ARGUS: A Coordination System to Provide First Responders with Live Aerial Imagery of the Scene of a Disaster (Demonstration)

F. M. Delle Fave, A. Rogers and N. R. Jennings
University Of Southampton
{fmdf08r, acr, nrj }@ecs.soton.ac.uk

ABSTRACT

We present ARGUS, a coordination system for unmanned aerial vehicles (UAVs) deployed to support situational awareness for disaster management settings. ARGUS is based on the max-sum algorithm, a well known decentralised coordination algorithm for multi-agent systems. In this demonstration, we present an interactive simulation environment, where a user acting as a first responder submits imagery collection tasks to a team of UAVs, which then use max-sum to assign themselves to the tasks. We then present a set of real flight tests, in which two Hexacopter UAVs again use ARGUS to coordinate over tasks. Our tests indicate that the system responds positively to the dynamism and the heterogeneity of the real world.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*multiagent systems, coherence and coordination*

General Terms

Algorithms, Experimentation

Keywords

Simulation, Coordination, Unmanned Aerial Vehicles

1. INTRODUCTION

Current research in artificial intelligence is dedicating great effort in developing technologies for disaster management (see, for instance, the ALADDIN project[1]). In such settings, first responders need to quickly assess the severity of a disaster in order to prioritise intervention. To this end, the deployment of autonomous vehicles, such as unmanned aerial or ground vehicles (UAVs and UGVs) is highly recommended, since these can provide information inaccessible to humans, either because they are able to fly or because they can reach dangerous areas. Such vehicles then should be capable of gathering such information in an efficient and timely fashion, without relying on valuable and scarce human resources to control them [2]. Thus, having them coordinate their decision making autonomously is a key factor to achieve an effective situational awareness. To this end, a variety of coordination algorithms has been studied in the literature, among which decentralised ones are typically preferred due to their scalability and their robustness to component failure [3]. In particular, the max-sum algorithm has been shown to perform well in a variety of simulated problems while requiring very little communication and computation [5].

However, despite its demonstrated potential, thus far, max-sum has not been deployed in real application domains. It has only been tested in simulation, which lacks the dynamism and the heterogeneity of the real world. Hence, to ascertain its effective performance, this paper introduces ARGUS a coordination system where the max-sum algorithm is deployed to coordinate a team of UAVs to provide live aerial imagery to the first responders operating in the area of a disaster.

The remainder of this paper is organised as follows. Section 2 describes the problem; Section 3 introduces ARGUS and Section 4 concludes.

[1] *http://www.aladdinproject.org/*

Appears in: *Proceedings of the 11th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2012)*, Conitzer, Winikoff, Padgham, and van der Hoek (eds.), June, 4–8, 2012, Valencia, Spain.

2. PROBLEM DESCRIPTION

At the scene of a disaster, first responders require up to date imagery to assess the situation. ARGUS provides such imagery by using a team of UAVs deployed over the area, each equipped with a miniature video camera that can stream live video over a short range wireless link. The first responders interact with the UAVs using a personal digital assistant (PDA), to request imagery collecting tasks. Each task T_i represents a location (in geographic coordinates) for which imagery is required. To submit a task, each first responder sets three properties: (i) a priority $p_i = \{normal, high, \ very \ high\}$, representing the importance of the task (i.e. collecting imagery of an occupied building is more important than doing so for an empty one); (ii) an urgency $u_i = \{normal, \ high, \ very \ high\}$ used to prevent tasks with low priority from remaining unattended (i.e. collecting imagery from an evacuated building is less important than doing so for a burning building but needs to be done) and (iii) a duration d_i, which defines the interval of time for which imagery needs to be collected. Note that a first responder does not know this duration with precision since it depends on the specific reason for which imagery is required (e.g. to search for a casualty or to check access to an area). Thus, three estimates are considered ($d_i = \{5 \, min, \ 10 \, min, \ 20 \, min\}$). In order to complete a task a UAV is required

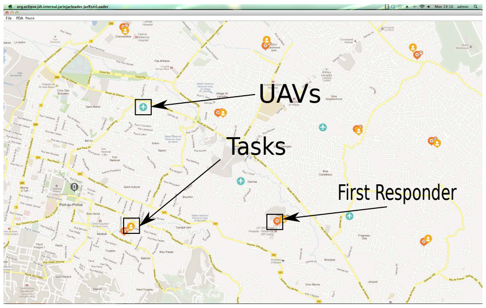
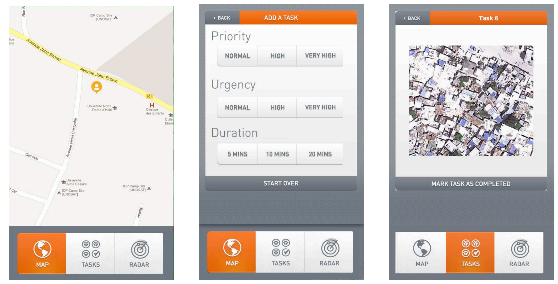


Figure 1: The area of a disaster where the first responders (FPs in the figure) and the UAVs operate, as generated by the software simulator.



