Network Interference on Cooperative Mobile Robots Consensus

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Abstract In this work we present the integration between a robot cooperative control strategy and a wireless network simulated with OMNeT++. We use a consensus control strategy to carry out a rendez-vous task where information is shared among a group of robots. These robots are then simulated in a MANET environment with a TDMA-based protocol to minimize message collisions. We consider two cases in this work: a fixed pre-determined topology, which does not accept new links, and a dynamic topology that creates new links as robots get within communication range. We show the impact of the network on the control strategy performing a rendez-vous task, considering both topologies. In particular, there is a considerable degradation of the rendez-vous task if care is not taken when deploying the cooperative control strategy, e.g. the initial message collisions due to desynchronized slot start. Finally, we compare these simulation results with those from a Matlab implementation of the control strategy using a typical simplified network model. The difference reveals the importance of using more accurate network models such as those of OMNeT++.

Keywords Mobile robots · Decentralized control · Cooperative strategy · Network protocols · Topology control · MANET

1 Introduction

Robotic tasks such as coverage, exploration, and cooperative transport, can take advantage of a group of cooperative mobile robots to achieve a better overall performance. In these scenarios, a fully distributed solution is frequently desired,

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consequently a decentralized decision architecture is needed and inter-robot communications play a vital role [1]. Ideally, the communication among the robots is bandwidth efficient, has low latency and has no obstructions [2]. However, this does not apply to real networks, especially in the case of Mobile Ad-hoc NETworks (MANET), which have limited bandwidth, propagation delays, access collisions, and limited range [3].

There are several approaches to deal with non-reliable communication in cooperative robotics: avoiding explicit communication completely (i.e. using local sensors, only), implementing a fault tolerant control strategy on each robot, implementing a reliable network protocol to avoid message collision or yet, simply ignoring all communication faults by considering an ideal communication medium. In this work we consider real explicit communication thus discarding the first and last approaches.

Nevertheless, there are solutions for network faults in the remaining approaches. The control approach makes the robot navigation robust enough to tolerate transient lack of information due to errors. In [9], the author developed a consensus strategy integrated with a predictive algorithm, which were capable of recovering from occasional network faults. In a similar way, the work in [11] uses a predictive adaptive control to minimize the effects of channel faults for wireless sensors and actuators.

In the network protocol approach, the solutions seek to solve the problem in the network layer through transmission control to avoid message collisions. In [12], the authors analyze the information flow and the impact of message exchange over a network for a group of robots. In [2] the authors propose a time division multiple access (TDMA) protocol with loose synchronization for MANET that does not need clock synchronization. Other recent work concludes that not only the network and its protocols have significant impact on a robot task, but also that the network cannot be simply modelled as percentage of faults [6].

In Robotics, many works still consider an ideal communication medium between the robots [6] or a few occasional faults, only. However, some initiatives already oppose to this trend, studying the network in a robotic context integrating robot models in network simulators. For example, the integration between NS2 and Arena Robotic Simulator [13], NS2 and Matlab [14], NS2 and ARGOS [6]. Despite showing the impact of the network in simple robots and tasks, these works do not evaluate the impact in complex control models.

Recent surveys on network simulators [20][21] show little performance difference among them and that most can be used for MANET simulations with good accuracy. NS3 has its merits as consuming less CPU and less memory, but OMNET++ has a better graphical user interface and thus, allowing a better debugging than the others. However, OMNET++ is not a network simulator, but a framework that gives the tools to make a network simulation. This framework also allows implementing non-network related algorithms as the robots movement and cooperative control strategy.

OMNET++ has received special attention of researchers and has been extensively used for several applications. It was integrated with Matlab [15] to simulate