"You are Green": a Touch-to-Name Interaction in an Integrated Multi-Modal Multi-Robot HRI System

Shokoofeh Pourmehr, Valiallah (Mani) Monajjemi, Seyed Abbas Sadat, Fei Zhan, Jens Wawerla, Greg Mori and Richard Vaughan
School of Computing Science, Simon Fraser University, Burnaby, BC, Canada
{spourmeh, mmonajje, sas21, fzhan, jwawerla, mori, vaughan}@sfu.ca
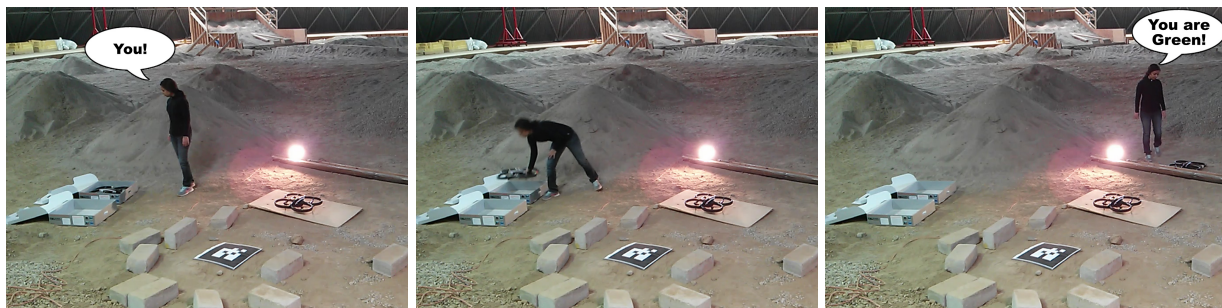
Figure 1: The touch-to-name interaction: The user first announces the desired number of robots with "You" or "You N" where N is the desired number of robots (left), then handles the intended robot(s) (middle); and finally assigns a name to the selected robot(s) that can subsequently be used to address this robot or team.

ABSTRACT

We present a multi-modal multi-robot interaction whereby a user can identify an individual or a group of robots using haptic stimuli, and name them using a voice command (e.g. *"You two are green"*). Subsequent commands can be addressed to the same robot(s) by name (e.g. *"Green! Take off!"*). We demonstrate this as part of a real-world integrated system in which a user commands teams of autonomous robots in a coordinated exploration task.

Categories and Subject Descriptors

H.5.2 [**User Interfaces and Presentation**]: Robotics, Human Multi-Robot Interfaces, Interaction styles

1. THE TOUCH-TO-NAME INTERACTION

We have developed a new multi-modal interface for human multi-robot systems (HMRS) whereby a user can name individual or teams of autonomous robots from a cooperating population. In the *Touch-to-Name* interaction the user verbally announces the desired number of robots N in the form "You N", (e.g. *"You two"*). If $N = 1$ the number can option-

ally be omitted, as in Fig. 1 (left). The user then physically handles the desired set of robots one after the other (Fig. 1 (middle)). Once the robots are thus selected, the user names the individual or group with a second verbal announcement, of the form "You are <NAME>" (e.g. *"You are Green"* as in Fig. 1 (right)). Further verbal commands can be addressed to this individual or group using the name.

1.1   Implementation

In our demonstration system each robot is equipped with a 3-axis accelerometer, a voice recognition system and a wireless communication channel to compare sensor information with its peers. For simplicity we used a centralized voice recognition system and a bluetooth microphone worn by the user during our experiments. But our method will also work with audio processing onboard the robots.

To determine which robot is selected by the user, all robots wait for the keyword *"You"*. When it is detected, the robots communicate over the wireless channel to compare their accelerometer readings with each other. The one with the highest acceleration magnitude in a recent time window is considered the one being touched by the user. Fig. 2 shows the acceleration magnitude of two robots, robot 1 is the one gently moved by the user and robot 2 is untouched. This election mechanism avoids the use of a predefined acceleration threshold by assuming that the robot that is being touched by the user has the highest recent acceleration readings.

The robots indicate their current state to the user with

bright colored LEDs. We found that compared to vision-based selection methods ([4, 2, 3]), using accelerometer data is much faster and computationally less expensive. It requires the human operator to touch the robot platform, but this interaction is simple and straightforward to implement.

