Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 120 (2017) 608–616

Procedia Computer Science

www.elsevier.com/locate/procedia

9th International Conference on Theory and Application of Soft Computing, Computing with Words and Perception, ICSCCW 2017, 24-25 August 2017, Budapest, Hungary

Fuzzy control of omnidirectional robot

Rahib H. Abiyev*[a], Irfan S. Günsel [a], Nurullah Akkaya [a], Ersin Aytac [a], Ahmet Çağman [a], Sanan Abizada [a]

[a] *Applied Artificial Intelligence Research Centre, Near East University, P.O. Box 670, Lefkosa, North Cyprus, Mersin-10, Turkey*

Abstract

This paper presents the design of fuzzy control system for an omnidirectional robot. The control structure of omnidirectional robot was described. The kinematics and dynamics of the mobile robot are presented. The design of control system is implemented for position and orientation angle in order to control the linear and angular speed of the omnidirectional robot. The designs of fuzzy controllers are performed and then these are used for the control of the holonomic 4-wheel-driven soccer robots. The designed fuzzy control algorithm has been extensively tested in simulation and provided satisfactory results in run time. The controller presented in this paper provides an optimal solution to minimize the differences between the reference trajectory and the current output. The obtained results demonstrate the effectiveness of proposed algorithms in robot soccer control.

Peer-review under responsibility of the scientific committee of the 9th International Conference on Theory and application of Soft Computing, Computing with Words and Perception.

Keywords: Robot Soccer; fuzzy control; obstacle avoidance.

1. Introduction

Recently numerous significant developments have been proposed for mobile robot system control. Mobile robot dynamics are nonlinear and has many uncertain factors. These are caused by friction, vibrations, payload variation, slippage between wheels and terrain and disturbance. Therefore it is difficult to obtain exact mathematical model for the design of control system. Since the modelling of these parameters is difficult they limit the effectiveness of

* Corresponding author. Tel.:+90 392 2236464; fax: +90 392 2233225
E-mail address: rahib.abiyev@neu.edu.tr

1877-0509
Peer-review under responsibility of the scientific committee of the 9th International Conference on Theory and application of Soft Computing, Computing with Words and Perception.
10.1016/j.procs.2017.11.286

control systems. Based on nonlinearities and uncertainty factors various control systems have been designed. Watanabe et al. (1998) considered feedback control, Liu et al. (2008) considered nonlinear controller design through trajectory linearization, Rossomando and Soria (2015) considered adaptive neural PID control, Hashemi et al.(2011) considered fuzzy PI control of omnidirectional robots.

Number of research works has been published on the design of control system of omniwheel robots. Omniwheel robot is a type of mobile robot that moves in all directions and very suitable for applications in dynamic environments. Omnidirectional robots are used in robot soccer game of the RoboCup competition. There are a number of robot soccer teams that have annual RoboCup competitions in the different countries. NEUIslenders team is one of them that has been designed in Applied Artificial Research Centre of Near East University. Abiyev et al. (2014), Abiyev et al. (2013) and Abiyev et al. (2012) are described the control structure of robot soccers.

In robot soccer game the environment where soccer robots move is characterized with fast changing dynamic areas with moving dynamic obstacles. Control system of these soccer robots includes a set of algorithms. These are vision module, decision making, path finding, obstacle avoidance and motion control modules. The design principles of these modules are represented in the papers of Abiyev et al. (2015) and Abiyev et al. (2010). Motion control module of robot soccer is one of the basic modules that controls the dynamics of the robot and drives the robot to the destination point. The obtaining of high accuracy control system is becoming important problem in conditions of uncertainty factor such as unknown frictions and disturbances.

Different approaches have been used to design control systems. These are sliding-mode control used by Mu et al. (2015), neural-networks used by Li et al (2015), fuzzy approach used by Masmoudi et al. (2016), Pena et al. (2015) and Treesatayapun and Guzman-Carballido (2009), neuro-fuzzy approach used by Philip Chen et al. (2014), fuzzy wavelet network used by Abiyev and Kaynak (2008), and Tsai et al. (2014), type-2 fuzzy approach used by Abiyev and Kaynak (2010), Abiyev et al. (2013), Hsiao and Wang (2013) are presented. Watanbe et al. (1998), Hashemi et al. (2011) uses PID and fuzzy control system for omni-directional robot. Masmoudi et al. (2016) design fuzzy PI controllers for goal position and orientation angle. The authors also designed two fuzzy controllers to control robot linear velocities and robot angular velocities. Liu et al. (2008) use trajectory linearization control based on linearization among a nominal trajectory. Here a nonlinear dynamic system is transformed to a linear system via a nonlinear coordinate transformation and a nonlinear state feedback. Hsiao et al. (2013) uses type-2 fuzzy system for sliding mode control of robot. As shown in these researches fuzzy logic is used as one of better technique for designing controllers. In this paper, fuzzy system is used for the control of omnidirectional robot. The fuzzy rules are designed for the fuzzy controller and applied for mobile robot control.

The paper is organized as follows. Section 2 describes the structure of control system of soccer robots. In section 3 the modeling of omnidirectional robot and the design of a fuzzy controller for soccer robot control are presented. In Section 4, the simulation studies and real life application are presented.

2. Kinematics and Dynamics of the Mobile Robot

The omnidirectional soccer robots and their control system are designed and manufactured in our research laboratory. The holonomic wheels with 3 degrees of freedom are used to design soccer robots. Abiyev et al. (2014), Abiyev et al. (2016) are presented the design modules of soccer robots. Fig.1(a) depicts the designed holonomic robot soccer. The soccer robot has four omni-wheels with a diameter of 61mm each. The wheel orientation of the robot is 30 degrees with the horizontal axis in front wheels, and 45 degrees with the horizontal axis in rear wheels (Fig.1(b)). The robot omni-wheels are connected to brushless DC motors and controlled by brushless DC motor drivers called Electronic Speed Controllers (ESC). Motor drivers are driven by a microcontroller. Microcontroller is connected to the computer via a wireless link.

The designed omnidirectional robot is used in NEUIslenders robot soccer team. Robot has decision making module that make the strategic planning of soccer robot to define its new position as it was mentioned by Abiyev et al. (2015). In the results of the decision making, the new coordinates of the soccer robots are computed. Using these coordinates soccer robots moves to its target locations. The control of position and rotation of the soccer robot is implemented by fuzzy controller which is presented in this paper. A fuzzy controller compute control signals for the wheels of the robot soccer