Minimality and Trade-offs in Automated Robot Design

1. Type and Duration

Full-day workshop

2. Title

Minimality and Trade-offs in Automated Robot Design

3. Organizers

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4. URL

http://minimality.mit.edu/

5. Abstract

Most fields of engineering are characterized by fundamental trade-offs between maximizing performance and minimizing resource usage; robotics is no exception. In robot design, trade-offs are distributed among subsystems such as sensing, actuation, computation, and power. A mathematical framework to describe these trade-offs does not yet exist.

The speakers and discussions in this workshop will focus on working toward formal representations that make automated reasoning and synthesis possible, and enable design choices beyond once-off, ad hoc solutions. The workshop brings together roboticists with a variety of backgrounds to start to answer the question: "How can computers and software help us navigate the space of design decisions?"

The workshop includes both invited speakers and a call for presenters who: (1) can share practical examples of resource-constrained robots and their performance envelopes; (2) are exploring abstractions and models which have promise as foundations for algorithmic design; (3) have novel and unconventional ideas for how to tame the computational complexities involved.

The intended outcome of the workshop is a better understanding of how informal design decisions, including those exemplified in a custom design card game — played and discussed after lunch — can be refined and systematized so as to become fit for automation.

6. Content

The workshop schedule is designed to be an engaging and lively event. This workshop follows the successful workshop held at RSS 2016[1], which led to extremely interesting discussions[2]. We will further dive into the question of how to automate the robot design process; what can be formalized, what can be synthesized and how to reason systematically about trade-offs.

The workshop will contain five sessions:

1. **Two morning sessions** (up until lunch): There will be short talks of 10-15 minutes, each followed by a 5 minute discussion. Rather than discussions of already published and completed work, priority will be given to interesting thoughts about the future research in this area. We will enforce a presentation format that will ensure lively and engaging presentations. This format will include concise and thought provoking answers to fundamental questions that the organizers will pose.
2. **First afternoon session**: This session is dedicated to playing the Robot Design Game (http://robot-design.org). The game, previously developed on the occasion of the RSS 2016 workshop, is an informal version of the problems we wish to solve. The game will stimulate interaction among participants and set the tone for the subsequent discussion regarding trade-offs and formalisms.
3. **Second afternoon session**: Additional short talks, in the same format as the morning session.
4. **Final session**: A final roundtable to discuss interesting ideas that came up during the day. We intend the outcome of the workshop to be a position paper that will be submitted to a top robotics journal; we will structure the roundtable discussion around the main ideas of the position paper and the elements that need to be included in it.

Invited Speakers:

- Magnus Egerstedt (GaTech) [confirmed]
- Daniela Rus (MIT) [confirmed]
- Steve LaValle (UIUC) [confirmed]
- Antonio Bicchi (UniPI) [confirmed]
- Radhika Nagpal (Harvard) [tentative]

Open call: We will have an open call for presentations. Using a web form, we will ask prospective speakers to share a brief position statement (2-3 paragraphs) about their views on the topics to be discussed in the workshop. We will select the speakers with the most original and diverse points of view, to ensure a lively workshop. We will also bias the selection towards junior researchers.

7. Plan to solicit participation

In addition to the usual methods (robotics-worldwide, direct email invitations, etc.) for soliciting participation in workshops, we will distribute a number of decks of Robot Design Game cards, including special cards advertising the time, place, and content of the workshop, to prospective attendees. This approach was observed to be effective for the RSS 2016 workshop, and could be carried out particularly effectively if the proposed workshop were held after the main ICRA conference.

Estimated number of attendees: The first workshop on this topic that took place at RSS 2016 attracted 40 participants. Due to the relative size of ICRA compared to RSS, we expect an audience of 120 or more.

