Doctoral Dissertation
Doctoral Program in Electrical, Electronics and Communications Engineering
(36$^{th}$cycle)

# Machine Learning for Perception and Autonomous Navigation of Service Mobile Robots

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Politecnico di Torino
2024

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Autonomous service robots are expected to revolutionize multiple industries and social contexts in the following decades. Service robots perform helpful tasks for humans or equipment, excluding industrial automation applications. Potential contexts that can benefit from adopting service robots include precision agriculture, search and rescue, indoor cleaning, social assistance, inspection, and exploration of hazardous environments. In the last years, research has significantly investigated mobile robots' robust perception and autonomous navigation capabilities to address complex service tasks in dynamic environments. In particular, perception refers to the ability of a robot to acquire, process, and understand information from its surroundings, such as images, sounds, and tactile sensory data. Autonomous navigation refers to the ability of a robot to plan and execute its motion, achieving its target goal without collisions or failures. In this context, the most recent data-driven approaches can empower service mobile robots with these required capabilities. Machine learning and Deep Learning are successful branches of Artificial Intelligence (AI) that have been widely applied to various complex tasks such as Pattern Recognition, Computer Vision, and Natural Language Processing, outperforming classical methods. Robotics represents another challenging application field for Machine Learning, as it involves complex and dynamic environments and high-dimensional and multimodal sensory inputs to solve a wide range of diverse and interactive tasks. This thesis aims to study novel methodologies to efficiently integrate AI in service robotics perception and autonomous navigation tasks. Precision agriculture and social indoor assistance are the applicative contexts for all the methods discussed in this dissertation. A complete Deep Learning pipeline for robot navigation in row-based crops is presented, combining different low-cost visual controller solutions with a way-point generator for global path construction. Various methodologies have been developed for indoor social assistance tasks, from online odometry correction to omnidirectional person following and monitoring. Consistent simulation and synthetic data adoption have enabled fast data collection to train the models, analyzing and mitigating the deriving sim-to-real gap with new techniques. Generalization is a fundamental aspect of robust AI-based perception in the real world, and a great focus has been devoted to investigating it from different perspectives. Domain Adaptation and Domain Generalization methodologies have been applied to image classification and segmentation tasks in the agricultural field, as well as a general study of backbone generalization properties. Extensive experiments and results obtained are presented for each presented methodology, together with a theoretical description of the methods and a complete review of related works. Moreover, a great endeavor has been spent to study and optimize the inference time of Deep Learning models on constrained resource hardware, such as the onboard computational units of mobile robots. Different approaches have been considered to allow for real-time prediction performances required by the robotic tasks. Overall, this dissertation aims to advance the efficient integration of AI and mobile robots, paving the way for further improvements in this rapidly evolving research field.