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Feedforward and Feedback Kinematics Controller for Wheeled Mobile Robot Trajectory Tracking

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***Abstract*—In this paper, trajectory tracking of a differential drive nonholonomic mobile robot is presented. In addition to the complex relations of the control system, the nonholonomic system adds complexity to the system which has been solved using the feed-forward and feedback fuzzy logic controllers. An innovative scheme has been developed to track the reference trajectory in the presence of model uncertainties and disturbances. The performance comparison of the proposed controller is done with the standard backstepping controller and the simulation results show that the developed controller is best suited for the tracking trajectory problems.**

***Index Terms*—WMR; trajectory tracking; kinematics; fuzzy logic**

I. INTRODUCTION

In the recent years, the tracking and control of wheeled mobile robots (WMR) has received lots of attentions from the robotic community because of many applications includes security, transportation, inspection and exploration. Due to the mechanical design and configuration, the WMR is classified into two categories: holonomic and nonholonomic. Holonomic robots are those in which the controllable degree of freedom is equal to total degree of freedom, whereas nonholonomic robots have less controllable degree of freedom compare to total degree of freedom and have restricted mobility [1]-[3]. Therefore, the controlling and trajectory tracking of nonholonomic WMR has been considered more challenging problem and many researchers proposed various controllers [3].

In case of trajectory tracking, the WMR has to follow a reference path either predefined or obtained from the other WMR. The standard technique to solve this problem is to design a kinematics controller which generates desired velocities based on position errors compare to reference position. Various researchers have proposed the kinematic controller for trajectory tracking based on "perfect velocity tracking" using e.g. fuzzy control [4], neural network [5], adaptive feedback [6], input-output feedback linearization [7], [8] and back-stepping [1], and so on. However, the presented works have poor transient and steady state characteristics in the presence of disturbance and model uncertainties. In addition, most of the works use simple trajectories with constant linear and angular velocities. In this research work, an innovative kinematic controller is proposed for trajectory following to generate the kinematic velocities. The controller structure uses feed-forward and feedback controllers. The feed-forward controller is designed based on reference positions and velocities along with error propagation model, whereas the feedback controller is designed using fuzzy logic. The effectiveness of the deigned controller is validated by computer simulations. In addition, the performance and effectiveness of the proposed scheme is compared with standard kinematic controller. The lamniscate curve reference trajectory is used for non-constant linear and angular velocities.

The main motivation of this work is to design a controller which can model the system with poor transient and steady state error in the presence of disturbances and model uncertainties. An innovative feed-forward and feedback controller is designed to cater above mentioned issues. Most importantly a difficult trajectory is chosen to test the controller so that the effectiveness of the controller may be verified. A comprehensive program using MATLAB (Simulink) is developed to test the feasibility of entire work which would be presented later. In this paper, a Fuzzy logic controller is used which is more dynamic and can model uncertainties in a better fashion. The novelty of this work is its comparison with the back stepping controller and the results shows the effectiveness of the proposed controller.

The breakup of the further work is structured as follows: Section II discusses the modeling of the WMR. Section III presents the designing of feed-forward and feedback kinematic controller. The simulation results are presented in Section IV. Finally Section V provides the conclusion.

II. KINEMATIC MODELING OF WMR

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