Fundamental Challenges in Robotics Workshop

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Dorsa Sadigh, Stanford

Kostas Bekris, Rutgers

Hadas Kress-Gazit, Cornell

Jake Abbott, Utah

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What will it take to go through the same transformation that NLP has experienced?

Dorsa Sadigh,
Stanford

… in other words,

what do foundation models mean for robotics?

The Vision of Robot Understanding

Kostas Bekris, Rutgers

Achieving "robot understanding" means that robots should be able to:

Effectively explain their reasoning and why they are making a choice. This is critical for:

- The humans interacting with the robots to trust them;
- More productive development of robot AI by human developers of the technology, and
- Assisting legal resolutions related to attribution of error in the case of accidents.

Identify when they cannot solve a problem instance and explore avenues on how to solve similar instances into the future.

- When robots today fail on a task, they often give up, not even asking for human intervention when needed.
- Robots that understand their tasks and contexts, should know that they cannot solve a challenge and work around the failure, including identifying the type of data or reasoning that will assist in addressing similar conditions in consecutive attempts.

Better adapt to a dynamically changing environment, which includes evolving human desires and needs.

- Most robotic systems today have a very static view of the target domain either given the prespecified models encoded by engineers or given the set of data that an ML model has been trained over.
- Robots can benefit from more open-ended, evolving models of their domain that allows them to identify changes in the underlying conditions and objectives.

Challenges for the next X year

Hadas Kress-Gazit, Cornell

- **Algorithms for verifying robots “in the wild”** – a priori verification (identifying possible failures before deployment) and runtime monitoring (identifying upcoming failures) for realistic full systems interacting with their environment
- **Specifications** – formal languages that capture desired robot behavior and that can be used for computation (verification, synthesis). Especially specifications for human-robot **interaction**
- **Algorithms for “explainable robotics”** – using specifications, formal methods, and HRI to enable robots to communicate their abilities, limitations, and possible failures to non-experts

Big, Open Problems in Manipulation, Medical Robots and Haptics

Jake Abbott, Utah

- How to perform dexterous noncontact manipulation of unknown objects, potentially using multiphysics solutions
- How to manipulate swarms of simple agents, in a probabilistic sense, within the human body
- How to make patient-specific robots that are optimized for specific anatomy, disease presentation, and/or treatment plan
- How to provide rich haptic experiences in which users may interact with a virtual world as they would with the real world, (relatively) unencumbered

Challenge 1: The Unexpected

Challenge 2: Representations And Metrics For Success

Joydeep Biswas, UT Austin

Challenge 3: Competence Awareness

How can a robot:

- ***Detect*** unforeseen errors?
- ***Overcome/Recover from*** such errors?
- ***Avoid*** such errors?
- Account for the ***likelihood of making errors*** when planning?
- Convey a ***well-calibrated competence assessment*** to operators?

Challenge 4: It's a Socio-Technical Problem!

We need robots to reason about both **explicit** and **implicit** communication under a **Theory of Mind**.

Marynel Vázquez, Yale

We need computational abstractions for **social context**.

We need **continual learning** over longer-term and rich, social interactions.

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Physics-Informed AI

- Data-driven AI requires a large amount of data to develop a complex model
  - Experimentally generating large amount of data is not feasible
- Manufacturing processes have a large amount of process knowledge
  - Using physics-informed AI will reduce data requirement by constraining the model
  - Using physics-informed AI will enable reducing the effect of experimental errors

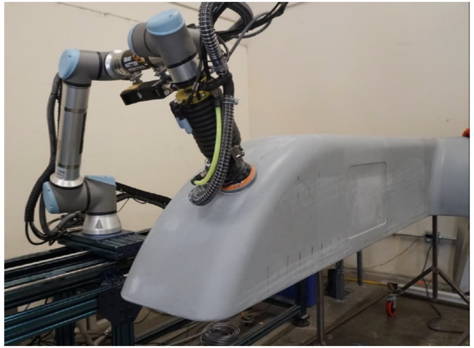

Image Source: Gray Matter Robotics

[Some of] Today's Manufacturing Challenges

SK Gupta, USC

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Human Interfaces

- Robots should effectively communicate with humans
- Models of humans interacting with each other may not be the best model for human robot interaction
  - Robots "thinks" differently from humans
  - Statistical machine learning will lead robots to process information in a different way from humans

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Trustworthy Systems

- Unambiguous Communication
- Ability to Explain Decision Making Rationale
- Consistency
- Predictability

Next Roadmap Update

Date	Activity
June 2023	Call for White Papers
July 2023	Submission Deadline
Sep – Nov 2023	Three workshops (East, Mid, West)
Jan 2024	Synthesis Workshop (~15 people)
Mar 2024	Initial Draft
Jun 2024	Roadmap Published

Please contribute white papers, attend workshops, …. It is YOUR roadmap