



Automation-Assisted Capture-the-Flag: Reachability-based Decision Aids for Human Agents

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Introduction

"I'm telling you all this for one reason – when you push anything to its limits, it tends to break... the airport gets overwhelmed when the slightest thing goes wrong... The phrase 'mad scramble' comes to mind. 'Mad scramble' and 'safety' don't really go together."

Don Brown, former air traffic controller and Safety Rep for the National Air Traffic Controllers Association, writing in The Atlantic, March 3rd, 2011

Automation has been too often relied upon as a substitution for human control. This leads to problems when the automated systems require human assistance such as when a fault occurs with the automated software, the automated system is given incorrect information, or other such circumstances. Humans that are distracted or less alert due to automation reliance have an increased probability of committing errors in emergency conditions when human control is required.

The goal is to determine the proper balance between automated systems and human control. To do this, we will construct a game scenario that has active human involvement augmented by a system for automated assistance.

Background

Capture-the-flag(CTF) **embodies the basic research challenges** in working with human agents, and provides a method for evaluating algorithms. An automation-assisted game of CTF is a great test-bed for designing **human/cyber-physical systems**.



Capture-the-flag contains these dynamics:

- Human players
- Adversarial
- Limited information
- Multiple agents
- Competing objectives
- Tested
- Fun

