A framework for adaptive task allocation during multi-robot missions

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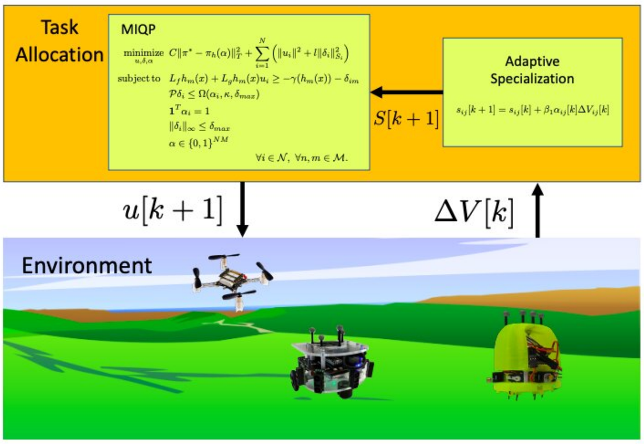

A figure illustrating the proposed feedback loop between the task allocation framework, the environment, and the adaptive specialization update. The effectiveness of the robots at each task is measured as ?V [k], which is passed to the adaptive specialization update law. Once the new specialization parameters are computed, the task allocation MIQP is solved and the inputs are sent to the robots. Credit: Emam et al.

In recent years, robots have become increasingly sophisticated, hence they are now able to complete a wide variety of tasks. While some robots are designed to work individually, for instance providing basic assistance in people's homes, others might be more efficient when deployed in teams.

During search & rescue missions, for instance after natural disasters, robots might be more effective as a team, as they could deliver supplies or search for survivors faster, covering larger geographical regions. To complete missions as a team most efficiently, however, robots should be able to cooperate well and effectively distribute different tasks among each other.

With this in mind, researchers at Georgia Institute of Technology (Georgia Tech) recently developed a framework for adaptive task allocation during missions that are to be completed by a team of robots. Their framework, presented in a paper pre-published on arXiv, can assign tasks to robots based on their unique capabilities and characteristics.

"Robot teams are envisioned to operate in dynamic environments and this paper proposes an updated rule that allows robots to know how fit they are for each of the various tasks they get assigned to on-the-fly," Yousef A Emam, one of the researchers who carried out the study, told TechXplore.

The framework developed by the researchers is based on a task allocation technique for heterogeneous multi-robot systems that they introduced in a previous paper. This previously devised strategy entails the use of an algorithm that accounts for differences in individual robot capabilities and allocates tasks accordingly. The allocation and execution of these tasks take place simultaneously.

"Our framework solves optimization problems online, telling individual robots how to prioritize their contributions to the various tasks they are to complete (i.e., task allocation), and how to do so (i.e., task execution)," Emam said.

In their study, Emam and his colleagues built on the task allocation strategy they previously developed, making it more responsive to changes in the robots' surrounding environment. In contrast with its previous version, their new framework does not require an explicit model of the environment or of robot capabilities that are unknown. Instead, it primarily considers the collective progress that the team of robots made on a given mission and each robot's performance on individual tasks.

"In our recent study, we developed a feedback law that renders the previously developed framework adaptive to environmental disturbances," Emam explained. "This means that even if the robot does not have perfect knowledge for how fit it Is for each of the tasks, it will learn it on the fly."

The researchers evaluated their framework in a series of simulations and found that it achieved highly promising results. In these experiments, their approach enabled effective task allocation among robots under a variety of environmental conditions, even in cases where the capabilities of individual robots were unknown before their deployment.

In the future, the task allocation and execution framework developed by Emam and his colleagues could enhance the cooperation between robots that are deployed as a team, improving their collective performance. This could ultimately facilitate the large-scale mobilization of robots during search and rescue missions.

"We are currently working on extending the framework to include each robot's features (e.g. sensors, actuators), so we can model feature failures online more explicitly," Emam said. "Moreover, another aspect we're looking into is the distribution of computation amongst the robots (decentralized)."

More information: Yousef Emam et al. Adaptive task allocation for heterogeneous multi-robot teams with evolving and unknown robot capabilities. arXiv:2003.03344 [cs.RO]. arxiv.org/abs/2003.03344

Gennaro Notomista et al. An optimal task allocation strategy for heterogeneous multi-robot systems. arXiv:1903.08641 [cs.RO]. arxiv.org/abs/1903.08641