Distributed control of autonomous agents with sensor fusion methodologies

Simon Cherlet
DySC, Ghent University
Technology Park 914
B-9052 Zwijnaarde
Simon.Cherlet@UGent.be

Cosmin Copot
DySC, Ghent University
Technology Park 914
B-9052 Zwijnaarde
Cosmin.Copot@UGent.be

Robain De Keyser
DySC, Ghent University
Technology Park 914
B-9052 Zwijnaarde
Robain.DeKeyser@UGent.be

1 Introduction

Stimulated by a worldwide demand for ever larger productivity in crop harvesting, agricultural manufacturers have pushed the size and power of contemporary combine harvesters to its maximum. However this trend is now steadily saturating due to several considerations such as cost, complexity, maintenance issues, and road transportation restrictions. Because of these problems manufacturers have to come up with other ways of making future farming even more cost efficient.

Bearing in mind the current state-of-the-art in autonomous vehicles, beit ground or aerial [1, 2], it seems the time is right to introduce a novel approach to the aforementioned problem. Namely, instead of using one very large, ponderous combine harvester, multiple somewhat smaller harvesting machines could be applied in such a way that only one of them (the leader) is being controlled by an operator and the others follow autonomously in a certain, predefined pattern. And to obtain enhanced control performance local sensory data on each of the harvesters (e.g. GPS, computer vision...) could be fused with information gathered by a quadrotor overflying the formation from above [3, 4].

2 Distributed multi-agent coordination

Over time a lot of research has been done on coordinated control of multiple autonomous mobile robots [5]. From a control engineering perspective, the goal is to compute the inputs that drive the vehicles along trajectories which maintain relative positions as well as safe distances between each agent while performing a certain objective. In this regard model-based predictive control (MPC) has proven to be very promising due to its ability to handle complex, constrained multivariable systems easily and effectively. However, the computational effort required for the inherent optimization scales poorly with the size of the system and can become prohibitive for large systems. To address this computational issue when applying a centralised MPC architecture, attention has recently focused on distributed MPC (DMPC) where each subsystem (i.e. vehicle controller) solves its own smaller optimization problem taking into account information communicated by its neighbour [6].

3 Goals

This research project aims at developing a DMPC framework for formation control of multiple autonomous ground vehicles extended with aerial agents (e.g. quadrotor) acting as remote sensors. Since this is actually a networked control system the framework should be able to deal with communication delays and information drop outs. From a global perspective, two major objectives are targeted:

1. To develop and validate a constrained DMPC scheme on a laboratory scale application consisting of n autonomous ground vehicles and a quadrotor acting as a remote sensor.
2. To develop a methodology for instrumentation and for variable selection with the purpose of sensor fusion as an aid tool to improve global control.

References

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