DEVELOPMENT OF HOLONOMIC MOBILE PLATFORM FOR FIELD ROBOTIC APPLICATIONS

A Thesis submitted to the
Department of Electronics and Telecommunications Engineering
University of Moratuwa
in partial fulfilment of the requirements for the
degree of Master of Philosophy

by

W.R. De Silva

Supervised by: Dr Rohan Munasinghe

Department of Electronics and Telecommunications Engineering University of Moratuwa, Sri Lanka

March 2011

DECLARATION

The work submitted in this thesis is the result of my own investigation, expect otherwise stated.

It has not already been accepted for any degree, and is not been concurrently submitted for any other degree.

W. R. De Silva

Date : 10 March 2011

We/I endorse the declaration by the candidate.

Dr Rohan Munasingha

Dr. Rohan Munasinghe
Senior Lecturer
Dept. of Electronic and
Telecommunication Engineering
University of Moratuwa.

Abstract

Most mobile platforms or vehicles used today are non holonomic. They only have one or two independent degrees of freedom. Due to that its maneuverability is limited and often requires much space to control functions like turning and parking. By improving degrees of freedom (improving the maneuverability) of a vehicle, it can follow many complex trajectories that are difficult or impossible by conventional non holonomic vehicles. Any mobile platform that has three independent degrees of freedom in a plane is a holonomic platform. Independent degrees of freedom means that it can change its orientation or position without effecting other motions unlike in car type vehicles that require turning or changing its orientation when need to move. Holonomic motion is very useful to acquire abilities such as, avoid any obstacle while keeping its orientation the same, capability to move in constrained spaces and track a target while moving in an arbitrary trajectories etc. Because of these advantages and capabilities some of the scientific and industrial researches are targeting to develop holonomic mobile platforms. Already robotics community have managed to build some working models and used in applications like robot soccer games and mobile robot manipulators. Many different mechanisms have been created to achieve the holonomic capability. These include various arrangements of Swedish wheels or omni wheels, chains of spherical or cylindrical wheels, ball wheels and powered caster wheels etc. While most of these designs are practical in indoor environments they are not suitable for outdoor operations in large scale versions. In this research project our goal was to develop a viable design to achieve holonomic capability that minimizes these problems and more suited to outdoor operations. The proposed design has a wheel arrangement similar to a car but with the capability of independent driving and steering capability of each of the four wheels. Car type rolling and steering mechanism avoid any uneven

wear of the wheels and avoid lateral forces applied on the wheels. Wheel driving and steering mechanism was designed such a way that wheels can be steered 360 degrees continuously without interfering with the wheel drive system. This enables the platform to move in complex trajectories continuously without stopping for wheel resetting. The developed platform has increased ground clearance that is necessary for outdoor rough terrain operations like farming. Although these benefits exist, controlling the robot to acquire the desired motion is very complex and need innovative algorithm. Four independent wheels with eight degrees of freedoms to achieve three degree of freedom motion is a redundant control problem and require complex control system. Using inverse kinematics model of the platform and multiprocessor design with advance micro-controllers we have tried to solve these issues and were able to achieve successful performance.

Dedicated to my parents Sujatha and Dayawansha

and

to my loving wife Nalika

Acknowledgments

I would like to take this opportunity to convey my sincere thanks to Dr Rohan Munasingha, my research supervisor in suggesting such a research project that invoked my design abilities. It has benefited immensely from his valuable advices, suggestions to fruitful the outcomes of the project. I also thank to Dr Palitha Dassanayake and senior lecturer Mr. Shiran Nanayakara for helping me for the control system design and implementation.

Further more I would like to express my great appreciation to all academic staff members of the Department of Electronics and Telecommunication Engineering and workshop staff for their kind support.

Finally I would like to thank to all my fellow researchers of the Intelligent Machines Laboratory for their enormous support throughout this period.

W Rameesha De Silva
Department of Electronics and Telecommunication Engineering
University of Moratuwa

Contents

List of Figures

List of Tables