

Balancing Control of a One-wheel Transportation Vehicle : Gyrocycle

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Abstract-- This paper presents the implementation and control of a one-wheel transportation vehicle called Gyrocycle. Gyrocycle is designed to be a future personal vehicle to carry a human operator that stands on and drive it. The vehicle uses the gyro effect induced by two flywheels to maintain balance itself. One of critical condition for the balancing stability is to control the tilt angle of the flywheels. However, the flywheels tend to lean against one direction. This leads to the instability of the system. To remedy this behavior, a PD control method with gain scheduling algorithm is used for controlling the balancing angle. Its balancing control performance is empirically confirmed.

Index Terms--One-wheel mobile robot, gyro effect, personal transportation vehicle

I. INTRODUCTION

Recently, mobile robots and automobiles are merged into one category of robotic vehicles to carry human drivers. Electric automobiles as an extended version of mobile robots are already in the market as a transportation system. Although the infrastructure for electric automobiles is not completely setup yet, the number of electric automobiles is gradually growing in all over the world.

Several different kinds of electric vehicles for a personal transportation system other than electric automobiles have been developed. One of successful electric personal vehicles in the market is Segway with two wheels to balance [1]. Segway uses the concept of the inverted pendulum system to balance and navigates with two wheels.

Many attempts of controlling two-wheel mobile robots from small size to large size have been made [2-5]. Other than control point of view, the complementary filtering method as one of sensor fusion algorithms has been used to obtain an accurate balancing angle used in the controller [4]. In the previous research, TransBOT, a two-wheel transportation vehicle with a driver sit has been developed. Instead of standing on the vehicle to drive the vehicle like Segway, the vehicle is designed for a driver to sit and drive the vehicle [5].

More challengingly, two-wheel mobile robots are transformed to a single-wheel mobile robot. Pioneering works on a single-wheel mobile robot have been presented from analysis to implementation [6-13]. The successful balancing and driving control performances of

Gyrover have been demonstrated [6]. Other designs and control methods of a single-wheel mobile robot have been presented in the literature [7-11].

In our research, a single-wheel mobile robot, Gyrobo has also been developed and controlled [12]. Gyrobo is balancing based on the gyro effect. A neural network control method is applied to control Gyrobo [13]. Both Gyrover and Gyrobo are aimed to maintain balance and navigate on the plane without any load such as a human driver. Obstacle climbing control performances of Gyrobo have also been demonstrated [14].

In this paper, the same concept of Gyrobo can be extended to Gyrocycle that is designed to carry a human driver. A one-wheel transportation vehicle, Gyrocycle is implemented and controlled. Several modifications in the design from Gyrobo have been made. Firstly, a small wheel has been replaced with a larger commercial motorcycle wheel. Secondly, two flywheels are used to generate larger gyro effects. Gyro effect generated by two flywheels helps a driver balancing the vehicle. Thirdly, a body is redesigned with steps that a human driver can stand on. Lastly, all the hardware including controllers are newly implemented.

The real Gyrocycle is shown in Fig. 1. Although the current system cannot be tested with a human driver on it, the actual balancing control performance of Gyrocycle itself can be tested.

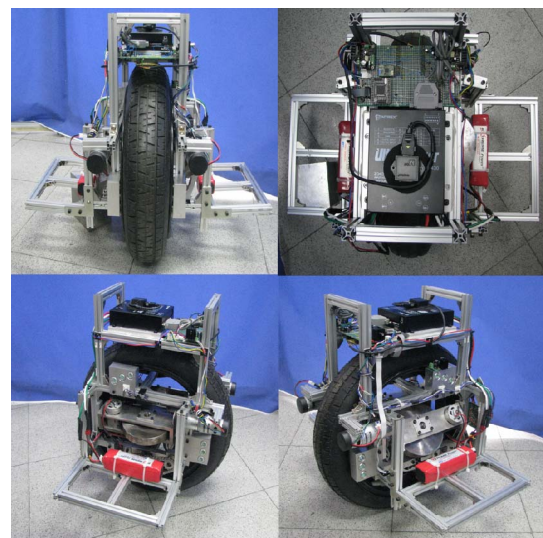


Fig. 1 Gyrocycle