

TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

Faculty of Electronics, Telecommunication and Information Technology

Eng. Sabou Sebastian

PhD Thesis

**THEORETICAL AND EXPERIMENTAL
CONTRIBUTIONS
IN THE FIELD OF ORIENTATION AND NAVIGATION
FOR INTELLIGENT SYSTEMS**

Summary

**Scientific advisor
Prof.dr.eng. Dorin PETREUȘ**

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Keywords: *sensors, obstacle avoidance algorithm, navigation, orientation, autonomous..*

Introduction and motivation of the PhD thesis

At international and national level, studies are being carried out on the issue of controlling robots with specific assistance to people with disabilities, developing solutions that are as efficient as possible and closer to human behavior. Implementations of features that closely mimic certain human behaviors have been implemented: grip, voice recognition, visual recognition; All this gives people with disabilities a certain degree of freedom and comfort. An important emphasis is also put on the implementation of local and remote management applications and solutions for dedicated systems for telepresence systems.

Starting from these ideas, the research carried out within the present PhD thesis focused on the development of a intelligent system able to guide itself autonomously and to be able to follow the imposed trajectories as well as the calculation of new trajectories, avoiding the possible obstacles or other limitations along on the way.

It was wanted to use components, computing systems and sensors that are available on the market, to be as cheap, as easy to program as possible, to result in a system that can be implemented by people without advanced knowledge of electronics, programming . Using the smallest and lowest-cost development systems, preferably using 8-bit common-mode microcontrollers, only in special situations where obtaining a data processing level requires the use of more complex systems is one for the purposes of this doctoral thesis.

Also, it is desirable to analyze and propose algorithms that are as easy to implement as 8-bit (preferably) 8-bit microcontrollers that provide sufficient performance for targeting and navigating a locomotor system for people with locomotor disabilities within a home or Of a room.

Objectives of the PhD thesis

The main objectives of the doctoral thesis are as follows:

- Integration of sensors (for inertial navigation and obstacle detection) available on the consumer market at a low price, obtaining results with minimal errors, using error-elimination algorithms.
- The study and implementation of data fusion algorithms provided by inertial navigation sensors that are available at the lowest prices.
- Study and optimization of some obstacle detection and avoidance algorithms using 8-bit microcontroller computing systems.

- Implementation of a simulator to verify obstacle avoidance algorithms, autonomous guidance and navigation algorithms for intelligent systems

Thesis structure

The thesis consists of six chapters, which highlight the ultimate goal of the intelligent system, able to guide itself autonomously, follow a required route and be able to detect possible obstacles and avoid them, returning to the original route , Using control systems and sensors that are the most affordable on the market at this time. Since, in the last years, the Department of Applied Electronics in Baia Mare has been established as the main direction of research, the study and the implementation of some systems of assistance for people with certain difficulties or disabilities (more for physical, locomotor, Manipulation) and this thesis has one of the aims to bring even closer to achieving a complete system of assistance. But the system can be used in a wide variety of applications such as: industry, automobiles, construction, warehouses, assistance for people with disabilities.

In **Chapter 1 Intelligent and Autonomous Systems** an introduction was made to the research field of the thesis, presenting the motivation for choosing this theme. The results obtained from a thorough research of what is on the current commercial market, the technologies used to implement such intelligent systems as well as a study on modeling and mapping technologies currently used for these systems have been presented.

Chapter 2 - Inertial navigation contains a basic theoretical study of mobile systems reference systems. This has resulted in a mathematical computational basis used in most of the leading algorithms investigated and implemented in this thesis. Each mobile system has its own reference system, each map has been made relative to its own reference system, the use of these maps requires the implementation of a switching algorithm that allows switching from a reference system to another reference system, thus using To the maximum of all available resources. Also, corroborating data from an available map with map data automatically generated by the system, known landmarks, known obstacles, is based on the study done in this chapter.

Chapter 3 - Study of Sensors for Autonomic Navigation and Navigation presents a study of inertial navigation sensors, errors based on the configuration used, a study for different sensor topologies as well as for determining and correcting errors that occur. A correction solution was proposed that was later used for the calibration of sensors to use the data from each sensor to increase the accuracy of the measurements.

Sensors used to determine obstacles were also studied to measure distances to them, technologies for commercial products were researched, the advantages and disadvantages of using it for this purpose were determined, some devices not specifically designed for such use.

Chapter 4 - Orientation of Autonomous Systems contains a theoretical and experimental study for interfacing the various sensor configurations available on the market, their use with accessible development systems (Arduino) as well as a study on ultrasound sensors and infrared sensors for determining obstacles.

Several types of data fusion methods obtained from sensors have been studied, the possibility of their implementation using the most common computer systems, especially 8-bit microcontroller systems, the results of the study showing the advantages and disadvantages of each method as well as the possibility Using as cheap and cheap as possible systems that can be purchased from the current market.

Chapter 5 - Navigation of Autonomous Systems is intended for autonomous system navigation, having a theoretical and experimental study of navigation algorithms and various sensor topologies. In this chapter the knowledge and results obtained in the previous chapters have been implemented through the development of a simulator, made using the Matlab environment, allowing the testing of several sensor configurations as well as the use of several mapping, orientation, obstacle avoidance algorithms And autonomous or assisted navigation of systems. The simulator also allows the use of real data, obtained by using a connected radio system that transmits data obtained by a real system.

An obstacle avoidance algorithm has been proposed and analyzed, it was simulated using the Matlab environment, the results being very encouraging, enabling implementation in real systems as well.

Chapter 6 Conclusions and further developments highlight the results obtained and show a number of possible directions for the continuation of the research and development of the theme proposed in this thesis. These results were obtained within the PhD program and the Sectoral Operational Program for Human Resources Development 2007-2013: "Inter-university partnership for excellence in engineering - PARTING", from the Technical University of Cluj-Napoca, finalized with an internship Research at the University of Debrecen-Hungary.

At the end of the thesis are presented the bibliographic references used during its elaboration and annexes that comprise the electrical schemes and the sources of the programs developed within this doctoral thesis.

The main contributions of the PhD thesis

Among the personal contributions made to this work by the author, one can remember:

- In the first part one can notice a good systematization of the information about the autonomous systems in general and the possibilities for their implementation.
- A detailed documentation and presentation of the use of digital circuits in the implementation of autonomous systems has been carried out.
- Carry out a theoretical study of the mathematical component in terms of inertial navigation systems
- Study of sensors with possibilities for use in the field of intelligence orientation and navigation
- Theoretical and practical proposal and verification of algorithms for data processing from sensors (sensor calibration, sensor data linearization, sensor data filtering).
- Study of laser sensors for distance determination, sensors not widely used in low cost autonomous systems
- There has been extensive documentation on the algorithms used to orient the systems as well as the practical adaptation and implementation of some for autonomous systems using 8-bit microcontrollers.
- A study has been conducted on the navigation algorithms used by low cost smart systems
- For a quicker evaluation of the various algorithms, a simulator with a graphical interface was created, using the Matlab program, which allows the simulation and emulation of algorithms, with the possibility to simulate certain specific sensors or to receive real data from the sensors using an interface Hardware and software
- It has been possible to optimize an obstacle avoidance algorithm by adding functions that have led to several advantages worth mentioning to reduce the likelihood of obtaining local minimums. The algorithm was simulated with both fixed objects and moving objects using the above mentioned simulator.

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