Chapter VII
A Biologically Inspired Autonomous Robot Control Based on Behavioural Coordination in Evolutionary Robotics

José A. Fernández-León
University of Sussex, UK & CONICET, Argentina

Gerardo G. Acosta
Univ. Nac. del Centro de la Prov. de Buenos Aires & CONICET, Argentina

Miguel A. Mayosky
Univ. Nac. de La Plata & CICPBA, Argentina

Oscar C. Ibáñez
Universitat de les Illes Balears, Palma de Mallorca, Spain

ABSTRACT

This work is intended to give an overview of technologies, developed from an artificial intelligence standpoint, devised to face the different planning and control problems involved in trajectory generation for mobile robots. The purpose of this analysis is to give a current context to present the Evolutionary Robotics approach to the problem, which is now being considered as a feasible methodology to develop mobile robots for solving real life problems. This chapter also show the authors' experiences on related case studies, which are briefly described (a fuzzy logic based path planner for a terrestrial mobile robot, and a knowledge-based system for desired trajectory generation in the Geosub underwater autonomous vehicle). The development of different behaviours within a path generator, built with Evolutionary Robotics concepts, is tested in a Khepera© robot and analyzed in detail. Finally, behaviour coordination based on the artificial immune system metaphor is evaluated for the same application.

INTRODUCTION

The main goal of this chapter is to describe the authors' experiences in developing trajectory generation systems for autonomous robots, using artificial intelligence (AI) and computational intelligence (CI) methodologies. During this engineering work, some questions have arisen that motivated the exploration of new techniques like ER and the behaviour coordination with artificial immune systems. This maturing process as well as new questions and hypotheses for the suitability of each technique are presented in the following paragraphs.

In order to provide paths to an autonomous mobile robot, being it terrestrial, aerial or aquatic, there are some basic building blocks that must be necessary present. One essential feature needed consists on on-board sensory systems to have perception of the world and the robot's presence in the environment. This will be called the navigation system. Another necessary feature is the low-level trajectory generation from the next target position and the robot's current position, referred as the guidance system. Finally, the lowest level feedback loops allowing the robot to describe a trajectory as close as possible to the proposed path (Fossen, 2002), (Meystel, 1991), named the control system.

A top hierarchy module is responsible of generating the next target positions for the robot, and then, the whole trajectory or path. This module is called the mission planner and varies according to the mobile robot application domain. The mission plan can be given beforehand (static planning) or it can be changed on-line as the robot movement progresses in the real world (dynamic planning or replanning). Mission replanning is the robot's response to the changing environment (obstacle avoidance, changes in mission objectives priorities, and others).

The navigation, the guidance and the mission planner systems providing trajectories for the mobile robot, may be considered as a supervisory control layer giving appropriate set points to the lower level controllers, in a clear hierarchical structured control (Acosta et. al, 2001). Consequently, every control layer could be approached with many different and heterogeneous techniques. Nevertheless, to better focus within the scope of this book, current technology on mobile robot path generation with AI and CI techniques will be analyzed in more detail in next sections.

BACKGROUND

The guidance system is usually designed to navigate joining two points, routing over intermediate points between actual robot position and the target position. These points, called waypoints, vary in number from one approach to another, but in every case, they represent intermediate goals to fulfil when going towards the final one. Even further, a complete mission is split in a great number of intermediate trajectories; each conformed by more than one waypoints. The navigation system comprises the data fusion necessary to locate precisely in 3D the robot rigid body (considering it as holonomic or non-holonomic) and the target position. The components within the navigation system can be geostationary positional system (GPS), an inertial navigations system (INS), a compass, a depth sensor, sonars, lasers, video images, and others. Thus, the navigation system provides the mission planner system, the guidance system and the control system with accurate data to achieve their objectives. Although this problem is faced with several techniques, AI is employed to organize the information in such a way that sensor readings are transformed into a kind of perception. Several approaches use artificial vision or pattern recognition with sonars, also considered as machine intelligence (Antonelli, Chiaverini, Finotello & Schiavon, 2001), (Conte, Zanoli, Perdon & Radicioni 1994), (Borenstein & Koren, 1991), (Warren, 1990), (Yoerger, Bradley, Walden, Singh & Bachmayer, 1996), (Hyland &