Flexible Autonomy for Multi-UAV Coordination

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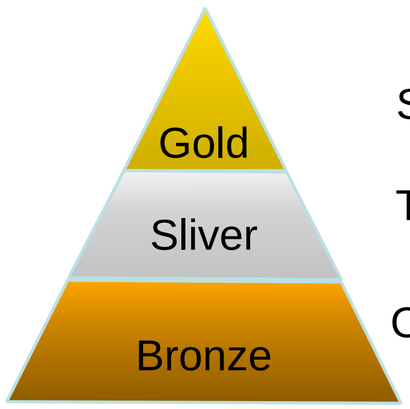
User Interface based on Gold-Sliver-Bronze Command Structure

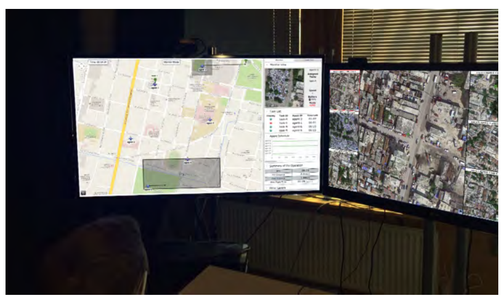


Strategic

Tactical

Operational

- UI design is based on Gold-Sliver-Bronze Command structure, which is used by emergency services of the United Kingdom.
- Tactical commanders assign tasks to UAVs (Monitor View)
- Controller view is used by Operation commander to control the agents (Controller view)



Flexible Autonomy Using the Max-Sum Algorithm

- Decentralised algorithm.
- The allocation is computed by the Max-Sum algorithm.
- Flexible Autonomy is introduced by the interaction of the commanders with the factor graph.

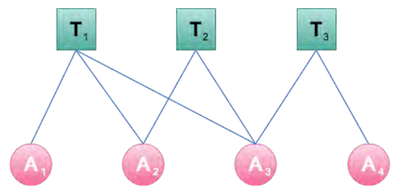
From variable to factor :

$$Q_{n\to m}(x_n) = \sum_{m' \in M(n)\setminus m} R_{m'\to n}(x_n)$$

From factor to variable :

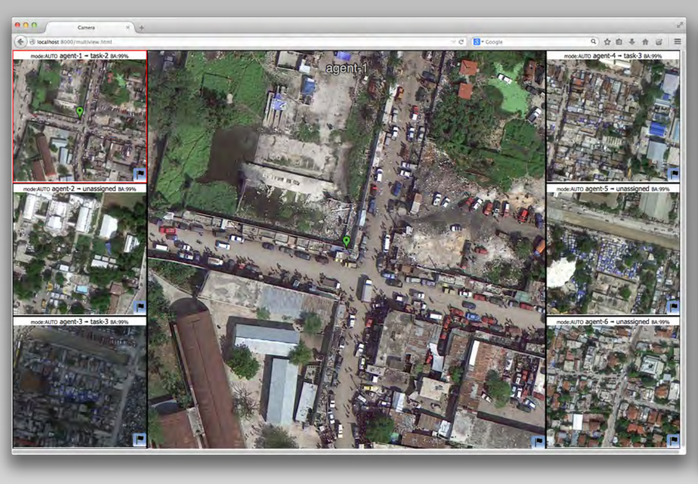
$$R_{m\to n}(x_n) = \max_{\mathbf{x}_m \setminus n} \left(U_m(\mathbf{x}_m) + \sum_{n' \in N(m)\setminus n} Q_{n'\to m}(x_{n'}) \right)$$

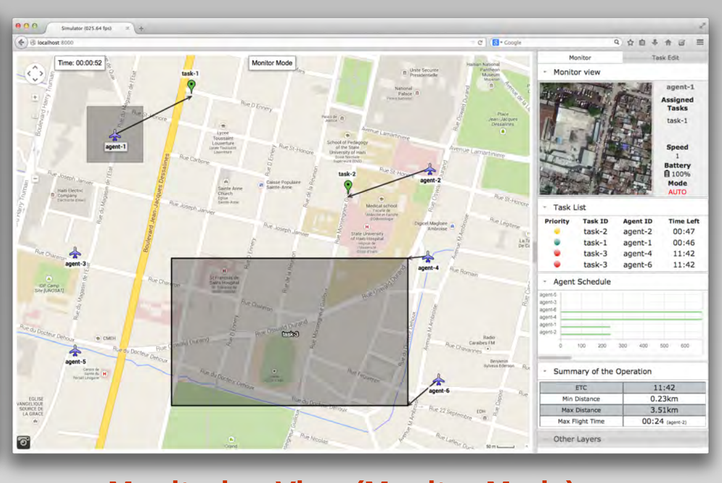
- Messages flow between function and variable nodes of the factor graph.
- Utility function is substituted for tasks and an agent works as a variable.

