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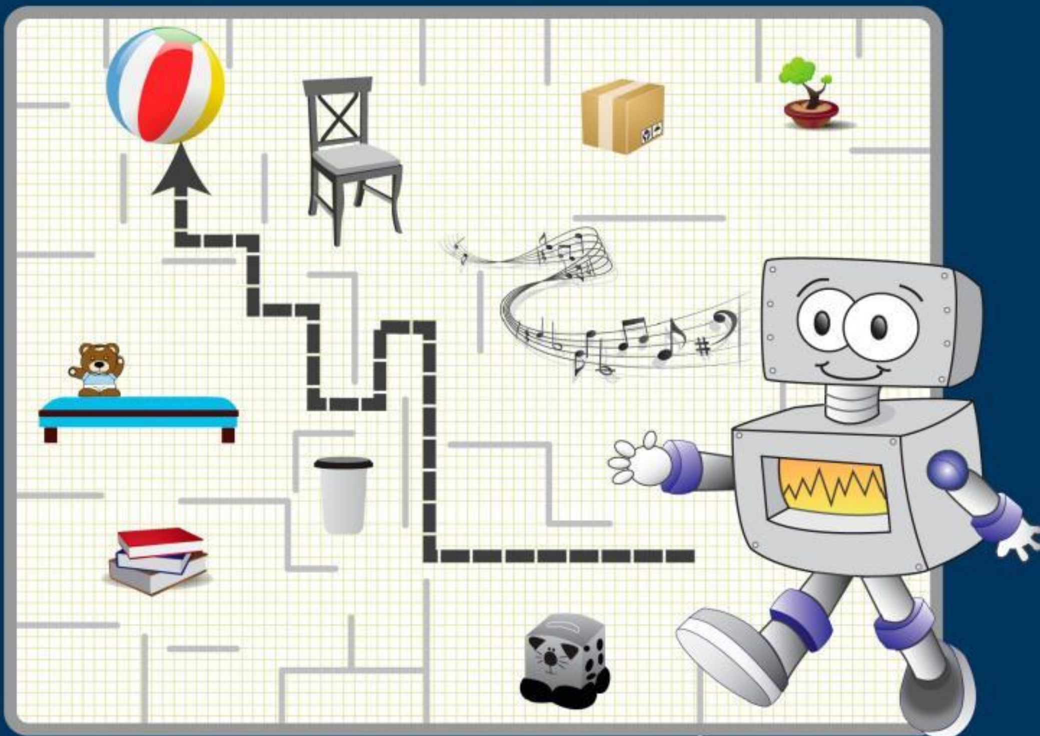

Optimal path planning for mobile robots using music-inspired algorithms

Optimal Path Planning For Mobile Robots By Using Music-Inspired Algorithms

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DEDICATION

This book is dedicated to our dearest families and friends.

CONTENTS

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1 INTRODUCTION

The grid-based environments have always been utilized for the needs of the global path planning problem. The global path planning problem, applied to the autonomous navigation on mobile robots, can be easily defined as finding an optimal or feasible route from a starting point to a predefined ending point in a real world environment. This environment can be either static or dynamic, and the mobile robot (i.e. search agent) must avoid collisions on its way to destination. This knowledge, given to the planner, is very crucial for the autonomy of the mobile robot. The global path planning problem does not find a direct frequent utilization in real-world applications, but it has been proven to be of enormous significance in the planning phase of the mobile robot before it starts its journey to its destination point. Most of the algorithms for global path planning include local and global planners and use sensor data and previously gathered and stored knowledge of the environment of interest. Whilst the local planner is dealing with the small obstacles in the environment, angles of turning and applying the appropriate needed velocities, the global planner is dealing with the greater obstacles and navigation to the goal. This implies that while the global planner performs navigation, the local planner is dealing with improving the path, thus avoiding the surrounding objects in the environment.

Grid based maps that are used for global path planning for mobile robots are frequently interpreted as two-dimensional or three-dimensional, depending on the complexity of the environment. These approaches include discretization of the environment and finding a collision-free path between two points in the world of interest, i.e. initial and goal position. In order to perform this, a connectivity graph needs to be constructed, and the appropriate algorithm has to be applied in order to find an optimal route. For the main purposes of solving this concrete problem, many metaheuristic algorithms have come into practice. Knowing that the global path planning problem is NP-complete and the metaheuristic algorithms are amongst the most suitable solutions of these types of problems, this is a justified approach.

