HAaC-ER: A Disaster Response System Based on Human-Agent Collectives

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UKRI Trustworthy Autonomous Systems Hub

The Four Pillars of Human-Agent Collectives

Flexible Autonomy
- Control shifts dynamically between human and agent(s).
- Hand-over points defined through interaction design rather than pre-scripted.

Agile Teaming
- Teams of humans and agents form dynamically.
- Human or agent may be in charge of different teams.
- Teams change as per the needs of the task at hand.

Incentive Engineering
- Humans and agents need to be incentivised to take action.
- Incentives typically chosen to maximise social welfare.

Human-Agent Collectives for Disaster Response

Emergency responders face numerous challenges in gathering situational awareness and responding to emergencies.

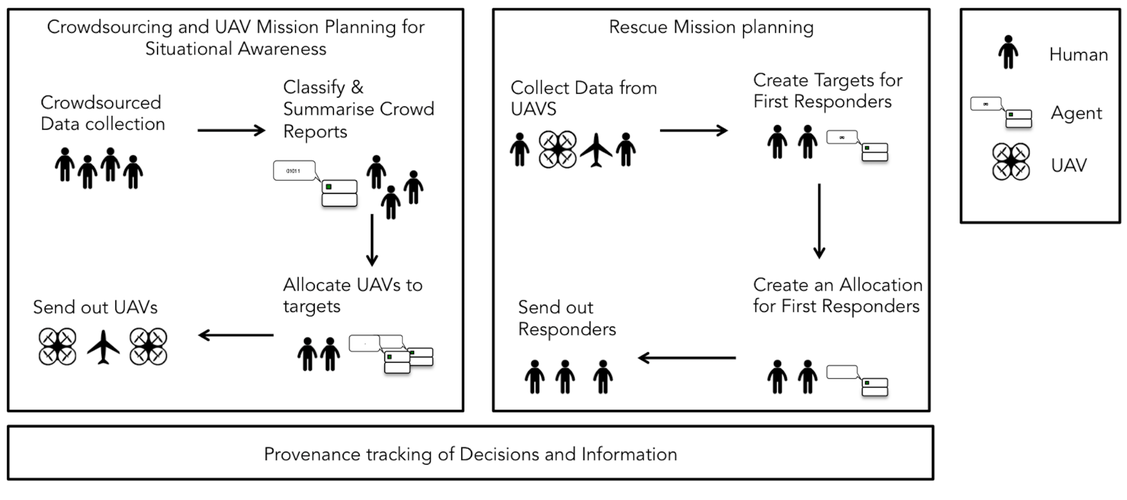
HAC-ER solves the following problems:
- Providing situational awareness from potentially inaccurate crowdsourced reports
- Coordinating multiple UAVs to identify casualties

CrowdScanner

Crowd Report Interpretation
- Online (imperfect) Crowds + Machine Learning (BCC+ NLP)
- Hire+Fire algorithm to recruit the best workers and get the best interpretation

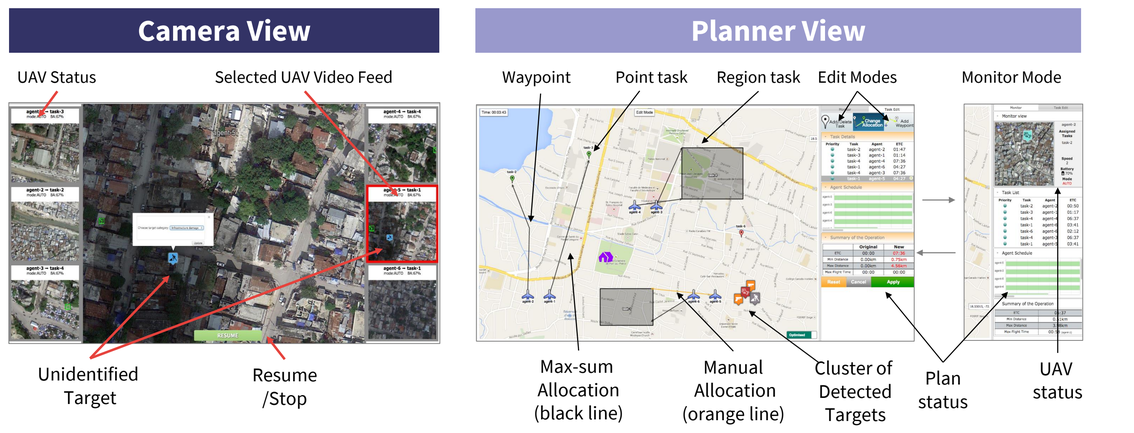
Heatmap creation
- Gaussian Process to model disaster
- Use classification output to generate intensity
- Heatmap of targets can then be used by UAV/Human Teams to prioritise areas

