Wizard of Oz Experiments for HRI

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Scenario

You have recently been selected as a new member of the Advanced Robotic Reconnaissance Team. Your job is to operate an intelligent, autonomous robot named Jr, during this mock training scenario.
NeutronRAE-II
- radiation (gamma, neutron)
- ambient temperature

Color Camera 1

Infrared Thermal Camera 1,2
- auto-colorization showing hottest area in image

MultiRAE Pro
- carbon dioxide
- electrochemical (e.g. carbon monoxide, oxygen, ammonia)
- combustible gases (e.g. methane, jet fuel, diesel fuel)
- volatile organic compounds (e.g. paints, cleaning supplies, pesticides)

Heartbeat Detector 2
- 2GHz radar to penetrate 35” barrier
- report heartbeat of single person

Intercom
- press and hold to speak and listen
- wait 3s before speaking

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1 30s transmission delay between robot and operator interface
2 Person detection using body heat signature from infrared thermal camera and heartbeat detector
Communicating with the Robot

• 2 types of orders: direct, standing
• R: “Roger. I have updated my mission to ____.”
• R: “Ready for orders.”
• P: “That is all.”
• 3 conditions
  – Condition 1: no example orders
  – Condition 2: simple orders
  – Condition 3: complex orders
Test Scenario

• Participant’s role is as a “Robot Specialist”
• Terrorists take over nuclear research facility
• Reactor state is unknown, may be compromised
• Building may be rigged with bombs (or not)
• There may still be terrorists inside (or not)
• One of the employees is unaccounted for
AddiGonal

• Receive orders from radio operator
• Carry out orders by tasking robot
• If terrorist compromises robot, run is over
• No live video, no real time map
• Paper map of places the robot knows about
• Engineer has yellow hard hat
• Terrorist has orange jumpsuit
Tasks Given to the Participant

• Continuously monitor sensors
• Search the entire building
• Find the missing employee
• Identify potential bombs (ammonia hotspots)
• Navigate to a precise location
• Deal with a failing sensor
Robot: Is that all?
Me: Yes.
Robot: Roger, I am heading to the South Wing.
Robot: I am sending you a picture.
Robot: I have arrived.
Robot: Ready for orders.
Robot: search engineering.
Me: That is all.
Robot: Roger, I have updated my mission to search engineering.
Robot: I am heading to the Engineering Room.
Me: Monitor gamma radiation.
Robot: Roger. I have updated my mission to monitor gamma radiation.
Me: Once in engineering take a picture.
Robot: I have arrived in the Engineering Room by the hallway.
Me: Take a picture.
Robot: I am sending you a picture.
Robot: I am starting to search the Engineering Room.
Me: Take a picture of the left side of engineering.
Robot: Sorry, I don't know what a left side of engineering is.
Me: Turn left and take a picture.
Me: That is all.
Robot: Roger. I have updated my mission to turn left and take a picture.
Robot: I am sending you a picture.
Me: Turn 180 degrees then take a picture.
Me: Turn 180 degrees then take a picture.
Me: That is all.
Robot: Roger. I have updated my mission to turn 180 degrees then take a picture.
Robot: I am sending you a picture.
Me: Finished searching engineering.
Me: Monitor heartbeat sensors.
Me: That is all.
Robot: Roger. I have updated my mission to monitor heartbeat sensors.
Robot: Enabling the heartbeat detection sensor.
Me: What is my battery level.
Robot: Continuing to search Engineering.
Robot: I detect a heartbeat.
Me: Take a picture.
Robot: Battery Level 26V.
Me: I am sending you a picture.
Results To Date

• 3 pilot participants to date
  – < 30 years old
  – Male
  – Computer Science and Robotics students
  – 2 grad, 1 ugrad
  – One in each condition
Initial Orders:

- Search the entire building for terrorist
- Monitor gamma radiation and report unsafe levels
- Missing employee is an engineer
  - Locate engineer
  - Visually confirm position
  - Determine if they are conscious
  - Attempt to establish communication
Initial Orders: Direct Orders (DO)

P1: if at any time unsafe gamma levels are found, stop and report your position
Robot: I have updated my mission to stop and report my position if at any time unsafe gamma levels are found.

P1: **Move to engineering.** If you encounter a person stop and send an image of that person.
Robot: Roger. I have updated my mission to move to engineering.

P1: **That is all**
Robot: I have updated my mission to stop and send an image if I encounter a person.

P2: monitor battery levels
Robot: Roger. I have updated my mission to monitor battery levels.

P2: **move to the south wing then turn left.**
Robot: Roger. I have updated my mission to take a picture when I arrive.

