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Embedded System for Motion Control of an Omni Directional Mobile Robot

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Abstract

This article describes an embedded system for controlling the mobility of omnidirectional mobile robots. A homonymic robot is a kind of omnidirectional mobile robot. It is capable of simultaneous and autonomous translation and rotation. A robotic soccer competition, the Robocop small-size league, will serve as the study platform for this article. The first part of this research will consist of the design and construction of an embedded system that will be capable of interacting with a remote server via a wireless connection and executing instructions received from the server after being configured. As a second contribution, we propose a fuzzy-tuned proportionate-integral (PI) route planner and an accompanying low-level controller for getting the optimal input for operating an omnidirectional mobile robot using a linear discrete dynamic model. Additionally, velocity and acceleration filters are used to conform to planning criteria and prevent slippage. Multiple –input -multiple-output velocity acceleration and deceleration are investigated using low-level optimal controllers such as a linear quadratic regulator (LQR). In this case, the LQR controller operates on the robot and receives data from motor encoders or sensors. A fuzzy adaptive PI is also used as a controller for position monitoring, and an appropriate vision system delivers position input. This research demonstrates a considerable advancement over a standard PI controller with regards to the fuzzy-PI LQR controller.

Introduction

In the future, mobile robots will have a profound effect on human society. Robots' duties will no longer be limited to safely completing assembly and manufacturing tasks. A mobile robot must be capable of traversing the real world to do hands-on activities that include unanticipated changes. Without initial maneuvering, traditional wheeled mobile robots (WMR) are incapable of running in the other direction. [2] Despite advancements in mobility, WMRs remain unable of competing with homonymic robots. For instance, a differential drive configuration places several motors in fixed positions on the robot's left and right sides. The phrase 'non-homonymic alludes to this robot's incapacity to drive in any direction imaginable. In contrast, a homonymic robot outfitted with Omni-wheels may drive in any direction at any time. The particular robotic application in question for which this project is being undertaken is for use in the Robocop-SSL soccer tournament. To offer precise motion control and route planning, the researchers are developing low- and high-level controllers. At the basic level, the controller controls the wheel speed, while at the high level; the controller controls the robot's position. At the lower level, the Loris used, whereas, at the higher level, Fuzzy Logic Control (FLC) is used.

According to [4] [6], When building a robot for the Robocop-SSL tournament, a team may opt to use existing open-source firmware created by other teams rather than beginning from scratch. This will save the team time and money. It is the lack of hardware matching that poses the most significant challenge to this approach since the firmware is often developed by programmers for particular target hardware. Consequently, the team must adapt significant portions of current code to work with the new hardware, which takes almost as long to complete as the process of developing firmware from scratch. To address this issue, we develop and build an adaptable embedded system. Because the Robocop-SSL robots are battery-powered, energy conservation is as important as flexibility. Therefore, we develop a low-level controller that is both energy efficient and capable of providing motor drivers with optimum input and precise wheel velocity. An omnidirectional robot's motion control system must include route planning and precise trajectory tracking as two critical components. Even though numerous studies have investigated the theoretical model implementation of omnidirectional robots' kinematics and dynamics using appropriate mathematical models, some traditional controllers continue to exhibit difficulties in localization when the target route and surface conditions change.

Background and Literature Review

This study utilizes a basic embedded system to manage the mobility of an omnidirectional robot while also taking into account the necessary robot hardware design. The majority of teams built their robots using an omnidirectional drive and competed in the SSL competition using this technique [1] [2]. This drive enables the robot to travel rapidly to any place in the field without turning its whole body. To accomplish this, customized wheels known as Omni-wheels are combined with motors that allow for friction-free movement in any direction. Additionally, secondary tiny wheels are parallel to the primary wheel. Extra wheels are required for an omnidirectional driving robot. Almost all teams have four-wheeled robots. The main purpose of having more than three wheels is to increase the robot's torque and acceleration, allowing it to travel rapidly over the field. An embedded system is a collection of hardware and software components. A robot's construction requires a variety of hardware and software components. To begin, the robot is propelled forward by four motors attached to the Omni-wheels. PWM signals or analog signals produced by a microcontroller through a digital to analog converter may be used to operate the motors (DAC). A radio device is used to receive instructions and transmit feedback from the team server.

