Ph.D. in Information Technology
Thesis Defenses

July 6th, 2023
at 15:00
Room ”Aula Seminari Alessandra Alario” and Online by Webex

Sara Furioli– XXXV Cycle

Design and on-field testing of Advanced Driving Assistance Systems for agricultural applications

Supervisor: Prof. **Matteo Corno**

Abstract:

Autonomous driving raises interest in several areas of modern society, seen as a means of increasing safety, improving efficiency and precision, and optimizing vehicle usage. The agricultural field witnesses autonomous driving progress at a higher pace than others: off-road autonomous vehicles can be easily tested (and eventually industrialized), unlike road vehicles which pose regulation issues due to the presence on roads of pedestrians and other vehicles. Autonomous navigation of agricultural vehicles is especially appealing to industry due to its potential to meet the strict requirements on precision imposed by sensitive procedures like seeding, harvesting, or pruning. It would also reduce man’s workload, easing operators from the driving task so that they can focus on the ongoing agricultural procedures.

Meanwhile, the problem is still very interesting from the research point of view, since the high precision requirements must be achieved in a complex and continuously changing environment (both due to seasonality and as a result of man’s activities), with reduced maneuvering space, and while working on high-value cultivation. In this scenario, vehicle global localization is still an open issue: GNSS technology is not always reliable as thick vegetation may cause signal loss. Relative-row localization is also essential, and cannot be done through the use of maps because they should be constantly updated due to the pronounced dynamism of the environment. Planning a local path is not a straightforward task, either: the vehicle must follow a global route dictated by the ongoing agricultural procedure and adapt it to growing vegetation and the presence of other obstacles. Once a local plan is generated, the path tracking task is relatively easily solved, given the low speeds involved in agricultural procedures.

Our research aims at investigating the above mentioned issues through the use of different technologies and approaching the problem at different automation levels. We propose an Advanced Driving Assistance System (ADAS) which cooperates with the tractor operator when the vehicle is between crop rows. It has the objective of keeping the vehicle aligned to the rows at a desired distance from them. We focus our attention to the industrialization aspect: the developed ADAS relies on cost-effective robust sensors with low computational effort requirements, industry-appealing characteristics that come at the price of lower precision and accuracy. We design a localization algorithm that deals with measurement noise in an innovative way. It is robust to different vegetation conditions, as it dynamically adapts to the current vegetative state, and to the loss of one or more sensors measurements.

We further propose a fully autonomous system that allows the vehicle to navigate the vineyard unsupervised following a park-to-park global reference path and reacting in presence of obstacles. The proposed system is robust to the loss of GNSS measurements, thanks to a global localization algorithm that exploits the sensor-fusion approach. We design a perception module that uses 3D LiDAR measurements to dynamically create a map of the vehicle surrounding. In doing so, it distinguishes between crop rows and generic obstacles, as the avoidance strategy is different in the two cases. The global reference path tracking task is performed by a local planner, which simultaneously implements an obstacle avoidance strategy, customized on the type of obstacle it deals with.
The performance of both systems modules is assessed either through experimental data, collected on-field in different seasons (hence, different vegetation conditions) or in simulation, in comparison with state-of-theart solutions. An experimental campaign, performed on-field with a tractor, validates the proposed closed-loop systems with satisfactory results.

PhD Committee
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