P2: search engineering.
P2: **that is all.**
Robot: Roger. I have updated my mission to search engineering.

P3: tell me when the radiation gets too high
Robot: Roger. I have updated my mission to report when the radiation level is high.

P3: If you get within 10 feet of a heart beat stop moving and alert me
Robot: Roger. I have updated my mission to report when I get within 10 feet of a heart beat and stop moving.

P3: send me a picture and then move the engineering room door.
Robot: Sorry, I don't understand move the engineering room door.

P3: **search engineering room.**
Robot: Roger. I have updated my mission to search the Engineering Room.
P3: **thats all.**

P3: tell me when the radiation gets too high
Robot: Roger. I have updated my mission to report when the radiation level is high.

P3: If you get within 10 feet of a heart beat stop moving and alert me
Robot: Roger. I have updated my mission to report when I get within 10 feet of a heart beat and stop moving.

P3: send me a picture and then move the engineering room door.
Robot: Sorry, I don't understand move the engineering room door.

P3: **search engineering room.**
Robot: Roger. I have updated my mission to search the Engineering Room.
P3: **thats all.**

P2: monitor gamma radiation
Robot: Roger. I have updated my mission to monitor gamma radiation.

Robot: Enabling the Radiation Sensor.

P2: once in engineering take a picture
Initial Orders: Standing Orders (SO)

P1: if at any time unsafe gamma levels are found, stop and report your position
Robot: I have updated my mission to stop and report my position if at any time unsafe gamma levels are found.
P1: Move to engineering. If you encounter a person stop and send an image of that person.
Robot: Roger. I have updated my mission to move to engineering.
P1: That is all
Robot: I have updated my mission to stop and send an image if I encounter a person.

P2: monitor battery levels
Robot: Roger. I have updated my mission to monitor battery levels.
P2: move to the south wing then turn left.
P2: upon completion take a picture
Robot: Roger. I have updated my mission to take a picture when I arrive.
P2: search engineering.
P2: that is all.
Robot: Roger. I have updated my mission to search engineering.
P2: monitor gamma radiation
Robot: Enabling the Radiation Sensor.
P2: once in engineering take a picture

P3: tell me when the radiation gets too high
Robot: Roger. I have updated my mission to report when the radiation level is high.
P3: If you get within 10 feet of a heart beat stop moving and alert me
Robot: Roger. I have updated my mission to report when I get within 10 feet of a heart beat and stop moving.
P3: send me a picture and then move the engineering room door.
Robot: Sorry, I don't understand move the engineering room door.
P3: search engineering room.
Robot: Roger. I have updated my mission to search the Engineering Room.
P3: thats all.
Detect the Engineer

P1 and P3 initially gave standing orders:
• P1: If you encounter a person stop and send an image of that person.
• P3: If you get within 10 feet of a heart beat stop moving and alert me

P1: are there any contacts in the vicinity using the heartbeat sensor?
Robot: I don't understand what contacts are.
P1: Can you detect any people in the surrounding area using the heartbeat sensor?
Robot: Yes. I detect a heartbeat in the Engineering Room.
P1: return an image in the direction of that heartbeat
Robot: Roger. I am sending you a picture.

Robot: I detect a heartbeat.
P3: aim at the heart beat then send me a picture.
... 
Robot: Roger. I have updated my mission to face the heart beat and take a picture.
Robot: I am sending you a picture.
Detect the Engineer

Manual Search

P2: take a picture.
Robot: I am sending you a picture.
Robot: I am starting to search the Engineering Room.
P2: take a picture of the left side of engineering.
Robot: Sorry, I don't know what a left side of engineering is.
P2: turn left and take a picture.
P1: that is all.
Robot: Roger. I have updated my mission to turn left and take a picture.
Robot: I am sending you a picture....
P2: turn 180 degrees then take a picture.
P2: that is all.
Robot: Roger. I have updated my mission to turn 180 degrees then take a picture.
Robot: I am sending you a picture.

Standing Order

P2: finish searching engineering.
P2: monitor heartbeat sensors.
P2: that is all.
Robot: Roger. I have updated my mission to monitor heartbeat sensors.
Robot: Enabling the Heartbeat detection Sensor.
...
Robot: Continuing to search Engineering.
Robot: I detect a heartbeat.
P2: take a picture.
...
Robot: I am sending you a picture.
Detect Ammonia

• Engineer is hurt and cannot move, needs help
• Engineer reveals that she overheard terrorist speaking of bombs and smelling fertilizer
• Radio operator tells specialist the terrorists used fertilizer based IEDs
  – Find all locations with high levels of ammonia
  – Collect visual information about locations
Detect Ammonia

P2: **monitor the multirae pro.**
P2: take a picture.
Robot: Sorry, I don't know how to motior.
P2: **monitor organic compounds.**
Robot: Roger. I have updated my mission to monitor organic compounds.
P2: **monitor for fertilizer.**
P2: what is your location?
Robot: Sorry, I don't know what a fertilizer is.
P2: My current location is South Wing by Engineering.
P2: take a picture.
Robot: I am sending you a picture.