[1] http://minimality.mit.edu/RSS2016/rss2016.html

[2] A summary of the discussions can be read at the URL: http://minimality.mit.edu/RSS2016/wsnotes.pdf

Similar events organized in the past: This is the list of workshops previously organized by the organizers, along with estimated peak attendance:

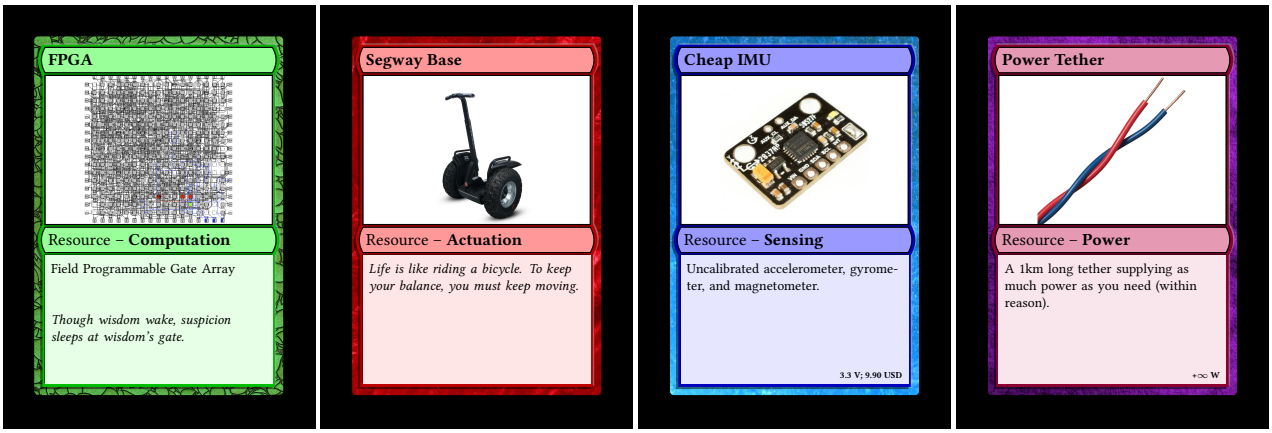
- Censi, Shell, O'Kane
  - RSS 2016 - Minimality and Design Automation (40)
- Censi
  - ICRA 2016 - Task Driven Representations (150)
  - RSS 2015 - The Big Questions in Robotics (90)
  - ICRA 2015 - Advances in Sensorimotor Learning (150)
  - ICRA 2015 - Innovative Sensing for Robotics (100)
- Shell, O'Kane
  - CASE 2016 - Workshop on Multi-Robot Systems in Automation: Topics in Planning and Control (30)
- Shell
  - AAAI 2015 - Research Issues at the Boundary of AI and Robotics (150)
  - RSS 2015 - Negative results in experimental robotics: Learning the right lessons from robots (15)
  - IROS 2014 - The future of multiple-robot research and its multiple identities (50)
  - AAAI Spring Symposium 2011 - Multi-Robot Systems and Physical Data Structures (15)
- Kress-Gazit
  - 5 workshops on Formal Methods for Robotics (ICRA 2009, 2010, CAV 2011, RSS 2013, 2014) Attendance at these workshops grew over the years with approximately 40-50 participants in the later conferences (RSS).

8. Plan to encourage interaction among participants

One session of the workshop is dedicated to playing the Robot Design Game (http://robot-design.org). This is a custom card game created by the organizers in the occasion of a previous workshop (during RSS 2016) and further refined since. This card game is played in small groups (5-6 people). We will make sure that each group contains a balance of senior researchers, early career researchers, and students.

As we have observed during the RSS workshop, the game greatly stimulates interaction among participants. During this workshop, we plan to use the great interactions enabled by the game to further refine the game and define a problem space that can be used to make actual progress on the topic. There will be a group discussion after the game, which will integrate the topics raised in the morning talks with insights from the game, further encouraging interaction.

Some sample cards from the Robot Design Game are below. Participants must design a robot from a randomly selected hand of actuators, sensors, power resources, computation resources, etc. The robot must complete a randomly chosen task in a random environment, such as "disarm an IED on Mars."



9. Dissemination

Presentation material: We will post all presentation materials and notes on a publicly available website (see the notes and slides from the RSS 2016 workshop at http://minimality.mit.edu/RSS2016/rss2016.html).

Position paper: The goal of the workshop is to obtain novel, automated, systematic approaches to robot design and, therefore, a special issue in an established journal is premature. Instead, the organizers will coordinate with the speakers a position paper that synthesize the point of views described in the workshop. Target journals could be: Robotics & Automation Letters; Nature Robotics; and Robotics & Automation Magazine.

10. Equipment

The workshop requires **tables** to play the card game. The organizers will provide a suitable number of custom-printed decks of the game.