# HAC-ER: A Disaster Response System based on Human-Agent Collectives (Demonstration)

https://vimeo.com/118831413


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## Categories and Subject Descriptors

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Innovative Applications; Human and Agents; Disaster Response.


## 1. INTRODUCTION

In the aftermath of major disasters (man-made or natural), such as the Haiti earthquake of 2010 or typhoon Haiyan in 2013, emergency response agencies face a number of key challenges [5]. First, it is vital to gain *situational awareness* of the unfolding event to determine where aid is required and how it can be delivered, given that infrastructure may be damaged. Useful information can come from a variety of sources, including people on the ground, relief agencies, or satellite imagery. However, making sense of this information is a painstaking process, particularly as the information sources are liable to noise, bias, and delays. Second, emergency response agencies typically need to gather additional information by deploying unmanned aerial vehicles (UAVs). Using multiple UAVs avoids risking human life but involves additional complexity in controlling the vehicles and visualising the information they feed back [1]. Tasks should be allocated to maximise the amount of information collected, whilst considering limited battery capacity and ensuring human coordinators are not overwhelmed by the need to manually operate individual UAVs. The third challenge is to use situational awareness to allocate relief tasks to emergency responders, for example, digging people out of rubble, moving water treatment units to populated areas, or extinguishing fires. It is crucial to consider the travelling time required for each task, as this blocks responders from performing other tasks [3]. However, the capabilities of individual responders must be considered to ensure that all tasks can be performed effectively and that no one is put in harm's way. For example, it may not be suitable to allocate medics to densely built-up areas where a fire is spreading, or to attend casualties during riots. Finally, given that the disaster environment is highly uncertain and liable to change significantly, it is crucial that emergency response agencies can track and verify the information and decisions that they use, allowing them to modify or reinforce the current course of action whenever new information is detected or previously trusted information is invalidated, e.g. through direct verification by other organisations.

Against this background, we propose a prototype disaster management system called Human-Agent Collectives for Emergency Response, or HAC-ER (pronounced 'hacker'), that demonstrates how humans and agents can be coalesced into teams called *Human-Agent Collectives* (HACs) [2] to address the above challenges. We designed our system collaboratively with emergency responders from Rescue Global[1] and other defence organisations in the UK, and trialled our system with over 100 users, to determine how HACs can support emergency response in different activities. In more detail, this paper first demonstrates a HAC that integrates crowdsourcing to gather, interpret and fuse information from both trusted agencies and members of the public on the ground, and thereby determine priority areas for responders. We then develop a system for multi-UAV coordination using a HAC, which involves both a distributed coordination algorithm and a number of human operators to prioritise search areas. Rescue targets identified by UAVs are then passed to a HAC composed of a planning agent and responders on the ground, who work together to determine a schedule for the completion of tasks. Finally, we employ a provenance tracking and analysis tool to allow the HACs to react to events and provide accountability for both human and agent-based decision making.

The details of the individual components of HAC-ER are fully described in [4]. In what follows we provide an overview of how the system is setup and then describe how the demo will be carried out. The video at `https://vimeo.com/118831413` gives an idea of how the demo will be setup.

## 2. SYSTEM DESCRIPTION

We designed HAC-ER with the aim to support the work of human emergency responders with a number of agent-based tools. In more detail, we first developed the Crowdscanner, a machine learning system that makes sense of crowdsourced reports from the local


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[1]`http://www.rescueglobal.org`.

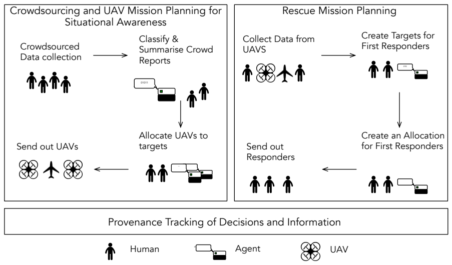


Figure 1: Information gathering and decision making process in the HAC-ER disaster management system.