Methods

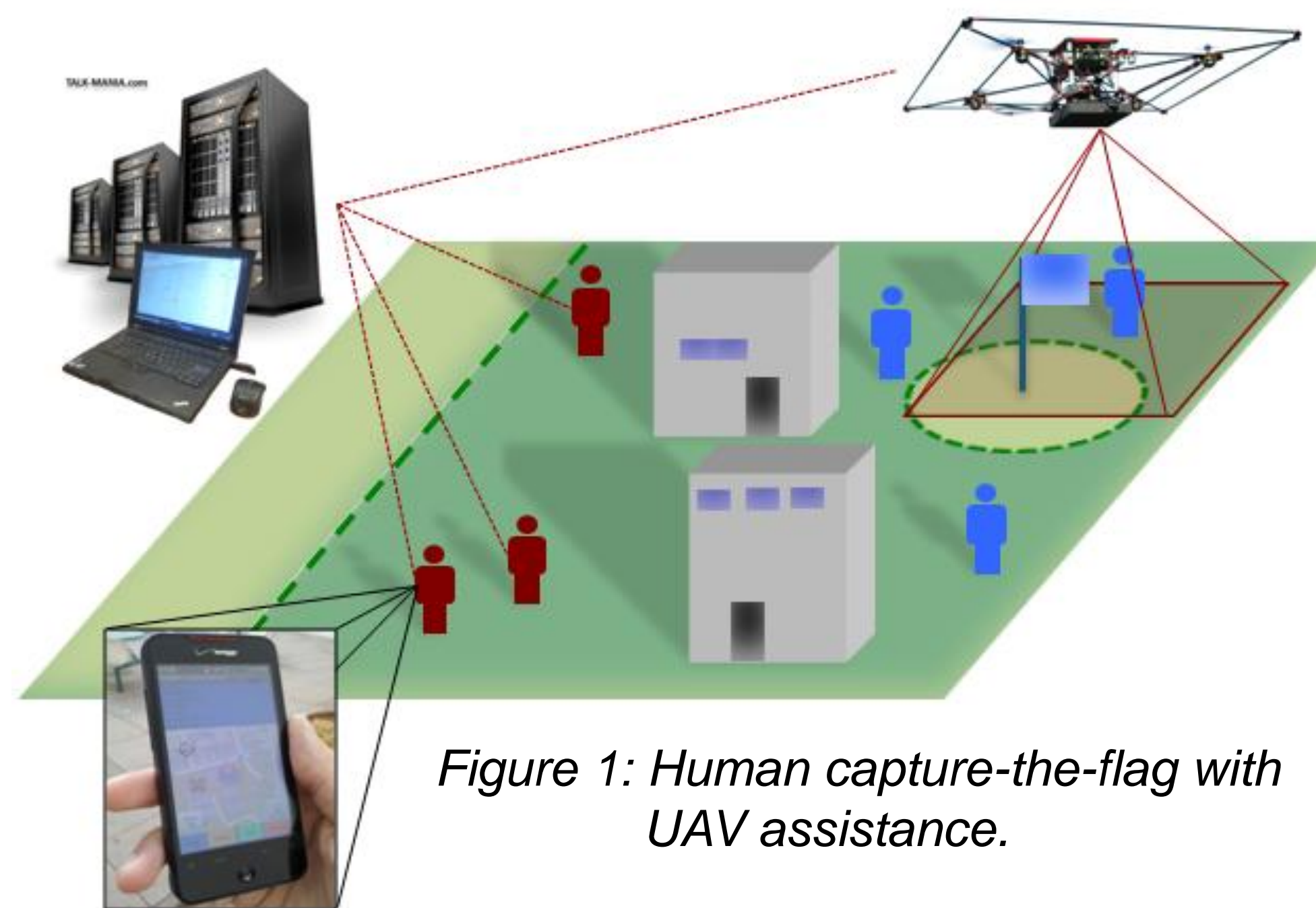
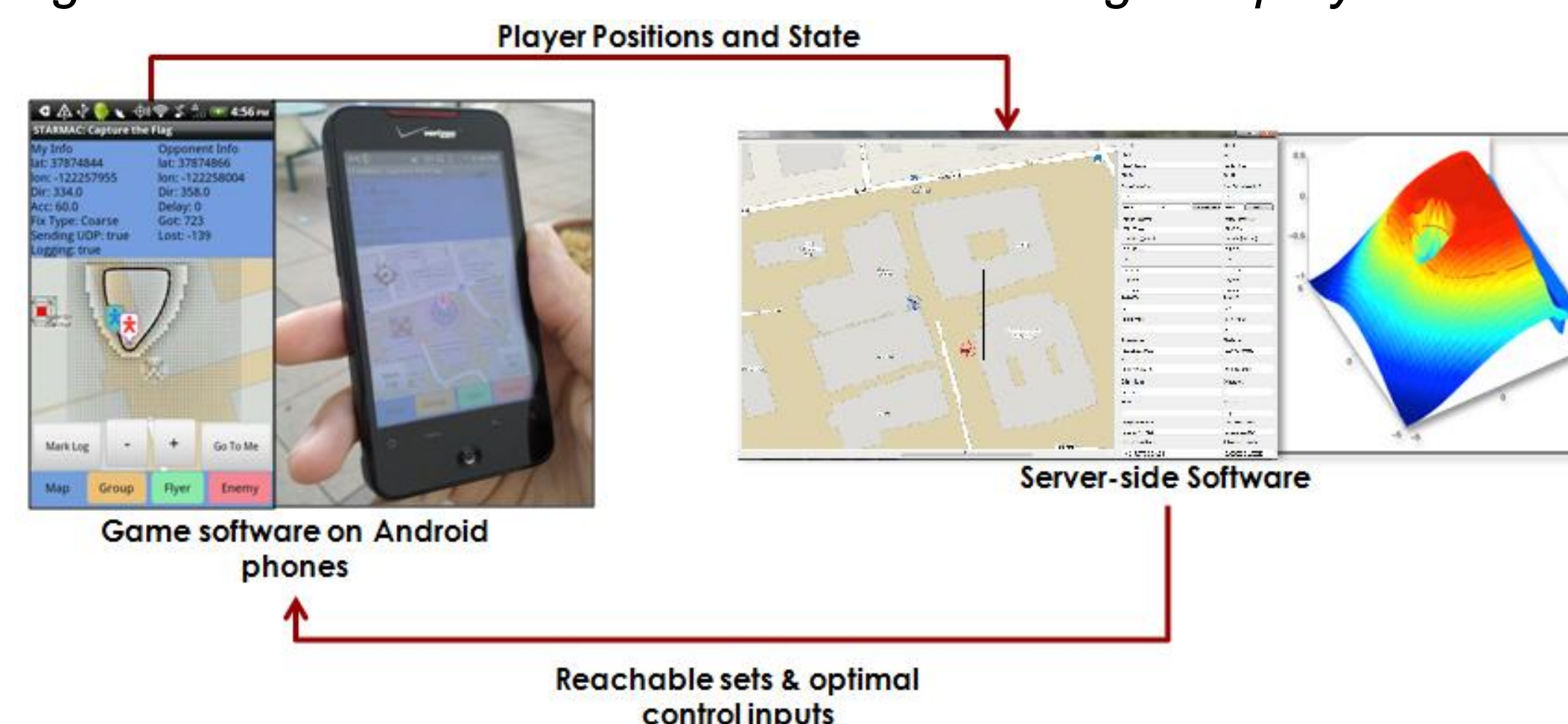


Figure 1: Human capture-the-flag with UAV assistance.