Each motor in CMDragons's robot is equipped with a deep quadrature encoder for velocity determination [4], [5]. When it comes to the PWM generator, quadrature decoders, and serial communication with other onboard components, an FPGA is essential. As an additional input, the robot gets information from a gyroscope, which controls the robot's movement following three different constants: acceleration, deceleration, and speed. Team members in the past have dealt with this problem by programming a robot to find the optimum set of motion profile features. Their approach sought to address the trade-off between the overall velocity of the robot and the instability of its motion. Using an FPGA, this technique is put into action. Furthermore, robotic applications must be able to adapt to changing surroundings. For planar trajectory following, an omnidirectional robot's speed and position accuracy are critical topics for significant research [7], [6]. Numerous researches have focused on the creation of dynamic and kinematic equations with consistent control.

Several papers demonstrate the dynamics and kinematics of omnidirectional mobile robots. Following linearized systems, dynamic models of robots have been constructed [2]–[8]. More precisely, two autonomous PID controllers are constructed to regulate direction and position independently of one another using a simple linear model. However, no investigation of a nonlinear connection between translational and rotational velocities has been conducted too far.

Conclusion

The purpose of this research is to develop simple and easy-to-use embedded system for controlling the motion of four-wheeled omnidirectional mobile robots. The two closed-loop structure control systems will both be able to receive instructions from the team server and send them to the robot to operate the robot in the x-y plane with efficiency and accuracy. The fuzzy adaptive PI algorithm relies on visual input to provide accurate target position guidance and therefore minimizes tracking mistakes. Two internal controllers— an inner loop controller and a discrete-time linear quadratic regulator — are all at work on the robot to get the most appropriate power for the motor drivers. This makes it easier for the robot to keep the wheel speed correct while using less energy. This research shows that utilizing a fuzzy-adjusted PI (LPQR) together with an LQR controller improves overall performance compared to conventional PI controllers. This simulation and experiment found that results obtained when no tension was added were superior to those obtained when stress was added.

References

[1] Caceres, C., Rosário, J.O.Ã.O. and Amaya, D., 2018. Design, simulation, and control of an omnidirectional mobile robot. *International Review of Mechanical Engineering*, *12*(4), p.382.

[2] Chen, Z. and Birchfield, S.T., 2009. Qualitative vision-based path following. *IEEE Transactions on Robotics*, *25*(3), pp.749-754.

[3] Delgado, R. and Choi, B.W., 2019. Network-oriented real-time embedded system considering synchronous joint space motion for an omnidirectional mobile robot. *Electronics*, *8*(3), p.317.

[4] M. C. Priess, R. Conway, J. Choi, J. M. Popovich, and C. Radcliffe, "Solutions to the inverse LQR problem with application to biological systems analysis", *IEEE Trans. Control Syst. Technol.*, vol. 23, no. 2, pp. 770-777, Mar. 2015.

[5] Najmurrokhman, A., Komarudin, U., Djamal, E.C. and Taufik, F., 2019, July. Speed Control and Obstacle Avoidance of a Hexapod Mobile Robot using Mamdani type Fuzzy Logic Controller. In *2019 6th International Conference on Instrumentation, Control, and Automation (ICA)* (pp. 199-202). IEEE.

[6] Nguyen, T., Mann, G.K. and Gosine, R.G., 2014, May. Vision-based qualitative path-following control of quadrotor aerial vehicle. In *2014 International Conference on Unmanned Aircraft Systems (ICUAS)* (pp. 412-417). IEEE.