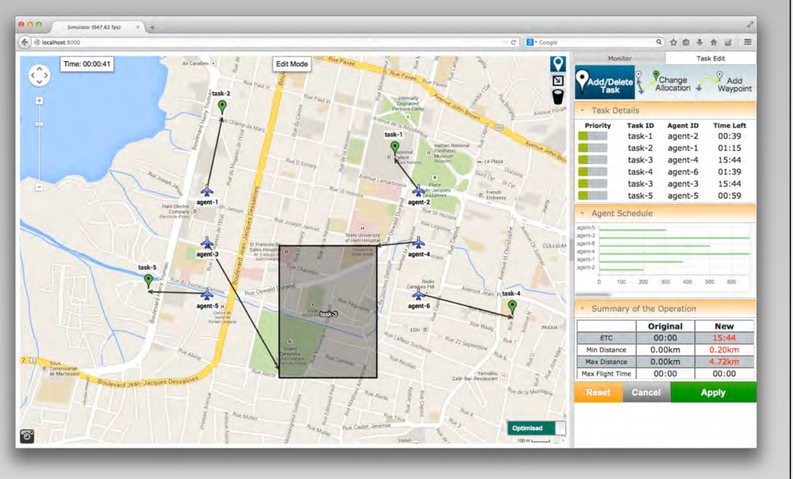


Multi-UAV Controller for Human-UAV Interaction

Monitor View - Silver Command

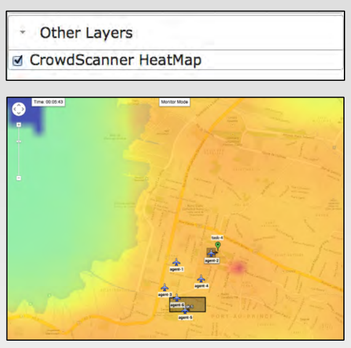






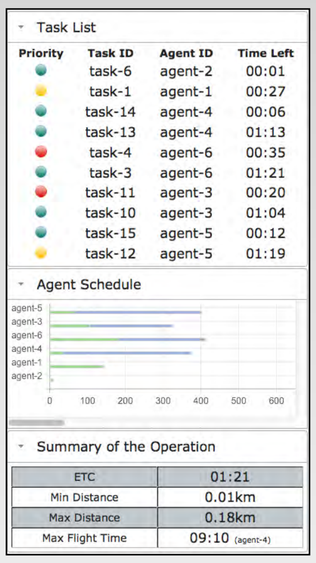
Multi-Screen View

- The screens of all agents can be viewed on the multiple screen mode.
- Targets are shown in the view.
- Sending a notification to the bronze commanders.



- Creating situational awareness map in Crowd Scanner.
- The Monitor view renders the Heat map created by smart Crowd sourcing.

Monitoring View (Monitor Mode)



Task List

Priority	Task ID	Agent ID	Time Left
	task-6	agent-2	00:01
	task-1	agent-1	00:27
	task-14	agent-4	00:06
	task-13	agent-4	01:13
	task-4	agent-6	00:35
	task-3	agent-6	01:21
	task-11	agent-3	00:20
	task-10	agent-3	01:04
	task-15	agent-5	00:12
	task-12	agent-5	01:19

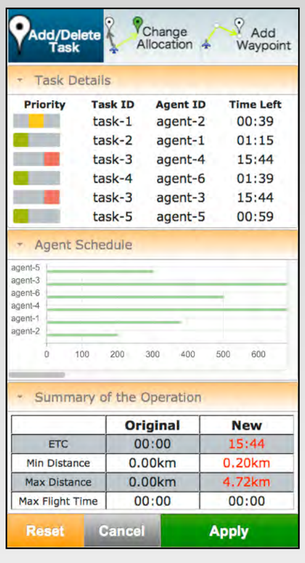
Agent Schedule

Summary of the Operation

ETC	01:21
Min Distance	0.01km
Max Distance	0.18km
Max Flight Time	09:10 (agent-4)

- The Monitor view shows the selected agent of camera view and its status.
- Task list shows the list of allocation and task priorities.
- Agent schedule displays current and one step ahead task plan and completed time.
- Summary of Operation indicates the ending time of the operations, and the maximum/ minimum flight distances of agents.

Monitoring View (Edit Mode)



- Edit mode allows the commanders to create region and single tasks, as well as, to modify allocation manually.
- A priority level can be chosen for the task (from green to red).
- Agent Schedule shows the expected plan for the agents.
- The new expected time and flight distances of the agents are displayed in Summary of the Operation.

Controller View - Bronze Command

- The Operational commanders (First Responders) observe the agent views to find the targets.
- The UI allows them to choose either Teleoperation and Auto control mode.
- An Agent can be controlled by a joystick on the screen.
- The targets are annotated by the operator (Infrastructure damage, medical care, crime unrest and water source).
- Annotated information is posted to Atomic Orchid.
- The Status tab shows other first responders and agents status.