Ph.D. in Information Technology
Thesis Defenses

March 27, 2023
at 9:30
PT1 Room and online by Webex

Stefano CARNIER – XXXV Cycle

Estimation Techniques for ADAS and Autonomous Driving Systems

Supervisor: Prof. **Sergio Savaresi**

Abstract:

Advanced Driving Assistance Systems (ADAS) and autonomous driving are among the most investigated and promising technologies of automotive research. ADAS automate and adapt vehicle technology to improve driving performance and safety. Self driving cars have the potential to reshape the mobility framework reducing traffic congestion, cutting CO2 emissions, facilitating transportation accessibility and, most importantly, increasing passengers safety. The development and implementation of such applications require an accurate and real time knowledge of the vehicle state variables. Cutting-edge sensors can now directly measure specific variables which provide a better understanding of the vehicle behavior and allows the design of improved control systems. However, advanced sensors are not always industrially viable off-the-shelf solutions. They sometimes lack reliability in specific driving conditions and may be too expensive to be part of stock sensor suites of low-medium class vehicles. This research addresses open topics in vehicle states estimation field to overcome the limitations of the actual solutions. To tackle the issue of expensive advanced sensors we propose cost effective solutions based only on vehicle stock measurements. To increase sensors reliability, we present sensors fusion techniques of measurements from advanced and stock sensors achieving accurate and robust estimation. All the presented approaches are validated through experimental data and tested as constitutive elements of advanced driver assistance and autonomous driving systems which, when needed, are specifically designed.

Filippo PARRAVICINI – XXXIV Cycle

A study on autonomous urban navigation on sidewalks applied to last mile delivery

Supervisor: Prof. **Matteo Corno**

Abstract:

Over the last few years, the number of outdoor applications that could benefit from the use of mobile robots has been steadily increasing. Last mile urban delivery is a good example of a field in which fast, compact and agile autonomous vehicles are regarded as a crucial factor to improve the service quality and efficiency. One of the key enablers for this type of robots is that of navigating on sidewalks, pedestrian areas and crosswalks. The challenges related to such pedestrian-like navigation are manifold, and range from the lack of strict regulations for pedestrian flow on sidewalks, to the need to actively interact with other road agents to achieve joint collision avoidance. The autonomous street crossing problem is a perfect example of these type of challenges. This dissertation presents a study on some of the fundamental algorithms allowing a mobile robot to safely navigate sidewalks and crosswalks. A two-wheeled, self standing robot designed for parcel delivery is used to experimentally validate the developed algorithms. The work detailed in this presentation contributes to improve the navigation capabilities of the prototype under many aspects. The first of them is the vehicle handling performance on uneven and irregular terrains. Within this context a set of robust state estimators, an innovative model-based slope angle observer, and a feed-forward controller to compensate control disturbances on inclined roads. All of them are shown to improve the vehicle handling, and can in general be applied to any vehicle with a Two Wheeled Inverted Pendulum configuration. The second explored aspect is related to the ability of the robot to perceive and understand the surrounding environment. Within this context the dissertation presents a camera-based algorithm that leverages map-based priors to detect semaphores and their logic state, and a novel lidar-based target tracking algorithm aimed at estimating the position and speed of incoming vehicles. The latter is then used as an input of a decision making algorithm enabling safe street crossing. Such decision making algorithm is developed within a broader study on the most relevant decision variables that a robot should consider when negotiating a crosswalk. The dissertation is concluded with a detailed statistical analysis of how human engage robots during obstacle avoidance maneuvers. The study gives evidence that pedestrian indeed behave differently when they cross a robot than when they encounter another human. At the same time it also demonstrates that the very well-known Social Force Model which was developed to predict human-to-human interactions can also be effectively used in the human-to-robot case.

Solomon PIZZOCARO – XXXV Cycle

Toward autonomous vineyard operations: development and in-field testing of a self-driving tractor

Supervisor: Prof. **Matteo Corno**

Abstract:

Since the early 1900s, automation has been shaping the agriculture industry on a global scale. Up to these days, the main automated operations are spraying, pruning, weeding, and soil monitoring. Some of these tasks still require the presence of the operator which fills the gap in perception and mobility. In recent years, thanks to the advancements in sensor technology and autonomous driving algorithms for road vehicles, more and more attention is being placed on self-driving tractors and complex crop management operations. Although there are various projects driven by these interests, fully autonomous navigation in orchards and many horticulture operations remain open

problems. In the first place, it is clear the need for robust and tailored perception solutions, that can cope with the seasonal changes and the unstructured nature of the agricultural field. Furthermore, the uneven and soft ground makes the modeling and control of the robot's motion very challenging. This work aims to address these challenges with the development of the main modules for autonomous grape harvesting. In particular, we present a complete navigation solution for an autonomous vineyard tractor and propose a computer vision algorithm for grapes and grape peduncle detection. The latter implements a YOLOv4 network for grapes and berries detection, and classical image processing techniques for grape peduncle detection. After a discussion on the perception challenges of a vineyard environment, we describe a localization scheme designed to cope with GNSS failures by fusing inertial sensors with an online calibrated magnetometer. Then, we describe a point cloud segmentation algorithm designed to filter the ground, leaves, and vine branches from the LiDAR data. The filtered point cloud, together with the reference path, is used to build a local map for the motion controller. The latter is based on the potential field method which makes it robust to vehicle and environment modeling errors. The local map is built such that the vehicle is attracted by the path and repelled by the obstacles. We validated the proposed navigation scheme during extensive tests on a real vineyard. Furthermore, the peduncle detection algorithm was validated on a quasi-realistic vine and resulted to be accurate and fast in the detection of grape peduncles, opening the way to autonomous grape harvesting.

PhD Committee

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