UNIVERSITY OF TECHNOLOGY SYDNEY
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Fast, Reliable and Efficient Database Search Motion Planner (FREDS-MP) for Repetitive Manipulator Tasks

by

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Certificate of Authorship/Originality

I certify that the work in this thesis has not been previously submitted for a degree nor has it been submitted as a part of the requirements for other degree except as fully acknowledged within the text.

I also certify that this thesis has been written by me. Any help that I have received in my research and in the preparation of the thesis itself has been fully acknowledged. In addition, I certify that all information sources and literature used are quoted in the thesis.

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Conference Papers

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ABSTRACT

This thesis presents FREDS-MP, a motion planning framework that leverages state of the art methods for solving a set of practical agricultural manipulator applications. Current methods exhibit unacceptably slow planning and execution times, hence FREDS-MP aims to bridge this gap by speeding up planning times whilst maintaining high reliability and solution efficiency. While only a specific set of applications are explored, FREDS-MP can be adopted for other similar applications seamlessly due to its general interface. FREDS-MP consists of three planning phases: offline, task and online. The offline planner pre-computes trajectories and cost information based on special cases that anticipate the real world. This pre-computed information is used by the task planner to compute accurate heuristics for sequencing tasks. The pre-computed trajectories are used as initial seeds by the online planner which utilises state of the art trajectory optimisers to adapt them in real-time to online tasks. Software simulations are performed to validate FREDS-MP and compare it to other state of the art planners. Further, the suitability of two commercial manipulators, six-DOF and seven-DOF, are compared for the intended applications. Several unconstrained and constrained tasks, commonly seen in agricultural applications, are tested under diverse obstacle configurations. Statistical results based on planner performance metrics are presented. From these results it was found that FREDS-MP significantly outperformed other state of the art planners when using a seven-DOF manipulator. Hence, an active perception experiment was carried out on a real Rethink Robotics Sawyer robot arm which was tasked to seek out apples on an artificial trellis and inspect them individually. The results from these experiments are presented and validate the practicality of FREDS-MP.

Abbreviations

DOF - Degree(s) of freedom

SEM - Standard error of the mean

IK - Inverse Kinematics

FK - Forward Kinematics

RRT - Rapidly-exploring Random Trees

TSP - Travelling Salesman Problem

BIT* - Batch Informed Trees

CHOMP - Covariant Hamilton Optimisation Motion Planner

GPMP2 - Gaussian Process Motion Planner 2

URDF - Unified Robot Description Format

OpenRAVE - Open Robotics Automation Virtual Environment

COLLADA - COLLAborative Design Activity

OMPL - The Open Motion Planning Library