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SELF GENERATION AND TUNING FUZZY RULES USING NEURO-FUZZY LEARNING ALGORITHM FOR TRAJECTORY TRACKING OF A MOBILE ROBOT

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ABSTRACT

In this paper, neuro-fuzzy learning algorithm will be implemented for self generate and tuning fuzzy rules to solve trajectory control problem. To implement this algorithm, the initial values of all weights corresponding to the fuzzy rules are given randomly and the initial of candidates fuzzy rules are computes. From training input-output data to fuzzy system, the objective function is evaluated to minimize error. Then, based on gradient descent, the algorithm updates the parameter of the center and the width of membership functions, the weights and the fuzzy rules. Using this algorithm, fuzzy rules and tuning parameter in the fuzzy rules can be learned without changing the fuzzy rule table form used in usual fuzzy applications. Simulation result demonstrates the feasibility of neuro-fuzzy algorithm for self generation and tuning fuzzy rules on the trajectory tracking of a mobile robot.

***Keywords**: Fuzzy logic, neuro-fuzzy learning, trajectory tracking, mobile robot.*

1. INTRODUCTION

In a conventional fuzzy logic approach the membership functions and the fuzzy rules are fixed and determined by the designer. To determine the fuzzy rules and tuning the parameter need more experience and more time. A problem occurs when a set of input data is observed from the process, the output of the fuzzy system cannot give an optimal result.

Due to the above problem, it is important to generate or to tune fuzzy rules by some learning methods. Seema Chopra et al. investigated how neurofuzzy technique can be applied in the area of control theory to design a fuzzy controller[1]. Yan Shi et al. developed a learning algorithm for tuning fuzzy rules by using input-output data based on gradient descent method. The advantage of this method is the fuzzy rules or membership functions can be learned without changing the form of the fuzzy rule table[2]. Yan shi et al. extended the idea of the neuro-fuzzy learning algorithm in case of fuzzy singleton type reasoning method. Since the flexibility of singleton type reasoning method, this algorithm is more reasonable and suitable to construct the fuzzy system [3]. Yan Shi et.al. proposed self tuning method for fuzzy if then rule generation based on neural network and clustering algorithm techniques. By this approach, the learning time can be reduced and the generated fuzzy rules are reasonable and suitable [5]. This paper implements the extended of the neuro-fuzzy learning algorithm for self generation and tuning fuzzy rules on trajectory control problem of mobile robot.

2. KINEMATIC MODEL OF MOBILE ROBOT

A two-wheeled mobile robot was chosen as the object in this paper (see Fig. 1). Its wheel rotation is limited to one axis. This kind of robot has non holonomic constraint, which should be considered during path planning. It is assumed that the vehicle moves on a plane without slipping, i.e., there is a pure rolling contact between the wheels and the ground. The kinematics model of a mobile robot is given by [4]:

$$\begin{aligned} \dot{x} &= v\cos\theta \\ \dot{y} &= v\sin\theta \\ \dot{\theta} &= \omega \end{aligned} \tag{1}$$

or, in more compact form as

$$\dot{\mathbf{x}} = f(\mathbf{x},\mathbf{u}) \tag{2}$$

Where $\mathbf{x} \cong [x \quad y \quad \theta]^T$ describes of the position and orientation of the center axis of the wheels mobile robot respect to global coordinate. $\mathbf{u} \cong [v \quad \omega]^T$ is the control input, where v and ω is the linear and angular velocities.

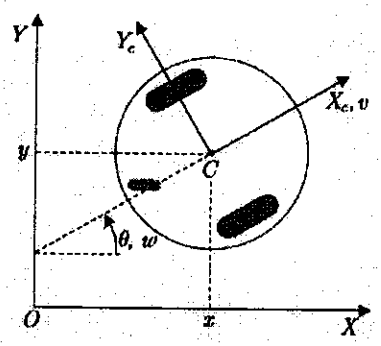

Fig. 1. Coordinate system of mobile robot

The control law of fuzzy is computed in discrete time. Thus, a discrete time representation of this model becomes necessary. By applying a sampling period T, a sampling instant k and