Design Tool for the Tip Over of Mobile Robots

Graduate

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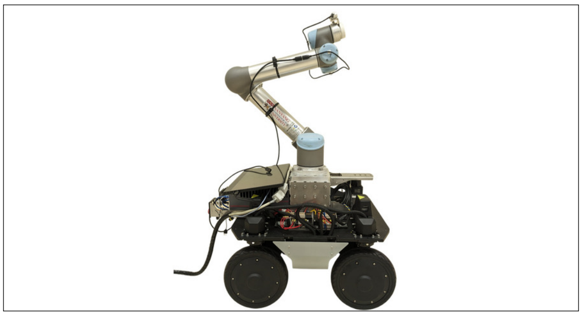
Introduction: The project is part of an exchange programme between the University of Applied Sciences of Eastern Switzerland and Nanyang Technological University (NTU). The Robotics Research Centre (RRC) of NTU wants to develop an omnidirectional robot with a manipulator mounted on top. A commercial platform was purchased and ROS2 was implemented on it to control the whole system. During the first test, the whole robot tended to tip over. This was due to the small distance between the axes of the wheels.
The aim of the thesis is to create a design tool or design process for creating new omnidirectional robots that do not tip over. It should be possible to create different manipulator and platform configurations and simulate them statically and dynamically. Overall, the platform shall be optimisable, i.e. with all input parameters of the manipulator and platform, the recommended axis distance shall be the output.

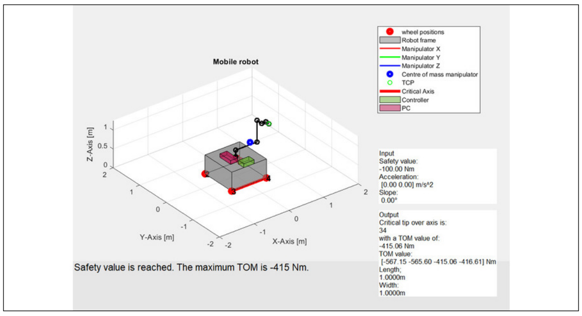
Result: The solution consists of three interrelated MATLAB scripts. The first is the Manipulator script. The user can create different manipulators using the Robotics Toolbox by Peter Corke. The toolbox has a function to create different manipulators with Denavit Hartenberg parameters. Newton-Euler Inverse Dynamics is used to calculate the forces and moments acting on the joints. This allows the influence of the manipulator on the whole system to be determined. This information is transferred to the second script, which is the Tip over script. The tip over moment method is used for the calculation. This makes it possible to determine whether a system is stable or not. The method calculates the negative moment acting around each pair of wheels to keep all the wheels on the ground.
Within the script, it is possible to create a platform with all the physical parameters and to mount various add-ons on it. The user has the option of running a simulation with their own axis distances or optimising them to a certain safety value. The last script is the spherical analysis. It takes the data from the other two scripts and creates a sphere by rotating the first and second joints of the manipulator. At each position of the sphere, the stability value is calculated and plotted. This should give the user more information about the created model and show critical positions of the manipulator.

Conclusion: Various validation tests were carried out using a mobile robotic platform and a UR10e. A measurement setup was created to check the static functions of the scripts. The robot was placed on four scales to calculate the corresponding tip-over value. There are some deviations, but these are due to the measurement setup of the built-in suspension. It can therefore be assumed that the design software is validated for static applications. The dynamic results were only compared with manual calculations as the measurement setup was not capable of this. A measurement setup for dynamic validation would be very complicated to set up. Overall, a versatile tool has been developed that simplifies the design of a wide range of manipulator/platform combinations, greatly reducing the time required to create new robots.

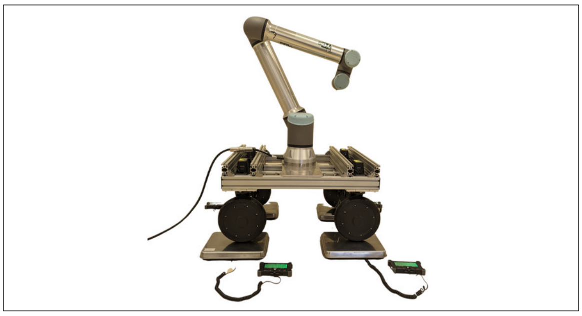
First Version of the Robotic System
Own presentment



Output Tip Over Script
Own presentment



Measurement Set Up
Own presentment



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Subject Area
Automation & Robotics

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