(a) The Map Interface

(b) The task input interface

(c) The imagery collection interface

Figure 2: The simulation software representing the PDA's interface

to fly to the specified location, station itself above it and stream live video to the PDA until the first responder indicates that the task is complete. The aim of the UAVs is then to *jointly* decide which task each vehicle should complete.

3. THE ARGUS SYSTEM

A video describing the system is provided at *http://vimeo.com/user9939345/videos*. In what follows, we describe the two ways in which we evaluate our system.

3.1 The Simulation Environment

Each user acts as a first responder and is given a PDA running a touch screen system to submit tasks to the the UAVs operating in the area of a disaster (Figure 1). The system is composed of three interfaces that allow the user to (i) submit tasks by selecting any location within his local area (Figure 2(a)), (ii) to specify the properties of the imagery collection task (Figure 2(b)) and (iii) to view the live streaming videos of the tasks that are being attended by a UAV (Figure 2(c)). These tasks can appear at anytime. Thus, the UAVs need to constantly revise their decisions over which ones to attend, and thus, they need to continuously coordinate. This happens in a decentralised fashion by using the max-sum algorithm[2]. The main aim is to maximise the number of completed high importance tasks (i.e. those with a very high importance) given the limited battery capacity of the UAVs which have to periodically leave the scene to recharge. For a more thorough description of the algorithm used in this dynamic optimisation setting see [1].

3.2 The Flight Tests

The ARGUS system was deployed on two Mikrokopter Hexacopter UAVs over three different settings (see [1] for more details) to ascertain its performance in the real world. The flight tests were run at a test facility outside of Sydney, in conjunction with the Australian Centre for Field Robotics (ACFR). A video summarising the flight tests can be found at *http://vimeo.com/user9939345/videos*. In the video (Figure 3), windows A and B show the hexacopters, window C shows the computation over the factor graph over which max-sum is running and window D shows the path of the UAVs.

4. CONCLUSIONS AND FUTURE WORK

In this paper we described ARGUS a coordination system for UAVs deployed to support situational awareness for disaster management settings. ARGUS is based on the max-sum algorithm, which, thus far, has been deployed only on simple simulated environments. The system was evaluated in two ways. First an interactive simulation environment was developed where first responders can submit imagery collection requests to a team of UAVs. Second, a set of real flight tests were performed to evaluate its performance in the real world. These tests indicated that the system responds positively to the dynamism and the heterogeneity of the real world. Thus they show that max-sum is a powerful technique to use to coordinate teams of UAVs for disaster management.

Our future work will be focused on scaling-up the system to consider a large number of UAVs and tasks.

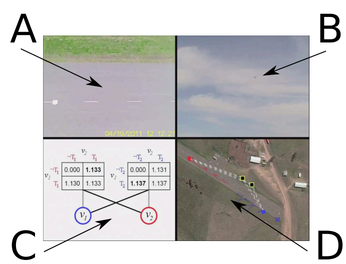


Figure 3: A snapshot of the video summarising the three flight tests.

[2] We adopt here a modified version of the algorithm to reduce the computation and communication in task assignment domains. See [4] for more details.

5. REFERENCES

[1] F. M. Delle Fave, A. Rogers, Z. Xu, S. Sukkarieh, and N. R. Jennings. Dynamic decentralised task assignment for teams of unmanned aerial vehicles. In *Proceedings of the IEEE Int. Conf. on Robotics and Automation (ICRA)*, 2012. (in press).

[2] M. R. Endsley. *Situation Awareness, Analysis and Measurement*. Lawrence Erlbaum Associates, 2000.

[3] J. How, C. Fraser, K. Kulling, L. Bertuccelli, O. Toupet, L. Brunet, A. Bachrach, and N. Roy. Increasing autonomy of uavs. *IEEE Robotics & Automation Magazine*, 16(2):43–51, 2009.

[4] K. Macarthur, R. Stranders, S. D. Ramchurn, and N. R. Jennings. A distributed anytime algorithm for dynamic task allocation in multi-agent systems. In *Proc. of the 25th AAAI Conf. on Artificial Intelligence (AAAI)*, pages 356–362, 2011.

[5] A. Rogers, A. Farinelli, R. Stranders, and N. R. Jennings. Bounded approximate decentralised coordination via the max-sum algorithm. *Artificial Intelligence*, 175(2):730–759, 2011.