Today

- Reading Discussion
- Embodiment
- Robot Bodies in ROS
- Homework 4 is out

Robot Training Sessions

- Look for announcement on Trunk with link to document
- If you cannot make any of the listed times, send me an email ASAP so we can find an alternative time

Immediate openings @ my lab

- Undergraduate Research Assistants
- Spring 2018, Summer 2018, Fall 2018
- If interested, send me an email with a resume and your availability in terms of terms and hours per week
- Credit options: Directed Study 194

Announcements

Reading Discussion
On explicit rules and planning

“This research seems particularly applicable to relatively routine environments with fixed patterns and rules governing them. While an extensive set of rules might cover many possible cases and scenarios, such a scenario may have too complicated a codebase to be easily deciphered by humans. [...] explicit rules may not provide the flexibility necessary for dynamic environments, especially those which do not fall into easy "true/false" distinctions.” - Selena

On Activity Recognition

“... the article only mentions the robot using camera-captured image processing to evaluate a human's action, but I would like to know if it uses any other sensors to collect data on humans. For example, if the robot hears a human talking, would it be possible for it to analyze whether or not the person is talking to the robot or to someone else. The robot could use its speech recognition in combination with image processing to see if the person is directing speech at the robot. Additionally, I was curious about how a robot responds to the different human activities it detects around it. [...] Would the responses be hard coded, or would the robot learn them as secondary requests and goals, similarly to verbal commands?” - Serena

On Object Exploration

“The question I have is that I want to know if this feature produces specific learning tasks for robots to learn or does the exploration happen when no particular tasks are assigned to the robot. Also, I am doing similar research in robot’s action exploration area.” - Yirong
On Verification

“To begin with, how does the Verification Principle conflict with some of the new methods of machine learning, such as reinforcement learning. Does this still count as verifiable? Another similar situation where this verifiability aspect seemed a bit counterintuitive is what happens if you have not one, but multiple robots trying to collaborate with each other? Can swarms of robots share information while still keeping this information verifiable? Would they only be able to verify this information if the robots are similar enough to share some common limitations?”
- Mateo

Hard-coded vs. learned knowledge

“Although Alpha Go wasn’t technically a robot (not embodied) it found new strategies in go that humans hadn’t thought about, and have since added to the game. A human programmed machine wouldn’t do this, because it would be playing with human assumptions and strategies.”
- Anne

On embodiment

“What constitutes a body? There are many experiences and actions that can be performed with a single arm attached to a central body or station. Is this enough? I am curious to know if the direction of robotics is heading towards building machines that mimic the human body, or if the principle of embodiment only implies that there must be some sort of physical representation of intelligence – whether that is as basic as a mechanical grabber/arm or as complex as "Leo" (the robot shown in the in-class video).”
- Margaret

Is AlphaGo a robot?

“... the existence of technologies like the Internet mean that a robot can indeed interact and verify things that are relevant to humans, without having a physical body. To again use Alpha Go as an example, alpha go did interact with the world, though sometimes through a human agent, and it definitely used a verification process, especially in its training.”
- Anne

Embodied AI

“While you can have various forms of AI (think AlphaGo, or Alexa & Siri that focus on responding to natural language processing), these are fundamentally different from robots. You can have significant advances in AI and create programs that can evolve and learn and improve their behavior for skills (playing games, conversing with humans), but what separates them from robots is they cannot interact with the physical world.”
- Matthew

Go Board
Embodiment

Embodied AI

Embodied Intelligence (EI) is a mechanism that learns how to survive in a environment (potentially hostile)

- Mechanism: biological, mechanical or virtual agent with embodied sensors and actuators
- EI acts on environment and perceives its actions
- EI learns so it must have associative self-organizing memory
- Knowledge is acquired by EI

Embodied vs. Traditional View of AI

Traditional View of AI

Mainstream Science on Intelligence December 13, 1994:
An Editorial With 52 Signatories, History, and Bibliography by Linda S. Gottfredson, University of Delaware

"Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience."

Embodied AI

Embodied AI

Agent Architecture

Reason

Long-term Memory

Short-term Memory

Perceive

Act

INPUT

OUTPUT

Simulation or Real-World System

From Randolph M. Jones, P : www.soartech.com

Traditional vs. Embodied AI

- Abstract intelligence
  - attempt to simulate “highest” human faculties:
    - language, discursive reason, mathematics, abstract problem solving
- Environment model
  - Condition for problem solving in abstract way
  - “brain in a vat”

- Embodiment
  - knowledge is implicit in the fact that we have a body
  - embodiment is a foundation for brain development
- Intelligence develops through interaction with environment
  - Situated in a specific environment
  - Environment is its best model
Embodiment in Humans

Human Brain at Birth
6 Years Old
14 Years Old

Synaptic Density over Time

Source: Getty Images

Rethinking the Brain, Families and Work Institute, Rima Shore, 1997.

Penfield (a.k.a. Sensory) Homunculus

Origins of the word Homunculus:
A miniature, fully formed individual believed by adherents of the early biological theory of preformation to be present in the sperm cell.

Discussion
- Would a robot's body ever need to change over time?
- Does AI require a physical body? Why or why not?

Robot Bodies in ROS

Position and Orientation in 3D
Quaternions

Roll - Pitch - Yaw

Converting between Quaternions and RPY

\[
\begin{bmatrix}
\phi \\
\theta \\
\psi
\end{bmatrix} = \begin{bmatrix}
\arctan\left(\frac{2q_yq_z + q_xq_w}{1 - 2q_y^2 - 2q_z^2}\right) \\
\arcsin(2(q_xq_y - q_zq_w)) \\
\arctan\left(\frac{2q_xq_y + q_zq_w}{1 - 2q_x^2 - 2q_y^2}\right)
\end{bmatrix}
\]

\[
q = \begin{bmatrix}
\cos(\phi/2)\cos(\theta/2)\cos(\psi/2) + \sin(\phi/2)\sin(\theta/2)\sin(\psi/2) \\
\sin(\phi/2)\cos(\theta/2)\cos(\psi/2) - \cos(\phi/2)\sin(\theta/2)\sin(\psi/2) \\
\cos(\phi/2)\sin(\theta/2)\cos(\psi/2) + \sin(\phi/2)\cos(\theta/2)\sin(\psi/2) \\
\cos(\phi/2)\cos(\theta/2)\sin(\psi/2) - \sin(\phi/2)\sin(\theta/2)\cos(\psi/2)
\end{bmatrix}
\]

Robot Bodies in ROS


Homework 4

- Robot Training Session
- URDF Tutorials
- Build your own robot using URDF

THE END