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Behavior-Based Control of Mecanum Four-Wheeled Omnidirectional Robot

A. Ghasemi, M. Sadedel*

Department of Mechanical Engineering, Tarbiat Modares University, Tehran, Iran

ABSTRACT: In this paper, a four-wheeled omnidirectional robot of the mecanum type is investigated. In this study, the kinematics and dynamics of the robot have been analyzed, emphasizing the influence of parameters and models on equations. The robot-based behavior control is carried out by applying kinematic equations. This method of control will enable the robot to reach its desired position despite obstacles. This method of control will enable the robot to reach its desired position despite obstacles. The work done in the robot control method is the main contribution of this study. This control method uses a behavior-based algorithm to guide a robot toward a target point by bypassing obstacles and selecting appropriate behaviors. We are interested in investigating the rotational motion of this robot, independent of its linear motion since it has three degrees of freedom on the plane. Therefore, during the movement of the robot and reaching the goal, the robot should always be oriented towards a moving point separate from the target point. The results show that this method gives a good estimate of the robot speed and the speed of the robot wheels and their torque.

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1- Introduction

Mobile robots are receiving a great deal of attention in the field of industrial applications as well as in the field of scientific research, thanks to their ability to replace humans to achieve difficult, tedious, and dangerous activities. Among the mobile robots, we can mention omnidirectional mobile robots. These robots have three degrees of freedom. Omnidirectional wheels are based on the concept of a central wheel with free rollers positioned at an angle around the wheel. Omnidirectional wheel mechanisms are different depending on the type of roller and the angles of placement of the rollers. Mecanum wheels are one of the types of omnidirectional wheels among other wheels. In this type of wheel, the angle of placement of the rollers in the wheel environment is 45 degrees [1].

Various methods for navigating and controlling independent mobile robots have been proposed in the literature. For example, the linear feedback method to track an omnidirectional mecanum robot [1], and the robust adaptive control method to control the same type of robot [2], and also the feedback control method for Omnidirectional mobile robots [3] have been used.

A suitable method for constructing a control system in order to achieve the movement of moving robots in dynamic and different environments is a behavior-based control strategy [4]. Since the control algorithm method of the behavior-based for such robots has not been studied in the literature, so the innovation is in implementing this control algorithm for such robots. This method was first introduced by Magnus [5]. This method uses behaviors such as going to goal and also the behavior of avoiding obstacles to move the robot. In addition, Ref. [5] explains that separated behaviors can be combined with some priorities to form a new behavior. One of the most essential advantages of this method is that it creates an integrated system, which makes the design procedure simpler. It also gives us the possibility to add new modes to the system without posing any substantial growth in complexity. In this method, there is no need for complex system dynamics and only by examining behaviors such as going to goal, avoiding obstacles, the movement of the robot is controlled. In fact, in Ref. [5], how to model a base behavior system by switching each of the separate parts corresponding to behavior is investigated. (Fig. 1)

2- Methodology

As already mentioned, for autonomous robots operating in a partially unknown, dynamic environment a successful way of structuring the controllers is within a behavior-based framework. In this method, the robot's distinctive behaviors such as going to the goal and avoiding the obstacle

*Corresponding author's email: hami

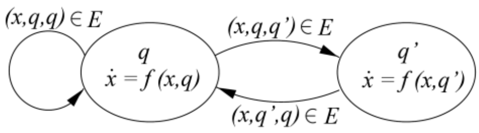

Fig. 1. method of switch between each behavior [5]

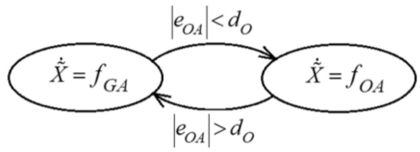

Fig. 2. Goal-to-goal and avoidance of obstacles behaviors [5]

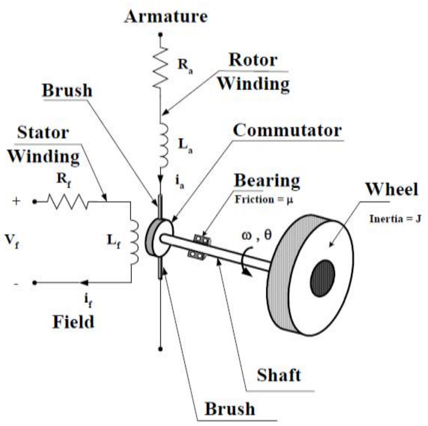

Fig. 3. DC Motor model [6]

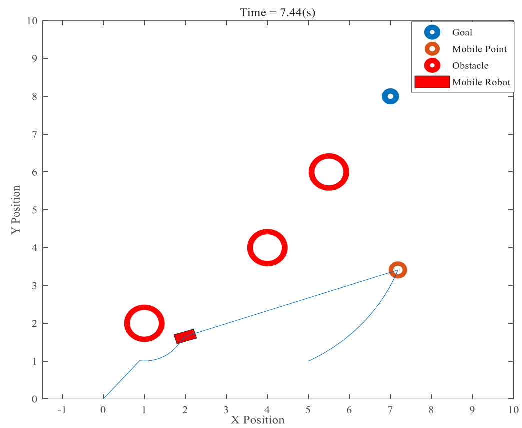

Fig. 4. The path of the robot towards the target and its orientation towards the moving point

are considered and the change between the mentioned behaviors is the sensory data and there is no display of the environment. The simplest way to control a moving robot so that the robot moves toward the target and does not hit an obstacle is to use go to goal behavior and the obstacle-avoiding behavior shown in Fig. 2. At first, the robot has an absorbing behavior towards the target and moves towards the target. If the robot approaches an obstacle while moving, it must avoid this obstacle. The key to designing this algorithm is how to switch between behaviors. How the robot bypasses the obstacle so as not to interfere with the behavior of going to the target. Therefore, in this section, we consider a d_O radius for the obstacle and an e_{OA} confidence interval, which indicates the distance of the robot from the obstacle. Now, if the distance of the robot to the obstacle is less than this e_{OA} value, the robot will be in the behavior of avoiding obstacles.