The CTF game is defined as a reachability problem. If the opponent is outside the reachability set of the player, then the player can avoid capture by following the directions provided by the automated system. If the opponent is within the reachability set of the player, then the opponent can potentially capture the player to protect his or her flag. This is when the player must decide to either follow the automated instructions or override them with his or her own strategy.

To implement the CTF game, each player transmits their position via smart phone to a central game server. The server maintains precomputed reachability sets of all possible game states and replies back with directions for optimal play. The players can gather recon information via UAV "spy planes". This keeps the player actively involved in deciding actions and developing strategies.

Figure 2: Phone and server communicate to guide players' actions.



Results

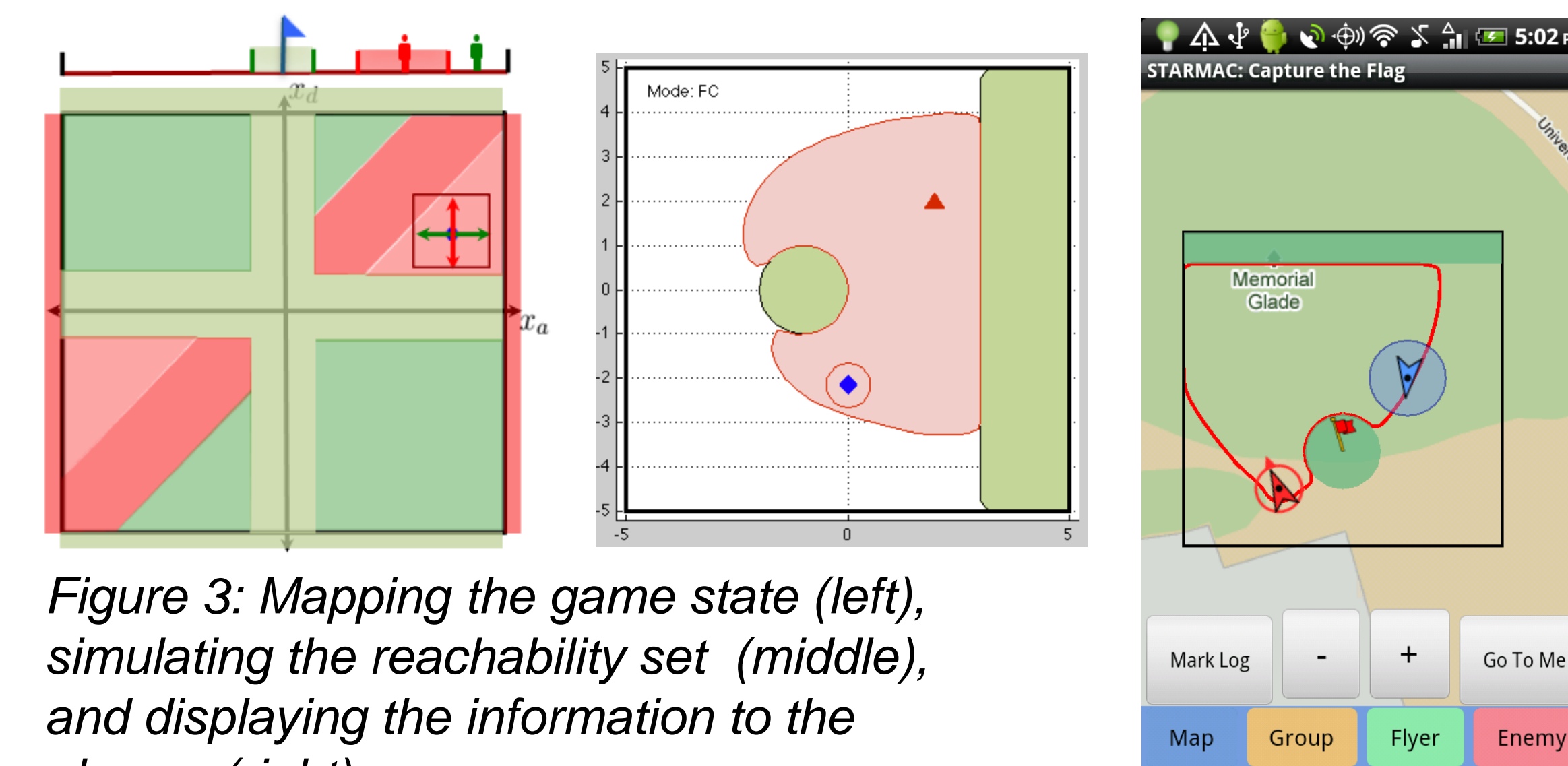


Figure 3: Mapping the game state (left), simulating the reachability set (middle), and displaying the information to the players (right).