P3: **report to me when you find high concentrations of ammonia.**
…
Robot: Roger. I have updated my mission to high ammonia levels.
P3: **report current ammonia levels and then attempt to go to the cafeteria.**
Robot: The ammonia level in the South Wing by Research is 0.784ppm.
P3: I have updated my mission to go to the Cafeteria.
…
Robot: Roger. I am heading to the Engineering Room.
Robot: I detect high levels of ammonia in the South Wing by Research.
Robot: Roger. I have updated my mission to take a picture of location with high ammonia levels.
P3: **take a picture of any location with high ammonia concentrations.**
Robot: I am sending you a picture.
Encounter Locked Door

- Doors to cafeteria are closed
- Robot cannot open the doors
- Specialist must ask radio operator what to do
- Engineer has a badge that will open the doors
  - Go back to Engineering Room and then return
Encounter Locked Door

Robot: Unable to navigate to the Cafeteria
P1: take an image
Robot: Roger. I am sending you a picture.
P1: Move to the south entrance and send the ammonia levels
P1: cancel that
P1: send an infrared image
Robot: Roger. I am sending you a thermal picture
....
P1: send heartbeat sensor readings
Robot: I do not detect a heartbeat.
P1: Move to the south entrance and send the ammonia levels

Robot: Search incomplete. Unable to navigate to the Cafeteria.
....
P2: what is your location?
Robot: My current location is South Wing by Cafeteria.
P2: return to engineering.

Robot: Search incomplete. Unable to navigate to the Cafeteria.
Robot: I have searched 3 rooms.
Robot: I am sending you a picture.
Robot: Ready for orders.
P3: what is your location?
Robot: My current location is South Wing by Cafeteria.
P3: return to engineering.
P3: that is all.
Robot: I have updated my mission to go to engineering.
Robot: I am heading to the Engineering Room.
Get Engineer’s Badge

**Scene 4**

**P1:** Move to engineering and move close to the person there.
Robot: I have updated my mission to move to engineering and move close the person.
P1 that is all.
Robot: Roger. I am heading to the Engineering Room.
Robot: I have arrived in the Engineering. I detect a person in the Engineering Room.

**P2:** return to engineering.
Robot: I have arrived.
P2: enter engineering.
Robot: My current location is Engineering by Hallway.
P2: take a picture.
Robot: I am sending you a picture.
Robot: Ready for orders.
P2: drive forward 1 meter then turn left.
Robot: Roger.
P2: that is all.
Robot: I have arrived.
P2: turn slightly right.
Robot: Roger.

**P3:** search for a heartbeat in the engineering room.
Robot: Ready for orders.
Robot: Roger. I have updated my mission to search for a heartbeat in Engineering Room.
Robot: Is that all?
P3: yes.
Robot: I am starting to search the Engineering by Hallway.

Robot: I detect a heartbeat.
Robot: I have updated my mission to go to the heart beat.
P3: head to the heartbeat.
Insights

• People seem overwhelmed by scenario
  – Lots to remember
  – Described as being “intense”
  – ROTC participants may be better with taking orders

• People had trouble remembering “That’s all”
  – Only required text interaction
  – People seemed to expect the robot to just start without explicit initiation command
Insights

• When should the robot stop?
  – Should you explicitly tell the robot when to stop?
  – Should the robot interpret implicit stop commands?

• Robot responses impact the way people talk
  – If responses seem dumb, the robot is dumb
  – Level of detail has direct impact on user’s awareness of what is happening
Evaluation Plans

• Wizard of Oz study first to discover how people will want to communicate with the robot in this scenario
  – Will produce an additional corpus
  – Allows us to measure number of statements that can be handled by the language system
  – Provides baseline to determine if people interact differently with the SUBTLE system instead of the Wizard

• Human subjects testing with full end to end system in the spring
Full System Testing

• Same scenario

• Sample metrics
  – Percentage of utterances understood
  – Percentage of utterances that could be carried out
  – Abstraction level of commands given (e.g., low level “drive forward one meter” or high level “go to the elevator lobby”)