The DARPA Robotics Challenge

Seth Teller (and many collaborators)

Electrical Engineering and Computer Science Department
Computer Science and Artificial Intelligence Laboratory
MIT

(RSS Lecture 20, May 13th, 2013)

Machines Teaming With People

- Live, rich representation of surroundings
- Natural interaction with users
- Specific task domains

Task domain: ordnance disposal

- ONR BAA 11-019 asks research community to
  "develop and demonstrate emerging technologies for dismounted missions to detect/locate, access, diagnose/identify, and render safe/neutralize explosive hazards, including IEDs and UXO."



- Object of interest may explode at any moment
- Approximately 5,700 EOD technicians in the DoD
  - Between 2001 and 2012: 114 KIA, 546 WIA

Motivation

Deepwater Horizon

ISS EVA

Fukushima Nuclear Plant

State of the Art: Teleoperation

- EOD (Explosive Ordance Disposal) training mission, filmed in April 2012 at NSWC-NAVEODTECHDIV

Teleoperation isn't the solution

- Degree of freedom (DOF) considerations:
  - High-DOF devices required by task domains … but only low-DOF devices are operable
- Communications considerations
  - Teleoperation requires highly available, high-bandwidth, low-latency connection … but this is unachievable in real settings
- Interface considerations
  - Dexterous manipulation requires coordinated whole-body motion, haptic (force) feedback… … but these are not easily available
- Cannot project human intent remotely

DARPA Robotics Challenge

- (Inaccessible) human environments
  - Must operate in human-built environments
  - Must use human-designed vehicles, tools
- Network constraints
  - Low bandwidth
  - Intermittent availability
  - High latency (e.g. in orbit)
- Goal: *capability*, not autonomy
  - Our focus: *punctuated* autonomy
- Two tracks: A and B

Boston Dynamics
Atlas Humanoid

Teleoperation Division of Labor

HUMAN + OCU

Perception

Scene interpretation
Object segmentation
Object identification
Inference of DOFs

Planning

High-level planning
Action selection
Workspace planning

Control

Inverse kinematics
Closed-loop control

Live video

ROBOT

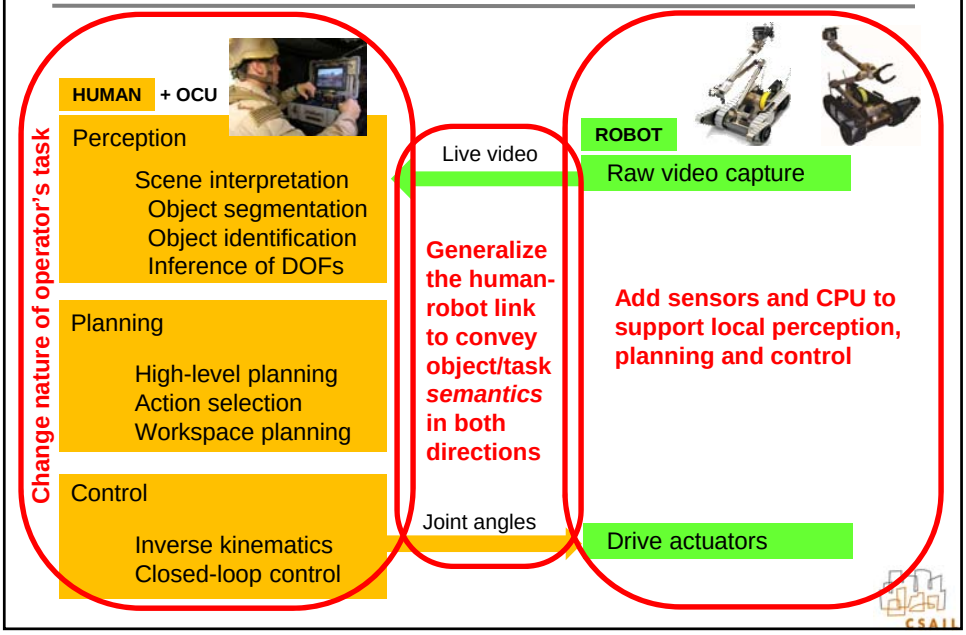
Raw video capture

Note: this forces operator to do something s/he is not very good at: real-time IK!

