# Chapter 38
# Wheelchairs Embedded Control System Design for Secure Navigation With RF Signal Triangulation

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## ABSTRACT

*In the mobile robotic systems a precise estimate of the robot pose (Cartesian [x y] position plus orientation angle θ) with the intention of the path planning optimization is essential for the correct performance, on the part of the robots, for tasks that are destined to it, especially when intention is for mobile robot autonomous navigation. This work uses a 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. It's a new technology utilization making good use of old ultrasonic ToF methodology that takes advantage of high performance multicore DSP processors to calculate ToF of the order about ns. A mobile robot platform with differential drive and nonholonomic constraints is used as base for state space, plants and measurements models that are used in the simulations and for validation the experiments. After being tested and validated in the simulator, the control system is programmed in the control board memory of the mobile robot or wheelchair. Thus, the use of material is optimized, firstly validating the entire model virtually and afterwards operating the physical implementation of the navigation system.*

DOI: 10.4018/978-1-5225-8060-7.ch038

## INTRODUCTION

The mobile robotics is a research area that deals with the control of autonomous vehicles or half-autonomous ones. In mobile robotics area one of the most challenger topic is keep in the problems related with the operation (locomotion) in complex environments of wide scale, that if modify dynamically, composites in such a way of static obstacles as of mobile obstacles. To operate in this type of environment the robot must be capable to acquire and to use knowledge on the environment, estimate a inside environment position, to have the ability to recognize obstacles, and to answer in real time for the situations that can occur in this environment. Moreover, all these functionalities must operate together. The tasks to perceive the environment, to auto-locate in the environment, and to move across the environment are fundamental problems in the study of the autonomous mobile robots. The utilization of a hierarchic and opened architecture, distributing the diverse actions of control on 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 (Normey-Ricoa et al., 1999).

Locomotion planning, under some types of restrictions, is a very vast field of research in the field of the mobile robotics (Siegwart & Nourbakhsh, 2004). The basic planning of trajectory for mobile robots implies the determination of a way in the space-C (configuration space), between an initial configuration and the final configuration, in such way that the robot does not collide with any 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 points boarded in this work was the development of a trajectory calculator for mobile robots.

The implemented simulator system is composed of a module of trajectory generator, a kinematic and dynamic simulator module, and an analysis module of results and errors. The simulator was implemented from the kinematic and dynamic model of mechanical drive systems of the robotic axles and can be used for the simulation of different control techniques in the field of mobile robotics, allowing the simulator system to deepen the concepts of navigation systems, trajectory 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 for the improvement of the system to minimize errors with the necessary adjustments and optimization (Antonelli et al., 2007).

The controller implementation in the embedded system uses rapid prototyping technique which allows, along with the virtual simulation environment, the development of a controller design for mobile robots. After being tested and validated in the simulator, the control system is programmed into the memory of the embedded mobile robot board. In this way, time and material are economized by first virtually validating the entire model and then operating the physical implementation of the system.

The hardware and mechanical validation and the tests were accomplished with a nonholonomic prototype of mobile robot model with a differential transmission.

This work uses a ToF of the RF digital signal interacting with RF beacons for computational triangulation in the way to provide a pose estimative at bi-dimensional indoor environment. It's a new technology utilization making good use of old ultrasonic ToF methodology that takes advantage of high performance multicore DSP processors to calculate ToF of the order about ns. A mobile robot platform with differential drive and nonholonomic constraints is used as base for state space, plants and measurements models that are used in the simulations and for validation the experiments.