



Outdoor Navigation: Time-critical Motion Planning for Nonholonomic Mobile Robots

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ABSTRACT

The question of timing in mobile robot navigation still remains an area of research not thoroughly investigated. In certain situations, a mobile robot may need not only to reach a desired location safely, but to arrive at that location at a specified time. Such a situation may have significant ramifications for applications to which a robot is tasked, for example patrolling large areas, delivering goods or coordinating multiple mobile robots. Thus, it is important for a mobile robot to be able to plan its trajectories and movements in order to navigate from initial location to a final destination whilst considering timing, orientation and velocity. Furthermore, it should also be able to detect and avoid any obstacles encountered in its path during navigating through the environment.

The aim of this research is therefore to develop a time-critical motion planning algorithm, which includes planning the trajectory, position and orientation of a mobile robot, with obstacle avoidance capability for a single or multiple nonholonomic mobile robots. In addition, the mobile robot should be able to replan its original trajectories in order to 'make up' any loss of time caused by avoiding obstacles. An Ackermann car-like robot has been considered specifically during the development stage, with consideration given to the kinematic and dynamic constraints of nonholonomic mobile robot in general. The resultant algorithm is based on the geometric approach.

In achieving the research objectives, this study is conducted in four stages. The first stage deals with the development of a new algorithm for time-critical motion planning in order to navigate safely in an environment, to reach the specified location at the specified time, with the required orientation, velocity and with the consideration of the kinematic and dynamic constraints of the mobile robot. In the second stage, the algorithm should have the capability to avoid any unknown static and dynamic obstacles when the mobile robot starts to move from its initial point. The algorithm should have the ability to replan its original trajectory to compensate for time loss due to avoiding obstacles. Prior to experimental works, the simulations will be carried out to ascertain the effectiveness of the algorithm. In the final stage, experimental works will be undertaken to validate the algorithms utilising an Ackermann car-like robot.

STATE OF ORIGINALITY

To the best of my knowledge, except where otherwise referenced and cited, everything that is presented in this thesis is my own original work and has not been presented previously for the award of any other degree or diploma in any university. If accepted for the award of the degree of Doctor of Philosophy in Mechanical Engineering, I consent that this thesis be made available for loan and photocopying.

Mohd Sani Mohamad Hashim

Date

PUBLICATIONS

Conference papers (Main author)

1. Mohd Sani Mohamad Hashim and Tien-Fu Lu, "Time-dependent motion planning for nonholonomic mobile robot", The 9th International IFAC Symposium on Robot Control (SYROCO'09), Gifu, Japan, 9-12 September 2009.
2. Mohd Sani Mohamad Hashim and Tien-Fu Lu, "Multiple waypoints trajectory planning with specific position, orientation, velocity and time using geometric approach for a car-like robot", 2009 Australasian Conference on Robotics and Automation (ACRA '09), Sydney, Australia, 2-4 December 2009.
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4. Mohd Sani Mohamad Hashim and Tien-Fu Lu, "Performance of a time-dependent motion planning for a car-like robot in static environments", 2012 International Conference on Man Machine System (ICoMMS '12), Penang, Malaysia, 27-28 February 2012.
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6. Mohd Sani Mohamad Hashim and Tien-Fu Lu, "Time-critical Trajectory Planning for a Car-like Robot in Unknown Environments", IEEE Business, Engineering and Industrial Applications Colloquium 2013 (BEIAC 2013), Langkawi, Malaysia, 8-9 April 2013.

Conference papers (Co-author)

1. Zhiyong Zhang, Dongjian He, Tien-Fu Lu and Sani Hashim, "Study on Steering Actuator Transfer Function of Picking Mobile Robot", 2010 International Conference on Communications and Mobile Computing (CMC 2010), Shenzhen, China, 12-14 April 2010.

Journal papers

1. Mohd Sani Mohamad Hashim and Tien-Fu Lu, "Real-time Control of Time-Critical Trajectory Planning for a Car-like Robot in Unknown Environments", International Journal of Engineering Research and Technology (IJERT), ISSN: 2278-0181, February - 2013 (Vol.2, Issue 2), 2013.

2. Mohd Sani Mohamad Hashim and Tien-Fu Lu, "Time-dependent Motion Planning for a Car-like Robot in Dynamic Environments using Geometric Approach", International Journal of Imaging and Robotics (IJIR), Revised, 2012.

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