Why did the Robot do That? and What will the Robot do Next?

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Understanding Autonomous Systems is Challenging

Understanding robot behavior is important:

> Robots are increasingly being utilized in important tasks such as search and rescue operations.

Understanding robot behavior is difficult:

> Their behaviors are often hard to understand, leading to users' mistrust and often abandonment of very useful tools.

People form beliefs about robot behavior through observation, but robots do not execute actions with the intent of conveying state preferences.

http://archive.defense.gov/DODCMSShare/NewsStoryPhoto/2013-12/hrs_tartan%20rescue.jpg

Communication is Vital to Understanding

We are developing algorithms for robots and autonomous systems to automatically explain their behaviors to users and are demonstrating that these explanations improve users' trust and acceptance.

We are exploring ways to have robots provide cues to help users understand and predict their actions.

How can we team the robots and their operators build trust and exploit autonomous behaviors?

Various Approaches

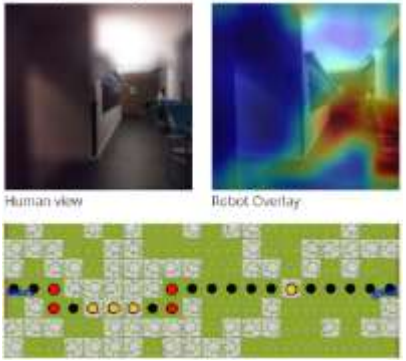
Take multiple approaches to address trust in robotics.

- Proactive modification of robot behavior to engender trust
- Verbal explanations of behavior
- Non-verbal explanations of behavior
- Human robot teaming for mission specific tasks

Analyzing human gaze to assess robot trust

Human Robot Teaming for Unmanned Surface Vehicles

Robot providing non-verbal Explanations



Robot Providing Verbal Explanations

Explanation 1: *"I started from room 3201, I went through the 3200 corridor, then I took the elevator and went to the seventh floor, then I took the 7th floor bridge, then I passed the kitchen, then I went through the 7400 corridor, then I reached room 7416."*

Explanation 2: *"I traveled 26 meters and took 152 seconds on the 7th floor."*

Modifying Robot Behavior Based on User Attention

How can we increase neglect tolerance – the length of time that users are willing to look away from their robots before they proactively monitor them again?

Neglect tolerance is widely used as a measure of trust in robots.

We seek to measure and use operator gaze to adapt robot actions.

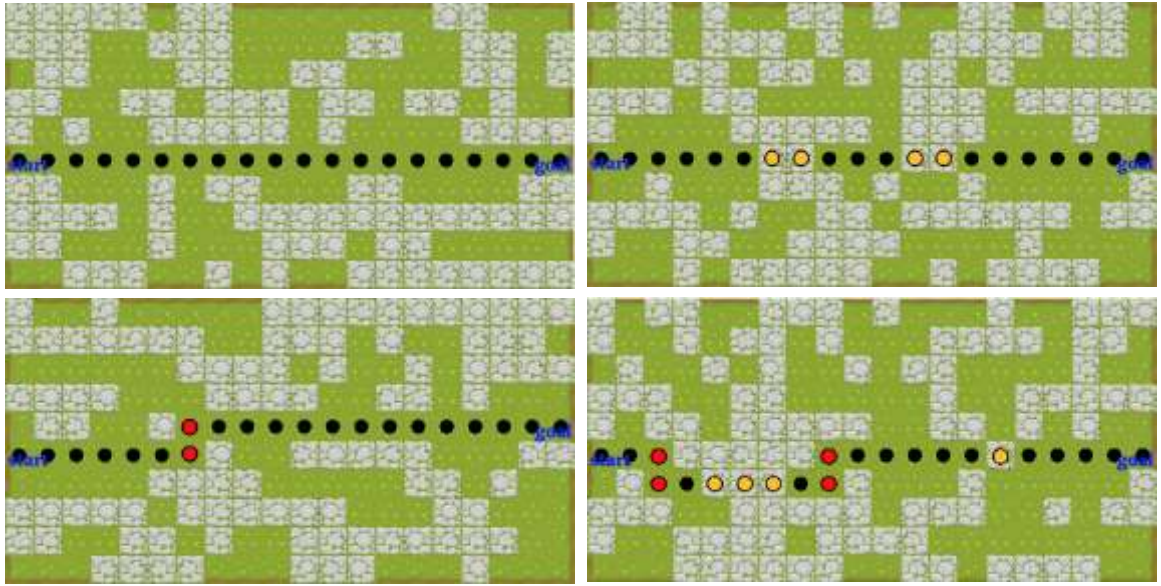
How might a robot behave (or “misbehave”) to confirm operator expectations of robotic motion?

Generating Trajectories to Convey System Intent

"Evaluating Critical Points in Trajectories" paper published and presented at 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN 2017)

How can the robot *generate* paths that indicate preference?

Can users infer preference based on these non-verbal explanations?



Conclusion/Recommendations Moving Forward

Working to understand robotic and autonomous systems is important.

We developed methods for robots to convey their intent in a manner that we can understand.

We are investigating how we can provide information to the robot to convey a sense of human intention to inform robot behavior.

We studied how presenting this information in conjunction with controlling a system can affect trust and performance.

Continue to work to explain autonomous systems to engender trust that systems will execute as we expect when we expect.

Future Directions

Working in parallel with existing Robot Operating System – Military (ROS-M) work to demonstrate these concepts on progressively more mature robotic systems.

Leverage these techniques to directly support mission challenges and in operational environments.

Explore more opportunities and approaches to explain additional autonomous systems e.g., machine learning based systems, artificial intelligence algorithms, etc.

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