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Doctoral Dissertation
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Paquitop and MoviWE.Q

Design, Development and Testing of Two Omnidirectional Devices for Indoor Assistance

By

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Declaration

I hereby declare that, the contents and organization of this dissertation constitute my own original work and does not compromise in any way the rights of third parties, including those relating to the security of personal data.

Luigi Tagliavini
2023

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Paquitop and MoviWE.Q

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This work reports the design, development, and testing of two omnidirectional mobile systems for indoor applications that share the same locomotion system: Paquitop, a lightweight mobile manipulator, and MoviWE.Q, an omnidirectional motorized wheelchair. At first, this Thesis presents bibliographic research on assistive robotics and electrical-powered wheelchairs with a particular focus on locomotion systems. Regarding motorized wheelchairs, the regulatory context is analyzed to guide the development of MoviWE.Q. Then, kinematic models are derived for three omnidirectional locomotion systems: a swerve-drive-based system (like the one adopted in Paquitop and MoviWE.Q), a four mecanum wheel platform, and a three omni wheel device. Based on their kinematic properties, these locomotion systems are compared. After this preliminary part, the mechanical and electronic design processes of Paquitop are described. Paquitop is conceived as a small, lightweight mobile robot that can easly move in indoor environments full of obstacles exploiting its omnidirectional locomotion system. Thanks to the adoption of conventional motor wheels mounted on vertical steering axes, the robot has full mobility in the plane of motion and it can better deal with ground unevenness if compared to solutions based on mecanum wheels or omni wheels. On the omnidirectional base platform of Paquitop, a collaborative robotic arm is mounted to interact with the surrounding environment, and different sensors and tools can be mounted based on the specific application. As an application example, this Thesis describes the project D.O.T. Paquitop, in which the robot was customized to be used in the blood bank of the Molinette Hospital (Turin, Italy) as a robotic assistant. On this matter, a first preliminary test was conducted in July 2022 at the blood bank of the hospital. The last part of this Thesis is devoted to the description of the electrical-powered wheelchair MoviWE.Q. This wheelchair is intended for indoor usage and it can be used in three modes: manual mode, assisted mode, and autonomous mode. In manual mode, the user seated on the wheelchair commands the system through his preferred control interface, e.g., three-axe joystick with conventional or unconventional handle, sip-and-puff interface, head movement interface, or other user's interfaces. In assisted mode, a caregiver drives the wheelchair with a sensorized handle mounted on the back of the chair. In autonomous mode, the wheelchair moves autonomously to the desired position,

avoiding static and dynamic obstacles. Firstly, the mechanical and electronic design of MoviWE.Q is presented. Then, the development of the sensorized handlebar for autonomous mode is reported and finally, the wheelchair testing is described. The experimental tests were performed to evaluate the performance of MoviWE.Q with a particular focus on its mobility. The work related to MoviWE.Q is part of a pending patent, while the project regarding the sensorized handlebar is under evaluation for future patent submission.