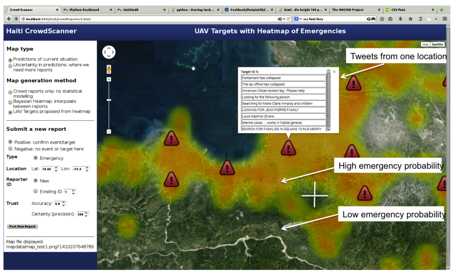


Figure 2: The Crowdscanner view.

population and emergency responders (demonstrated on Ushahidi data) and generate heatmaps for Emergency Commanders to visualise key priority areas (see Figure 2). We then show how information from heatmaps can be used in determining UAV deployment plans that are generated using a decentralised coordination algorithm (see Figure 3). Fig. 1 describes these two steps (top-left box) as part of an OODA loop, where the information gathered from the crowd (Observe) is used to decide on a plan for the UAV deployment (Orientate/Decide), which is then is carried out (Act). During UAV missions, Commanders at headquarters will typically monitor the video feeds coming back from the UAVs, while Operators will supervise individual UAVs, and, at times, tele-operate them to gather more detailed information. As targets on the ground (e.g., casualties, collapsed buildings, fuel sources) are identified through this process, these targets are used by Commanders to allocate tasks to First Responders (FRs). To help make these decisions, we developed interfaces for mixed-initiative task allocation, whereby human commanders interact with planning agents running coordination algorithms that exploit sensor data (see [4]. Through this interaction, planning agents can compute plans that are efficient and *acceptable*, i.e. satisfy human preferences. The different steps of the mission planning process are graphically expressed in Fig. 1 (top-right box). In general, a large amount of information is generated by various actors (humans, software agents, and UAVs) in a disaster response operation. Hence, a major contribution of this paper is the method by which provenance is tracked and used in different parts of the decision making process to provide accountability and ensure dependencies between information and decisions are continuously recorded. This tracking system underlies all the decision making processes in our disaster management system (the bottom box in Fig. 1).

# 3. DEMO SETUP AND REQUIREMENTS

The demo will walk the attendees through the OODA loop described in Figure 1. The demo will require:

- Three wide screens (32 to 48 inches).
- Tablets to demo UAV controller and a Mobile Responder App (will be provided for).

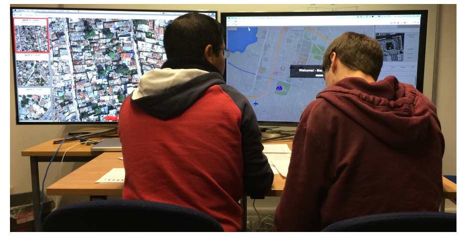

Figure 3: The multi-UAV interface in action.

- Projector screen and a projector to demo the interactions with the interfaces.

The demo will show:

1. how information generated by the Crowdscanner using input from the crowd and emergency responders. This will involve playing a data file that replays the reports collected during the Haiti earthquake and letting the Crowdscanner produce the disaster heatmap as described in Section 2. The Crowdscanner will then display the targets it believes are the most important points of interest. These points of interest will then be generated on the multi-UAV controller interfaces.
2. how the multi-UAV control interfaces will be manned by two operators that will allocate tasks to the UAVs in flexible ways using the max-sum algorithm. In turn, a tablet-based controller will be used to show how control is transferred back and forth between a human operator and the UAV coordination system in flexible ways. The output of the UAV deployment will be a set of verified targets that will be transferred over to the AtomicOrchid system as tasks that need to be completed (e.g., pick up casualty, extinguish fire).
3. how the AtomicOrchid system will be manned by one operator who will construct a plan for (simulated) FRs on the ground to go and carry out tasks. A mobile responder app (running on a smart phone) will be shown to work live with the system to demonstrate how control is passed between human responders and the planning system.
4. How, during a live exercise, provenance is tracked in the system whenever a new event occurs and alters the current plan of the responders based on an analysis of dependencies between information and decisions throughout the operation.

A video of the demo is available at: `https://vimeo.com/118831413`.

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