Motor speeds,
joint angles

Drive actuators

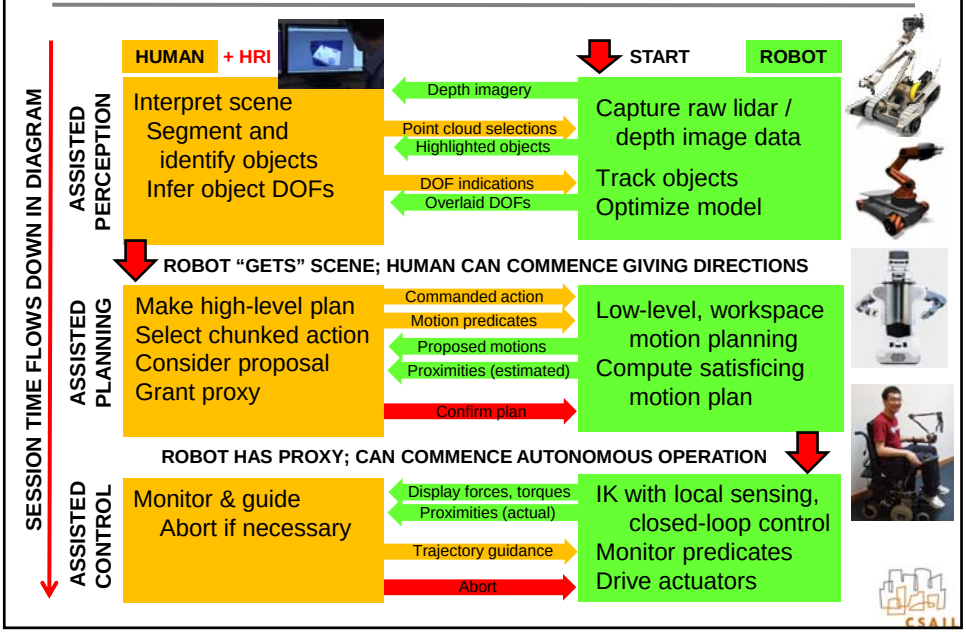
Changes to System Architecture



Our Approach

- Human operator "chunks" mission into actions
  - Operator generates chunks matching robot's abilities
  - Uses HRI to define objects/tasks, convey them to robot
- Operator helps robot interpret situation, plan actions
  - Robot displays its world model and intentions to operator
  - Operator can confirm, modify, or discard the plan
  - Robot executes action while respecting local constraints
- In principle, this approach has the potential to:
  - Increase efficiency while reducing operator fatigue
  - Reduce task error rate, mission failure rate
  - Reduce system size, weight, power, complexity

Teleautonomy Division of Labor



Recent DRC Videos

- Getting up, walking, manipulating
- Next steps:
  - Qualifiers (by May 15th)
  - Virtual challenge (by June 28th)
  - Atlas humanoid platform to MIT (July 15th)
  - First physical challenge (December 2013)
  - Second physical challenge (December 2014)

Key Technical Capabilities

- Human-robot interface
  - Maintain situational awareness; convey intent
- Assisted perception
  - Lock onto rigid, articulated objects
- Assisted planning
  - Retain gist of plan while adjusting locally
- Assisted control
  - React to disturbances, pause (safely) when needed to replan and/or request help

Conclusion

- Novel approach to achieving remote dexterous mobile manipulation
- Factor task across human, robot
  - Human: form high-level plan, help robot
  - Robot: maintain persistent form of hints, carry out low-level actions autonomously
- Actively fielding approach in three settings
  - Autonomous forklift
  - EOD mitigation
  - DARPA Robotics Challenge