The Challenges of Human-Autonomy Teaming

Dr. Alonso Vera
Chief, Human Systems Integration Division

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Overview

Three Themes

- Ongoing need for human engagement with autonomy
- Not designing autonomous systems to interact with humans increases costs
- At a system level, autonomy coupled with human intelligence will remain superior to either on its own
Machine Intelligence

We appear to be at an exciting time with respect intelligent machines (again).

• Four Related Areas of Development
  1. Big Data - volume, velocity and variety
  2. Deep Learning
  3. Networked operations and cyber-physical systems
  4. Moore’s Law (exponential growth, doubling of components on an integrated circuit every two years): faster, bigger computers driving change with increasing velocity

• Stephen Hawking, Bill Gates and Elon Musk have all recently warned about the potential dangers of AI.

• Also interesting time in terms of self-driving cars and companies with robotic operations/factories like Amazon, Tesla and Toyota

• Big Blue, Watson, Pokerbot

• Google DeepMind AI Division beats human at GO (Jan 2016)

• First AI investment software hits Wall St. (Feb 2016)
Progress in Artificial Intelligence

Weak AI
Pattern analysis, image recognition (e.g., NLP, SDCs, Go, Watson)

Strong AI
Adaptive problem solving, reasoning, generalizable
The Littoral Combat Ship

• New, highly autonomous vehicle

In the end, the ship required 60 sailors, all E5 or above

… and they are still encountering major issues
Manpower Reduction: Start with the Human (Not the Technology)

The Autonomy Paradox

(Blackhurst, Gresham & Stone, 2011)

- Autonomy doesn’t get rid of humans, it changes their roles
- DoD has shifted from Levels-of-Automation to Cognitive Echelons

As machine intelligence advances, the need for better human interfaces increases

The Littoral Combat Ship
Built to be operated by 45 sailors

Dr. Larry Shattuck, NPS (pg. 13-15)
Architecture based on autonomy performing all skill and rule-based roles, as well as most knowledge-based roles. Manpower reduced by two orders of magnitude with remaining expert humans teaming with machine intelligence to solve complex problem solving under uncertainty. Machine intelligence for airspace management evolves from the outset to support teaming with small set of expert humans to support cooperative problem-solving.
What are the Challenges of Working with Autonomy?

• Lack of transparency about intent, state awareness, risk/confidence posture, graceful degradation, etc.

• Part of the challenge is just the reverse though. Given that the Autonomy does not know what the human is trying to do, it is difficult for the system to know to engage in ways that are useful.
Toward Human-Autonomy Teaming?

Caged Robots

Domesticated Robots
Designed for Teaming
Path to Collaborative, Human-in-the-Loop Planning Systems

Mars Rovers
- MSLICE
  - Mars Science Laboratory Interface
  - Mars Exploration Rover: Maestro & MAGPen
- SPIFe
  - Phoenix Science Interface
  - Phoenix Lander

ISS
- ISS
  - Power Planning & Analysis Tool
  - Score

LASS
- LASS
  - LADEE Activity Scheduling System
  - Assisted Replanning
  - Analog Mission Self-Scheduling
  - ISS Self-Scheduling

Playbook

Mars 2020

Timeline:
- 2003
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
International Space Station

CAST – Crew Autonomous Scheduling Test:

- Playbook Check-Out by Scott Kelly on Station in August 2015.
- Astronaut Peggy Whitson trained on Playbook in July 2016.

ISS Mission Control

- Three integrated planning systems: Power, Attitude Control and Crew Activity
- Crew activity includes ESA JAXA and Payloads
Affordances from the Environment

idealised flowfield (after Gibson, 1950)
Using Affordances

- Application of Gibsons’ Ecological Psychology
  - Alternatives to using human central attention resource
  - A car more like a horse
Apple Research on Teaming of IISs with Humans

- Characterizing calorie burn during swimming and using learning algorithms to tune the functionality to individual differences
- Developed novel experimental hardware and tested on 700 swimmers
- To develop a feature on one app for the new iWatch

http://www.cultofmac.com/444551/why-apple-is-the-new-nasa/?&tc=em
Airspace is a complex system and complexity will only continue to increase.

Humans are both limiting and enabling parts of the system (pilots have to address unexpected safety issues on 20% of flights*).

DoD → $3B on H/A Teaming in FY17

* From Asiana 214 Docket
The Economics of Human-Centered Automation

• For lower costs, higher efficiencies and overall improved system performance:
  • Characterize nature of human roles (skills, rules, knowledge, expertise) and tasks (e.g., proportion of hard and soft constraints)
  • Wrap autonomy around remaining human roles from the beginning

Critical to shape the autonomy industry
• e.g., Apple v. Littoral Combat Ship

Dr. Jon Bornstein, DoD Autonomy Roadmap Autonomy Community of Interest
Teaming of Human and Machine Intelligence

• Even as computers get very “intelligent”, it is very likely that the nature of the their intelligence will be different than that of humans (unless they become omniscient or we program them to function just like humans)
• Humans are particularly good at adaptive problem-solving and discovery, areas where there has been little machine intelligence progress
• Successful efforts going forward will be those that wrap new machine intelligence capabilities around human competencies in order to get the most out of each

Goal: Design the human into the process. Focus on how the system will communicate it’s state to the human so that the human can help in un-anticipated situations, and vice versa.

What data and how it is presented to each agent such that each can bring its unique capabilities to bear on it.
Final Thoughts

• Humans will remain important components of complex systems
• Use human adaptive expertise as much as possible
• Use human cognitive & perceptual system as much as possible in interactions
• Robotics progressing faster than AI
• Be aware of areas where you don’t have big data
  • Not all problems are associative in nature
• Don’t assume search will solve all problems
Thank you