We have successfully created the phone and server portions of the game. In our initial field testing, players used the data provided by the automated system to *influence* their respective strategies, *not replace it*. When presented with data that suggested a losing state, players would "ad-lib" a strategy to trick the opponent out of the reachability set, occasionally resulting in a winning state. This is what we hope will happen as testing continues.

Future Work

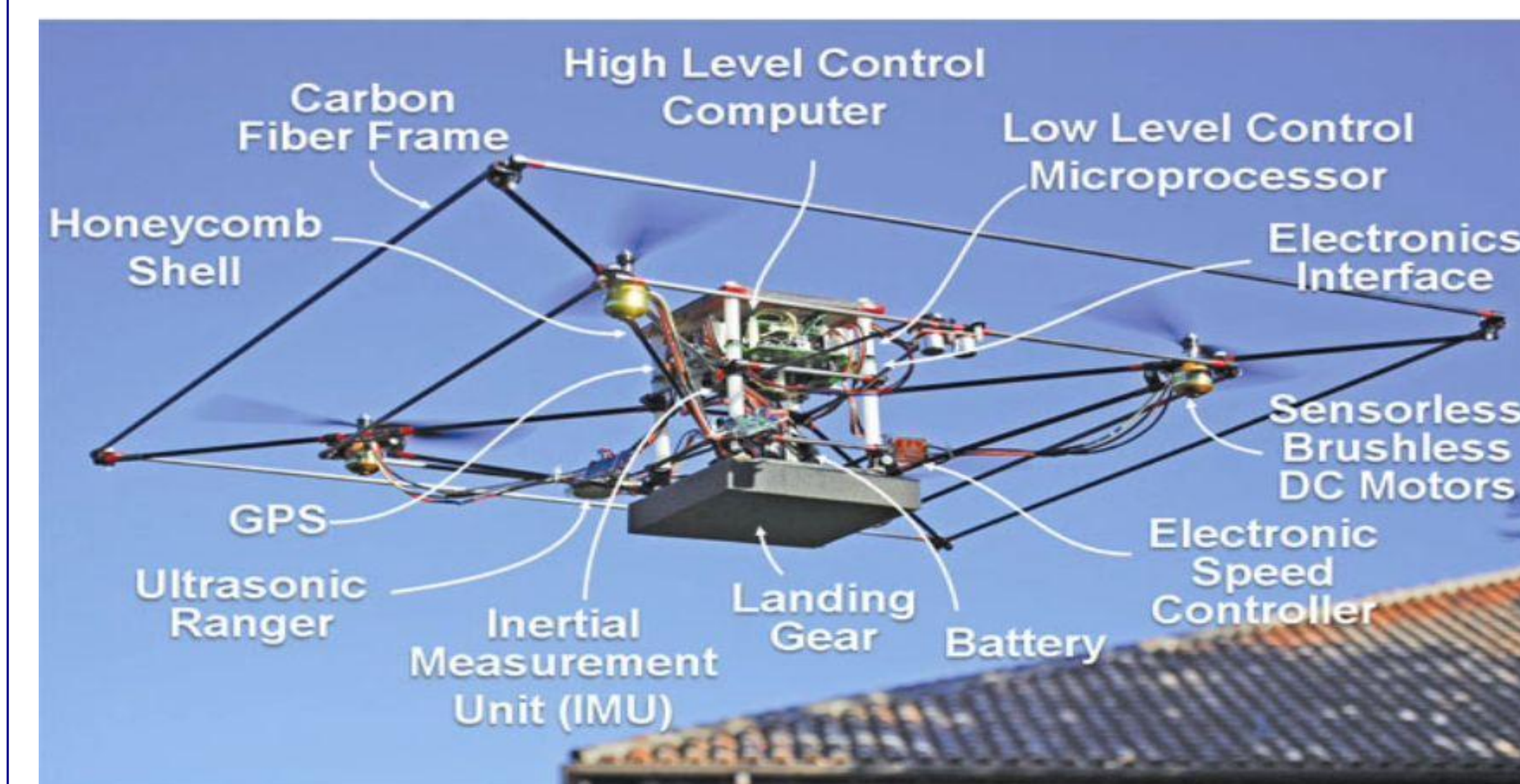


Figure 4: STARMAC UAVs will be used for reconnaissance.

- Integrating STARMAC UAVs into the system to acquire information about the game state and relay it back to the human players.
- Control with partial information.
- Multiple players.