods can be classified according to three approaches; deliberative, reactive and hybrid approaches (deliberative-reactive) [4]. Deliberative approaches operate on static environments, where the input information is provided by the user or from the sensors to produce a valid path before the agent begins its navigation. This type of approach is executed in a succession of actions. The perception involves the understanding of the environment based on a model given by the user or the information detected by the sensors. Then the planning module runs. This module is used to identify the position of different obstacles in the environment using the model found in the perception phase to find an optimal path between two positions. Finally, the agent starts its navigation according to the trajectory found [5] [6]. When planning is local, and the environment is uncertain, the use of a reactive method [7]is a necessity. In this approach the perception module works instantaneously and in real time to perceive the state of the current position of the mobile agent. At every moment the sensor provides the next action to realize, without having a prior knowledge about the location of the fixed and mobile obstacles. This approach differentiates by the absence of the building modules of the environment and planning. The hybrid approach is the combination of both deliberative and reactive approaches to enjoy the benefits of each one.When the deliberative module takes care of the global planning (global level), the solution found will be sent to the local level which is the reactive module to execute it and refine it according to the data it receives from the sensors [1]. In this work, we are interested in the global planning where all the information of the environment is known in advance and before the navigation process, we adopt the deliberative approaches using genetic algorithms (GAs). This paper is organized as follows: the first section will highlight the background of this work by giving a theoretical presentation of genetic algorithms, while the second section will present the proposed path planning algorithm. The last section will then sum up the simulation result and the comparison between our method and those existing in the literature.

2. GENETIC ALGORITHMS FOR PATH PLANNING

2.1. Genetic Algorithms:

Genetic algorithms (GAs) were originally developed by John Holland in 1960 [8]. GAs are natural inspired algorithms which are based on the concepts of Darwinian evolution that involve an initialization method, fitness function to evaluate each chromosome, natural selection, crossover, and mutation operators [9] [10]. The GAs begins by generating randomly an initial population which represents the possible solutions(chromosomes) to the problem to be optimized [11]. Each chromosome is then evaluated by an adaptation function to determine the quality of every potential solution [12]. After that, genetic operators are used to create the new progeny; selection to choose the parents which will be subjected to the reproduction according to their adaptation values [13]. Later crossover is applied to products new offspring by recombining data from the two parents selected in the previous step [14]. Mutation is used to guarantee the diversity of the population by changing the genetic structure of some individuals according to a mu-