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Chapter V

Evolutionary Learning of Fuzzy Control in Robot-Soccer

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ABSTRACT

In this chapter an evolutionary algorithm is developed to learn a fuzzy knowledge base for the control of a soccer micro-robot from any configuration belonging to a grid of initial configurations, to hit the ball along the ball to goal line of sight. A relative coordinate system is used. Forward and reverse mode of the robot and its physical dimensions are incorporated, as well as special considerations to cases when in its initial configuration, the robot is touching the ball.

INTRODUCTION

An important aspect of fuzzy logic application is the determination of a fuzzy logic knowledge base to satisfactorily control the specified system, whether this is derivable from an appropriate mathematical model or just from system input-output data. Inherent in this are two main problems. The first is to obtain an adequate knowledge base (KB) for the controller, usually obtained from expert knowledge, and second is that of selection of key parameters defined in the method.

The KB is typically generated by expert knowledge but a fundamental weakness with this static acquisition is that it is frequently incomplete, and its control strategies are conservative. To overcome this one approach is to construct self-organising fuzzy logic controllers (Yan, 1994). These self-organising fuzzy logic controllers are used mainly for the creation and modification of the rule base. Of interest is the question of how this self-organisation and adaptation can be carried out in an automated fashion. One way is to incorporate genetic/evolutionary algorithms to form genetic fuzzy systems, (Karr, 1991; Thrift, 1991; Cordòn, 1995).

Evolutionary learning of fuzzy controllers in a three-level hierarchical, fuzzy logic system to solve a collision-avoidance problem in a simulated two-robot system is discussed in Mohammadian (1998a). A key issue is that of learning knowledge in a given layer sufficient for use in higher layers. We need to find a KB that is effective, to some acceptable measure, in controlling the robot to its target from 'any' initial configuration. One way is to first learn a set of local fuzzy controllers, each KB learned by an evolutionary algorithm from a given initial configuration within a set of initial configurations spread uniformly over the configuration space. These KBs can then be *fused* through a *fuzzy amalgamation* process (Mohammadian, 1994, 1998b; Stonier, 1995a, 1995b), into the global (final), fuzzy control knowledge base. An alternative approach (Mohammadian, 1996; Stonier, 1998), is to develop an evolutionary algorithm to learn directly the 'final' KB by itself over the region of initial configurations.

In this chapter we use this latter approach and incorporate special attributes to cover the difficult cases for control when the robot is close and touching the ball. A relative coordinate system is used and terms are introduced into the fitness evaluations that allow both forward and reverse motion of the soccer robot. We define the robot soccer system, the design of the fuzzy controller, the design of the evolutionary algorithm and finish with a short presentation of results for control of the robot from a far distance from the ball and from configurations close and touching the ball.

ROBOT SOCCER SYSTEM

The basic robot soccer system considered is that defined for the Federation of Robot-Soccer Association, Robot World Cup (*www.fira.net*). All calculations for vision data processing, strategies and position control of the robots are performed on a centralised host computer. Full specifications of hardware, software and basic robot strategies that are employed in this type of micro-robot soccer system can be found in Kim (1998).

Kinematics

The kinematics of a wheelchair-style robot is given by Equation 1 from Jung (1999).