To calculate the actual speed of the robot wheels, the wheel motor model is needed. Here, Ref. [6] is used to model the robot. A dc motor is used for modeling, which is shown in Fig. 3 of the motor model.

3- Results and Discussion

Considering the kinematic and dynamic relationships of the robot, as well as considering the method of controlling the behavior-based algorithm, the robot has been simulated in a MATLAB environment. In this simulation, the omnidirectional robot starts moving from a certain point of stillness to reach the desired position while moving, the robot must cross several obstacles with specific behaviors. In addition, while moving, the angle of orientation of the robot head should be such that it always follows a moving point.

At the end of the simulation, it was observed that the robot speed and torque follow a similar pattern during the movement. In these diagrams, it is clear that as soon as the obstacle reaches the speed and torque of the robot wheels, it changes drastically.

By modeling the motor for the robot wheels, as shown in Fig. 5, the actual speed of the wheels changes better and smoother when reaching obstacles. This is also physically interpreted correctly. By modeling the motor, it becomes clear that speed and torque are interdependent. Therefore as shown in Fig. 6, the torque graph changes like speed, which depends on the inertia of the motor shaft and the coefficient of friction

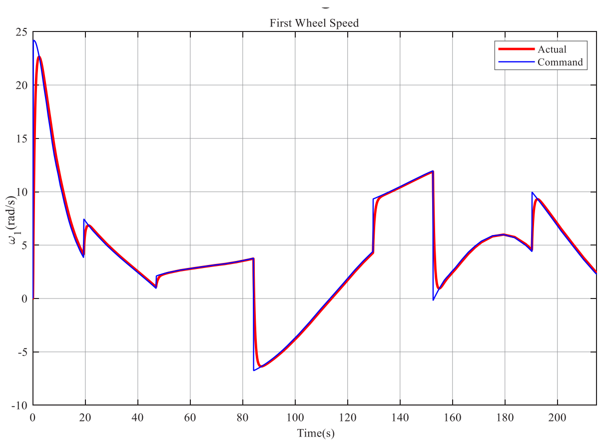

Fig. 5. The rotational speed of the first wheel

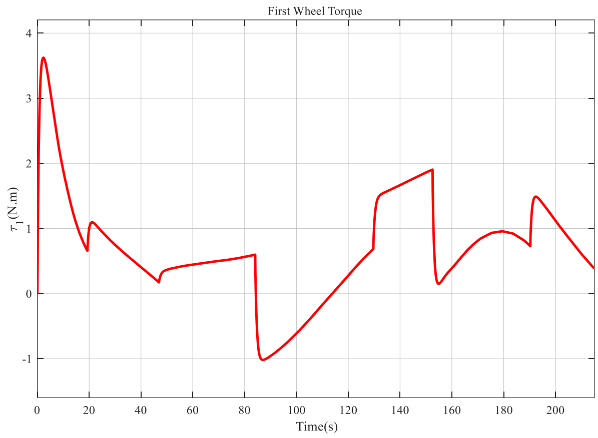

Fig. 6. The amount of torque in the first wheel

between the motor shaft and the bearings in the motor.

4- Conclusion

In this paper, a method of controlling the behavior-based on a four-wheeled mechanic robot was discussed.

The main contribution of this study is the implementation of this algorithm. The wheels were modeled to compute their actual rotational speed. The results proved that the proposed controller leads to a limited range of torque and speed. It was found that the torque is directly related to the rotational speed of the wheel. Finally, it can be concluded that this algorithm accurately controls the linear and rotational motion of the robot.

References

[1] S. Mellah, G. Graton, E.-M. El-Adel, M. Ouladsine, A. Planchais, Trajectory tracking and time delay management of 4-mecanum wheeled mobile robots (4-MWMR), in: ACD'19: 15th European Workshop on Advanced Control and Diagnosis, Bologne, Italy, 2019.

[2] V. Alakshendra, S.S. Chiddarwar, Adaptive robust control of Mecanum-wheeled mobile robot with uncertainties, Nonlinear Dynamics, 87(4) (2017) 2147-2169.

[3] K. Watanabe, Y. Shiraishi, S.G. Tzafestas, J. Tang, T. Fukuda, Feedback Control of an Omnidirectional Autonomous Platform for Mobile Service Robots, Journal of Intelligent and Robotic Systems, 22(3) (1998) 315-330.

[4] M. Khazaee, M. Sadedel, A. Davarpanah, Behavior-Based Navigation of an Autonomous Hexapod Robot Using a Hybrid Automaton, Journal of Intelligent & Robotic Systems, 102 (2021) 29.

[5] M. Egerstedt, Behavior based robotics using hybrid automata, in: International Workshop on Hybrid Systems: Computation and Control, Springer, 2000, pp. 103-116.

[6] B.M. Nouri, Modelling and control of mobile robots, ICMSAO/05, American University of Sharjah, UAE, (2005).

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