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An Evolutionary Algorithm for Autonomous Robot Navigation

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Abstract
This paper presents an implementation of an evolutionary algorithm to control a robot with autonomous navigation in avoiding obstacles. The paper describes how the evolutionary system controls the sensors and motors in order to complete this task. A simulator was developed to test the algorithm and its configurations. The tests were performed in a simulated environment containing a set of barriers that were observed by means of a set of sensors. The solution obtained in the simulator was embedded in a real robot, which was tested in an arena containing obstacles. The robot was able to navigate and avoid the obstacles in this environment.

Keywords: Evolutionary Algorithm, Autonomous Navigation, Artificial Intelligence, Simulation

1 Introduction

The navigation problem in mobile robotics is the problem of making navigation decisions for one or more autonomous mobile robots, placed in an arbitrary environment, to accomplish certain predefined tasks[5]. There are many aspects of this problem: environment settings, application peculiarities, robot characteristics, and task priorities. Many techniques such as fuzzy systems and evolutionary algorithms have been used in an attempt to solve this problem.

Evolutionary Algorithms (EAs) are a computing strategy that solves difficult optimization problems. EAs are inspired by biology, more specifically in the Darwinian Theory of Evolution. They abstract and mimic some of the traits of natural evolution to produce functional adaptive processes [1]. Genetic algorithms are intrinsically parallel because the search enables discovery of multiple solutions, and can control a population of robots that work simultaneously.

This paper describes a genetic algorithm, where the population exists as actual robots that exchange genetic information in order to adapt to solve a particular problem. The goal is to train a robot to interact with an unknown environment. Our main contribution is a novel chromosome encoding for mobile robotics and also a simulator for this task. As a case study,

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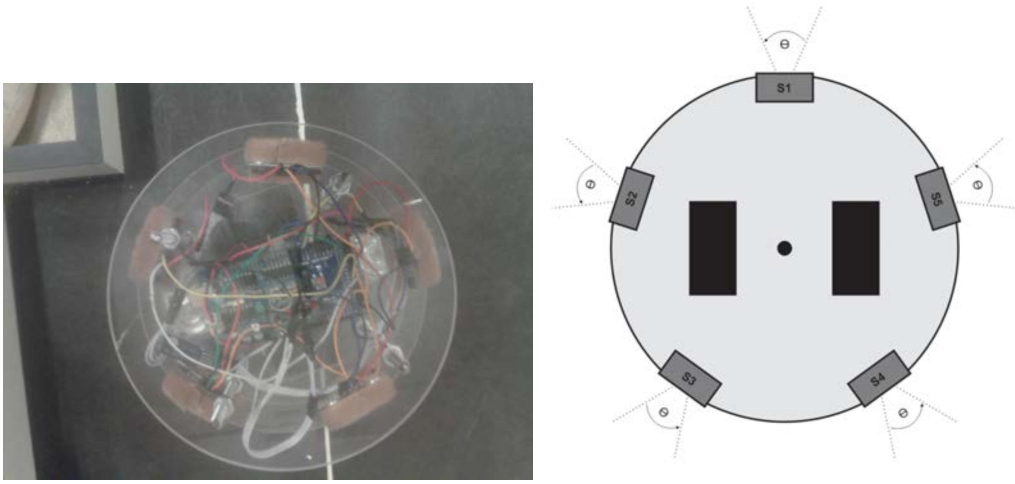
we randomly initialize the robot to test whether it can actually be trained by evolution to do something practical such as exploration with obstacle avoidance.

2 The Proposed Simulated Hardware

The mechanics of the robot architecture were inspired by the Khepera III [4], a research platform for mobile robots widely used around the world. The developed platform is shown in Figure 1. It comprises the engine, motor controller, micro-controller, and the sensors in pentagonal configuration.



(a) (b)

Figure 1: Real (a) and simulated (b) robot configuration.

The simulation was carried out in a MATLAB environment that included a differential drive that simulates the physical behavior of the robot using the equations of motion of a wheeled robot differential. The differential steering model is a simple and reliable wheel-based drive system that is commonly used in smaller robots. It is essentially the same system used in a wheelchair: two wheels, mounted on a single axis, are independently controlled, providing both drive and steering functions. Known equations are used to predict how a robot equipped with such a system will respond to changes in its wheel speed and what path it will follow under various conditions.

3 The Proposed Algorithm

In robotics, the use of evolutionary algorithms has been proposed for both optimizing morphology and for developing navigation control strategies [2]. These algorithms have been used mainly because autonomous robots and their controllers are unstructured, i.e., environments are flexible and/or partially unknown. This makes the design task very difficult for human designers. It is extremely difficult to know a priory every situation that a robot will encounter.

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