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Developing of trajectory tracking control method for nonholonomic wheeled mobile robots under uncertain external disturbances

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Introduction. Trajectory tracking task is one of the most difficult challenges in nonholonomic wheeled mobile robot (e.g. differential drive or car-like robots) applications. Such robots characterized by constraints that restrict its motion and increases the complexity of trajectory tracking due to the limitation in manoeuvrability. These challenges become more complicated with the existence of uncertain external disturbances [1], such as slippery surfaces, uneven terrain, frictions, or dynamic obstacles, which decrease tracking performance and affect the stability and safety of the system. To address these problems, several solutions are considered [2], such as using sliding mode control to consider some bounded disturbances or using neural network models for motion control of mobile robots under the condition that all kinematic parameters of the robot are known. This work suggested a trajectory tracking control method based on adaptive control integrated with kinematic and dynamic models for enhancing the accuracy of tracking and the performance of the robot, and combined with developing a disturbance observer for estimation and compensation of the perturbations in real time [3].

Main part. To solve the discussed problems which affect the general performance of the mobile robot, several steps have been done by this work, as follows:

1. A study of the kinematic and dynamic models of the car-like mobile robot is done, which considered as the core of autonomous vehicles applications, addressing its constraints and the case where not all kinematic and dynamic models' parameters are known.
2. An adaptive control method is considered to deal with the unknown parameters problem by designing a kinematic controller for dealing with tracking error and generate the reference velocities and a dynamic controller, so the actual velocities track the desired ones.
3. The effect of external disturbances on the motion of the robot is estimated by developing a disturbance observer, so it can be compensated and cancelled which enhance the robustness of the system and reduce the deviation from the desired trajectory.
4. Several experiments are done using MATLAB simulation to test the efficiency of the suggested method.
5. The work also discussed the concept of using neural networks models for optimizing the choice of gain parameters of the controller and its effect on enhancing the tracking accuracy and speed.

Conclusions. In this work, a control method for of car-like mobile robot for trajectory tracking tasks was developed based on adaptive control and disturbance observer-based technique, for addressing the problem that not all model parameters are known and the presence of external disturbances. In addition, a study of using neural networks models for controller gain parameters choice optimization is conducted, considering its effect on the performance of the robot.

List of references:

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