Multi-Robot Systems and Communications Limits

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ABSTRACT

The defining characteristic of a multi-robot system, as opposed to “a bunch of robots”, is coordination. This coordination requires communication, which is almost always in short supply. An analysis of our own multi-robot systems, which suffered from extremely poor communications performance (around 1 kB/second shared between 14 robots [1]), revealed a troubling fact: a large fraction of our communications bandwidth was used to transmit information that was either already known or uninteresting.

Like others, we are investigating formulating communications as a planning problem. At each point in time, a robot can choose from multiple messages. For example, a robot might opt to send a fragment of a SLAM-derived map (a large message), a simple position update (a small update), or decline to send anything at all. The challenge is in determining which plans are better than others. Information-gain methods lead to relatively straightforward algorithms, but it is often difficult to disambiguate between useful and useless information.

A more principled approach grounds the utility of a proposed communications plan in terms of the expected increase in the system reward. In other words, how much additional reward does the robot predict the system to earn if it transmits a particular message? Unfortunately, a full probabilistic approach to this problem leads to a decentralized partially-observable Markov decision process (known to some as a Dec-POMDP-Com). Solving such a problem quickly becomes intractable. (That said, in real-world communication-constrained settings, we are willing to trade significant computational time for a reduction in communication requirements.)

Our approach to this difficulty is to make egregious simplifying assumptions! But simultaneously, we argue that some of our simplifications—such as assuming that the transition probability function is deterministic—aren’t as egregious as they at first seem. We argue, for example, that a robot under closed-loop control (i.e., almost every robot) is nearly deterministic. In the talk, we will describe some of our other assumptions, and present some early performance results from our system.

Along the way, I may also mention some of our synergistic work in predicting when robots will be able to communicate [2], and complain about the real-world performance of radios used ubiquitously in robotics (and some of the ideas we’re pursuing to address them).

REFERENCES