Using voice input gives the user the ability to control teams of robots hands-free. Draper et al. [1] showed that using voice commands can significantly improve an operator's ability to control teams of UAVs, compared to manual controls. While our demonstration shows the human handling each robot to provide the haptic input, the same effect can be achieved by pushing or kicking the robot, nudging a joystick that drives the robot, or moving an actuator that has sensor feedback.
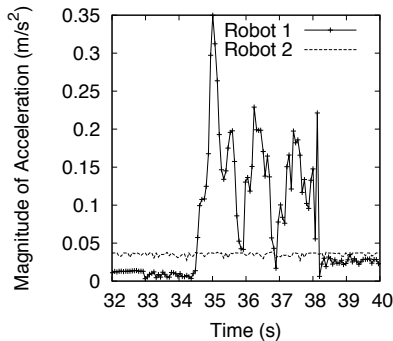

Figure 2: Accelerometer readings of two robots during the selection procedure. Robot 1 is selected and Robot 2 is untouched.

After the user has selected the desired robot or robots, she can assign a team name using a different voice command (i.e. "*You are Green*" to create a team, or "*Join Green*" or *Leave Green*" to modify a team. The user can thus create a direct addressing scheme to previously anonymous robots, and can command a team of arbitrary size with a single subsequent command. The team manipulation interactions can happen at any time.

This multi-modal HMRS interface allows the user to walk freely among the robots. These interfaces are well suited for systems that require human's supervision for dynamic task allocation, team composition and team re-composition.

2. INTEGRATED MARTIAN HRI

We demonstrated a working system in the Mars Dome facility at the University of Toronto, a 50m diameter circular, covered arena simulating Martian terrain (Fig. 1). The task of each robot is to autonomously explore and map the world using visual SLAM from its onboard video camera. The robots used were two AR.Drone 2 UAVs, each controlled over WiFi by a laptop. Robots were autonomous at all times. All the user interactions could have been performed wearing a spacesuit, and the user had no instrumentation apart from an earpiece microphone.

In addition to our Touch-to-Name interaction, we added the verbal commands "Take off", "come back", and "land", which

can be issued to any named robot or team, e.g "Green! Take off.". Robots would verbally confirm their state over a loudspeaker using voice synthesizer. After take-off and while hovering, each robot looks for a human face in its camera feed. When a face is detected, the robot flies to face the user at a preset distance and angle. The user can move her body to position the robot as desired. When the robot is suitably positioned, the user tasks it to explore either to the left or right of the user by waving the left or right hand [3]. The system can be seen working in the video `http://youtu.be/SxeVZdJFB4s`.
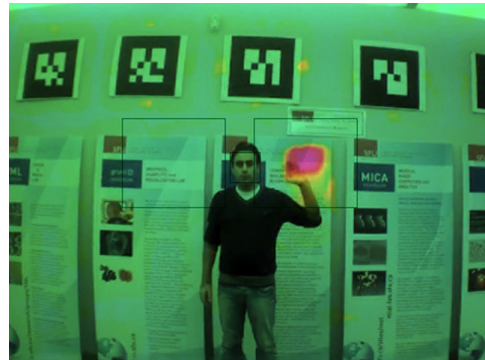

Figure 3: Face detection and motion-based hand gestures are used to relocate and command the flying robot. [3]

Informally, we found that (i) all spoken commands were correctly recognized; (ii) the intended robot was always correctly identified; (ii) feedback from LEDs and synthetic voice was helpful to the user. Overall, we found the proposed concept worked well for this scenario, and we expect it to be widely applicable.

We have demonstrated that Touch-to-Name works as part of an integrated system to allow a single user to control a multi-robot system in a coordinated exploration mission in a semi-realistic setting.

3. REFERENCES
[1] M. Draper, G. Calhoun, H. Ruff, D. Williamson, and T. Barry. Manual versus speech input for unmanned aerial vehicle control station operations. In *Proc. of the Human Factors and Ergonomics Society Annual Meeting*, 2003.

[2] M. Lichtenstern, M. Frassl, B. Perun, and M. Angermann. A prototyping environment for interaction between a human and a robotic multi-agent system. In *Proc. Int. Conf. on Human-Robot Interaction*, pages 185–186, 2012.

[3] V. M. Monajjemi, J. Wawerla, R. T. Vaughan, and G. Mori. HRI in the sky: Creating and commanding teams of UAVs with a vision-mediated gestural interface. In *Proc. Int. Conf. on Intelligent Robots and Systems*, 2013.

[4] S. Pourmehr, V. M. Monajjemi, R. T. Vaughan, and G. Mori. You two! take off! creating, modifying and commanding groups of robots using face engagement and indirect speech in voice commands. In *Proc. Int. Conf. on Intelligent Robots and Systems*, 2013.