Autonomous robots that work without any manipulations performed by human are necessary in the field of robotics. In order to finish tasks, autonomous robots must be intelligent and capable of performing their own action. When the mobile robot makes a decision to perform a suitable action, optimal planning depending on the task ought to be established. Also, it's crucial to plan a path free of collisions whilst minimizing the known costs, like time, energy and distance. When the mobile robot is moving towards a destination point in its previously defined environment, finding an optimal or feasible path is needed, thus avoiding the obstacles on its journey while satisfying some of the criteria of the autonomous requirements, i.e.: heat, energy, time and safety. Accordingly, the most important and the key action of global path planning for mobile robots is finding a collision-free path [1].

Many researches are published on the matter of path planning for autonomous mobile robots. Navigation planning is one of the crucial tasks in the intelligent control for the autonomous mobile robot. Frequently this is divided into path planning and trajectory planning. Plath planning has a goal to generate a path free of collisions in an environment with static or moving obstacles, thus optimizing it respecting certain criteria [2,3]. Trajectory planning has a goal to determine the moving of the mobile robot through the previously planned path. Many approaches have been suggested so far to address the problem of motion planning for mobile robots. It the environment is a known static area and the generating of the path is made in advance to the motion, it's called an offline algorithm. Thus, one may conclude that the algorithm is online if it's capable of producing a new path according to the changes occurring in the environment [1].

The robotic systems capable of concrete degree of autonomy are the main goal of the autonomous mobile robots and are wanted in many fields [4,5,6,7,8,9]. The main focus is on the ability for independent motion while they are trying to imitate the biology concepts. Biological models are really of the greatest interest since living creatures are certainly a kind of prototype of autonomic behaviors. Intelligent autonomous systems (IAS) have many possible applications in a wide range of industry fields, going from space research to handling materials, and from industrial tasks to helping people in need. This means that the recognition, learning, making decisions and ability to act give the basic problems of obstacle avoidance in an IAS. Here, three levels of recognition are needed, namely: imprecise data processing (gathered from the sensors), constructing a knowledge base, and constructing a map of the environment. In order to solve these types of problems and to outrun the drawbacks of classical approaches considering real time execution, independence and intelligence, current approaches are based on hybrid intelligent systems [1].

The designers of the IAS are in search of creating dynamic systems that perform navigation and behaviors with a concrete goal, just like the man in real situations when the conditions are intense. The complexity of the environment is a specific problem to solve, since environments can be imprecise, vague, dynamic and partially structured or unstructured. Thus, IAS must be capable of understanding the structure of these types of environments. To get to the goal without colliding on their path, IAS must be enriched with abilities of recognition, learning, making decisions and executing actions [1].

The capability to obtain these advantages, i.e. to process and provide the knowledge gives the key to a concrete type of intelligence. Building this type of intelligence is an ambition in the design and development of intelligent autonomous vehicles. Furthermore, the mobile robot is a desired tool for researching other related problems from artificial intelligence considering understanding the world and executing a given action, like planning missions, obstacle avoidance and gathering data from different sources [1].

Current researches on IAS gave accent to promising results for further researches in the field of mobile robotics where real time, autonomy and intelligence have gained popularity significantly more than optimality and completeness. Many navigational approaches exchanged the explicit knowledge representation with an implicit one based on obtaining intelligent behaviors that provide the robot with the ability to interact effectively with its environment, orienting in the environment, exploring it autonomously, recovering from possible failure and performing a set of tasks in real time [1].

A robotic vehicle is an intelligent mobile machine capable of autonomous operations in structured and unstructured environment, capable of gathering data from sensors (communicating with the environment), thinking (planning and reasoning), and executing (moving and manipulating). Accordingly, current researches in autonomous exploring, intelligent components, multi robotic systems and massive parallel processing made the IAS frequently used, especially in planetary researches, mining, and highways [10,11,12,13,14]. However, the recent mobile robots perform little recognition activities, like intelligent thinking, and the reasons are:

- Perception does not satisfy the required standards.
- A great part of the intelligence is connected to behavior specific for a concrete task and is more correlated with concrete devices

The global path planning problem is very challenging NP-complete problem in the domain of robotics and artificial intelligence. Many metaheuristic approaches have been developed up to date, to provide an optimal solution to this problem. This book presents a novel Quad-Harmony Search (QHS) algorithm based on Quad-tree free space decomposition methodology and Harmony Search optimization. The developed algorithm has been evaluated on various grid based environments with different percentage of obstacle coverage. The results have demonstrated that it is superior in terms of time and optimality of the solution compared to other known metaheuristic algorithms.

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