Chapter 24
Wheelchair Secure Navigation with RF Signal Triangulation and Genetic Algorithm Optimization

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ABSTRACT

This chapter describes an approach of secure navigation systems for wheelchairs and mobile robots platforms, using RF signal triangulation and Extended Kalman Filter in conjunction with Genetic Algorithm for indoor trajectory optimization. Initial systems are implemented and tested at virtual environment with conception of supervision and control systems for mobile robots, which are capable of operating and adapting in different environments and conditions. Validation of this environment is made in a non-holonomic mobile robot and in a wheelchair; both used an embedded control rapid prototyping technical for best navigation strategy implementation. ToF (Time-of-Flight) of the RF digital signal interacting with beacons for computational triangulation in the way to provide a pose estimative at bi-dimensional indoor environment, where GPS system is out of range, are depicted. A non-linear filter based on a genetic algorithm as an emerging optimization method to search for optimal positions is described.

INTRODUCTION

The main objective of this work is to present a proposal of a virtual environment implementation for rapid prototype project and simulation with conception of supervision and control systems for mobile robots, including this work at area of Mechatronics and Robotics researches (Habib, 2008). Those mobile robots platform are capable to operate and adapting at different environments and conditions. The purpose of

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this virtual system is to facilitate the development of embedded architecture systems, emphasizing the implementation of tools that allow the simulation of the kinematic conditions, dynamic and control, with real time monitoring of all important system points. In the way to accomplish these tasks, open control architecture is proposal, integrating the two main techniques of robotic control implementation in the hardware level: microprocessors systems and reconfigurable hardware devices. The utilization of a hierarchic and opened architecture, distributing the diverse actions of control in increasing levels of complexity, the use of resources of reconfigurable computation and the validation of this environment are made in a virtual simulator for mobile robots (de Melo, Demian Junior, Lopes, & Rosario, 2012).

The locomotion planning, under some types of restrictions, is a very vast field of research in the field of the mobile robotics (Siegwart, Nourbakhsh, & Scaramuzza, 2011). The basic planning of trajectory for the mobile robots imply the determination of a way in the space-C (configuration space) between an initial configuration of the robot and a final configuration, in such a way that the robot does not collide with no obstacle in the environment, and that the planned movement is consistent with the kinematic restrictions of the vehicle (Graf, 2001). In this context, one of the boarded points in this work was development of a trajectory calculator for mobile robots.

The implemented simulator system is composed of a trajectory generating module, a kinematic and dynamic simulator module, and an analysis module of results and errors. It was implemented from the kinematic and dynamic model of mechanical drive systems of the robotic axles and can be used for simulation of different control techniques in the field of the mobile robotics, allowing itself to deepen the concepts of navigation systems, trajectories planning and embedded control systems. All the kinematic and dynamic results obtained during the simulation can be evaluated and visualized in graphs and table formats in the results analysis module, allowing the improvement of the system, minimizing the errors with the necessary adjustments and optimization (Kala, Shukla, Tiwari, Rungta, & Janghel, 2009).

For controller implementation in the embedded system, it uses the rapid prototyping which is the technology that allows in set, with the virtual simulation environment, the development of a controller project for mobile robots. After tested and validated in the simulator, the control system is programmed into the memory of the embedded mobile robot board. In this way, an economy of time and material are obtained, validating first the entire model virtually and after operating the physical implementation of the system.

Genetic algorithms (GA) have proven to be effective in different mobile robot applications. In (Chen & Zalzala, 1995) a genetic approach to mobile robot motion with a distance-safety criterion is presented. Hein and Meystel (1994) have developed a GA that finds admissible control trajectories that tend to minimize the vehicle's transit time through the obstacle field. Other applications include the planning of control and trajectories for automated delivery vehicles and the optimization of control for racing vehicles. Hu and Simon (2004) described a route construction heuristic for a vehicle routing problem. Kang et al. (1995) present a GA for global path planning to a goal for a mobile robot in a known environment (Motlagh, Tang, Ismail, & Samin, 2008).

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