Issues in Natural Dialogue Interaction with Teams of UAVs

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Human control of Unmanned Aerial Vehicles is a stressful task involving high levels of alertness. Currently, it typically takes four human operators to control a single UAV. However manufacturers such as Boeing desire to reverse that ratio, whereby teams of multiple UAVs are controlled by a single human. There are two broad approaches to potentially achieving this:

1. Make UAVs more autonomous by building in greater AI techniques, particularly at the mission level (e.g. [3]);
2. Design interfaces that better support interaction with UAV teams, in particular, ones that reduce the cognitive load of interaction.

Our approach is to take the second approach, using multimodal spoken-language dialogue interfaces to build on advances on the first approach.

There are important arguments for using interfaces involving spoken-language dialogue for controlling complex autonomous devices such as UAVs, including:

- Such interfaces typically require less training;
- Language is an efficient and powerful medium of communication;
- The collaborative nature of dialogue allows opportunistic communication and provides natural constructs for alerting and situating a user;
- Speech interfaces allow hands-free operation;
- The interface imposes less cognitive load on the operator.

CSLI has built multimodal dialogue interfaces for a variety of applications involving dynamic, complex environments, including mission-level control of a robotic helicopter [2]. The approach has been to imbue the interface with *conversational intelligence*, which includes knowledge of a device's capabilities, activities, and situation—and the ability to reason and converse about them—to accept complex commands, update the human operator of progress on multiple concurrent tasks and important environmental changes, and to provide appropriate situational grounding to support the user switching attention between different activities [1,2].

When we consider dialogue with teams of multiple UAVs, however, a number of novel issues arise which have not previously been fully addressed. These include:

- The ability to converse about the different stages of teamwork: team formation; joint plan construction; role and task allocation; execution performance and monitoring; recovery from failure. These may have to be addressed in the context of a command-and-control organizational structure;
- Representing capabilities and activities of individual UAVs and relating them to the team-level activities;
- Minimizing information overload: deciding how much of the inter-agent traffic (typically in some Agent Communication Language) should be communicated to the user;
- Managing and reconciling different perspectives of UAVs, and fusing information obtained from multiple viewpoints;
- Supporting natural dialogue interaction with multiple participants: recognizing intended addressee of a command; supporting opportunistic use of shared dialogue context.

In particular, interacting with multiple agents can be significantly more complex than one-on-one interaction if it is not implemented well.

Our approach is to extend the dialogue interface's conversational intelligence to include a model of collaborative activity between autonomous agents, as well as linguistic models of interaction that account for multiple participants.

Our presentation will contain illustrative scenarios and further details on the issues involved in multi-UAV dialogue interaction, and will describe our approach to these problems, including an architecture for human dialogue with UAV teams.

References

[1] Alexander Gruenstein and Lawrence Cavedon, Using an Activity Model to address issues in task-oriented dialogue interaction over extended periods, *AAAI Spring Symposium on Interaction between Humans and Autonomous Systems over Extended Operations*, Stanford CA, 2004.

[2] Oliver Lemon, Alexander Gruenstein and Stanley Peters, Collaborative activities and multi-tasking in dialogue systems, *Traitement Automatique des Langues (TAL),* 43(2), 2002.

[3] Peter Wallis, Ralph Rönnquist, Dennis Jarvis and Andrew Lucas, The automated wingman—Using JACK for unmanned autonomous vehicles, *IEEE Aerospace Conference*, Big Sky MT, 2002.