The OODA Loop in HAC-ER



Two loops interleaving human and machine decision making:
- **Crowdscanner**: human-machine collaboration for report classification and heatmap generation.
- **Multi-UAV controller:** flexible autonomy for human-machine task allocation to multiple UAVs
- **AtomicOrchid:** human-agent task planning for live deployments

Multi-UAV Controller



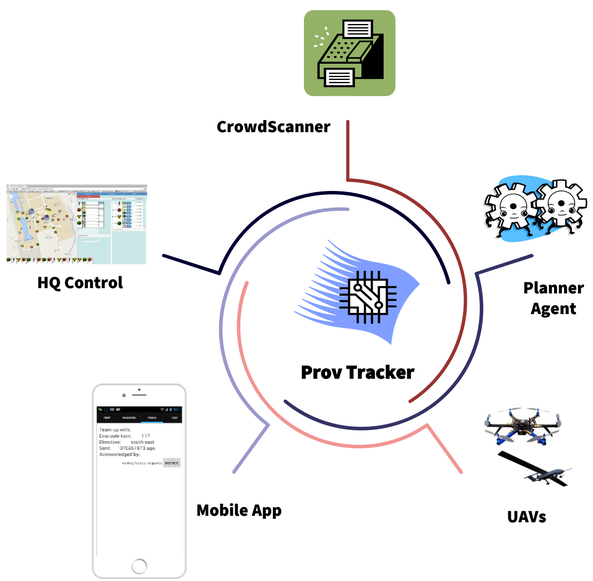
Humans prioritise targets to gather 1st hand information and UAVs run max-sum for target allocation. Flexible autonomy interfaces for human-agent interaction:
- Humans confirm targets through camera view (and teleoperate if needed)
- Correct max-sum plans
- React to UAV drop-outs through mixed-initiative re-planning
- Transfer of control between Silver, UAVs, and Bronze operators
- UAVs Targets confirmed for Responders to be deployed
- Trialled with 40 participants (IJCAI to appear)

Prov-Tracker

Post-hoc analysis
- Learning from what happened
- Identifying best practices, dependencies, etc.

Provenance Analytics
- Machine learning to identify patterns in provenance
- Identifying instruction messages (78% accuracy)

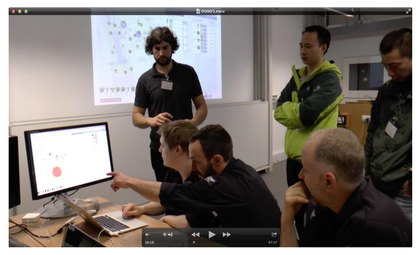
Timely Decision Support
- Live monitoring of provenance for changes
- Ensures the whole system reacts to changes

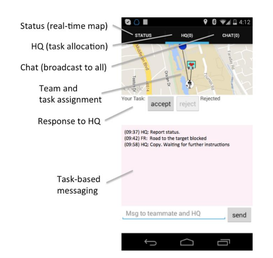


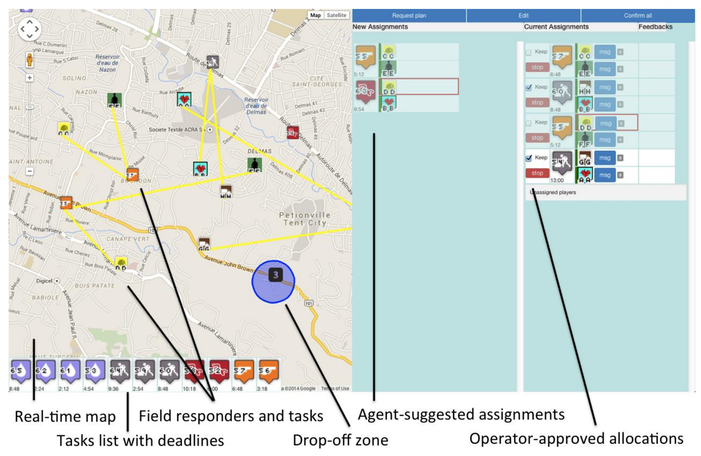
Mixed-Initiative Task Allocation

Human-Agent Silver team allocate tasks to Bronze responder team

Agent uses Multi-agent Markov Decision Process
- Computes best task for each responder, and best path for each task
- Takes into account task deadlines
- Models environment (buildings and lakes are obstacles)







BAE SYSTEMS

ACFR Australian Centre for Field Robotics

SECURE

RG Rescue Global — Crisis and Disaster Response

University of Southampton