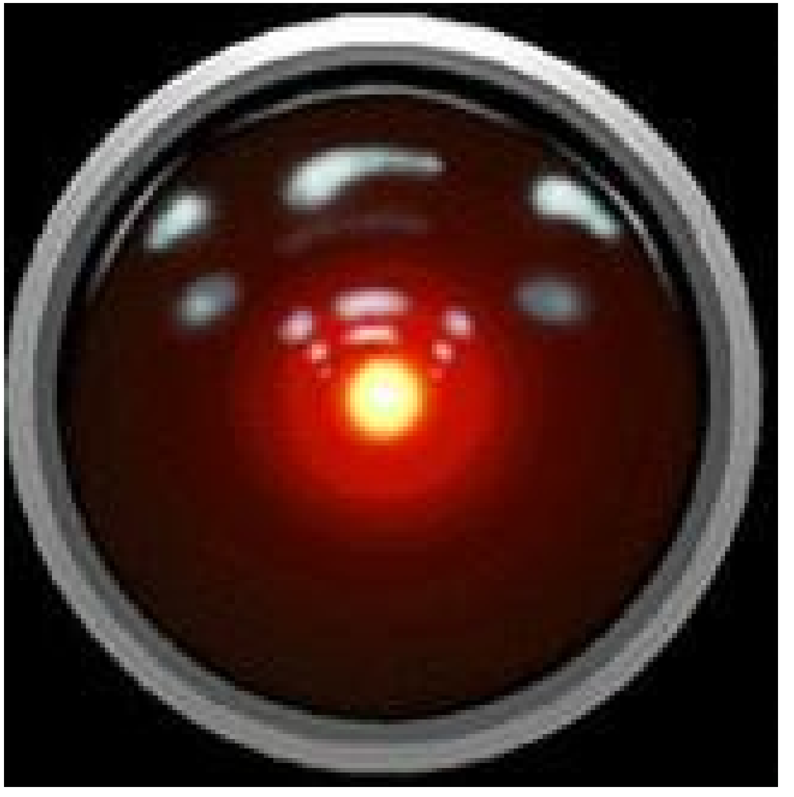


CS 378: Autonomous Intelligent Robotics

Instructor: Jivko Sinapov
http://www.cs.utexas.edu/~jsinapov/teaching/cs378/

Announcements

A few volunteers needed for explore UT

- Help setup and run the mobile robots during the open house
- Help run a drone robot demo
- Saturday at 10 am (event starts at 11 am)
- Email me if interesting in helping out
- Everyone is welcome to the event

Announcements

Homework 4 is due this Friday night

Readings for this week

Hoffmann, Matej, and Rolf Pfeifer. "The implications of embodiment for behavior and cognition: animal and robotic case studies." arXiv preprint arXiv:1202.0440 (2012).

Hoffman, Guy. "Embodied cognition for autonomous interactive robots." Topics in cognitive science 4.4 (2012): 759-772.

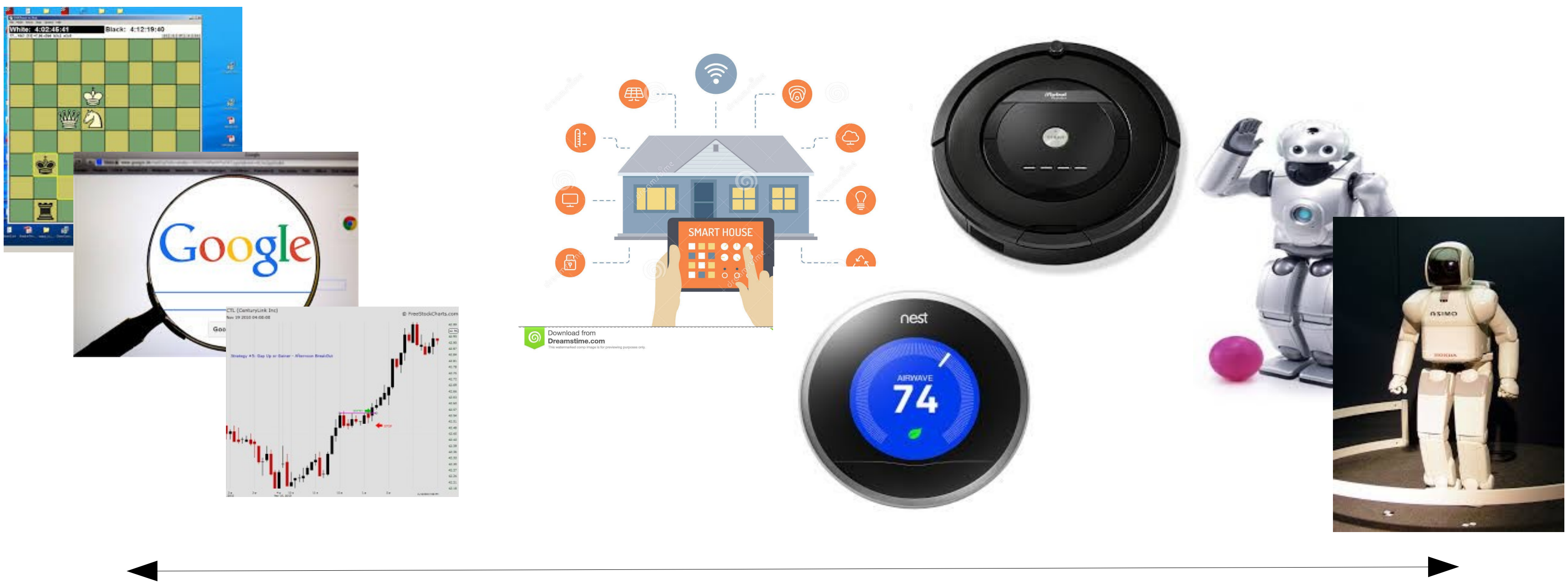
Michel, Philipp, Kevin Gold, and Brian Scassellati. "Motion-based robotic self-recognition." Intelligent Robots and Systems, 2004.(IROS 2004). Proceedings. 2004 IEEE/RSJ International Conference on. Vol. 3. IEEE, 2004.

Today

- Robot Bodies in ROS
- Homework 5 preview
- Homework 4 Q & A / Help

Embodiment

Embodiment



No body

Body

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****."*

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”

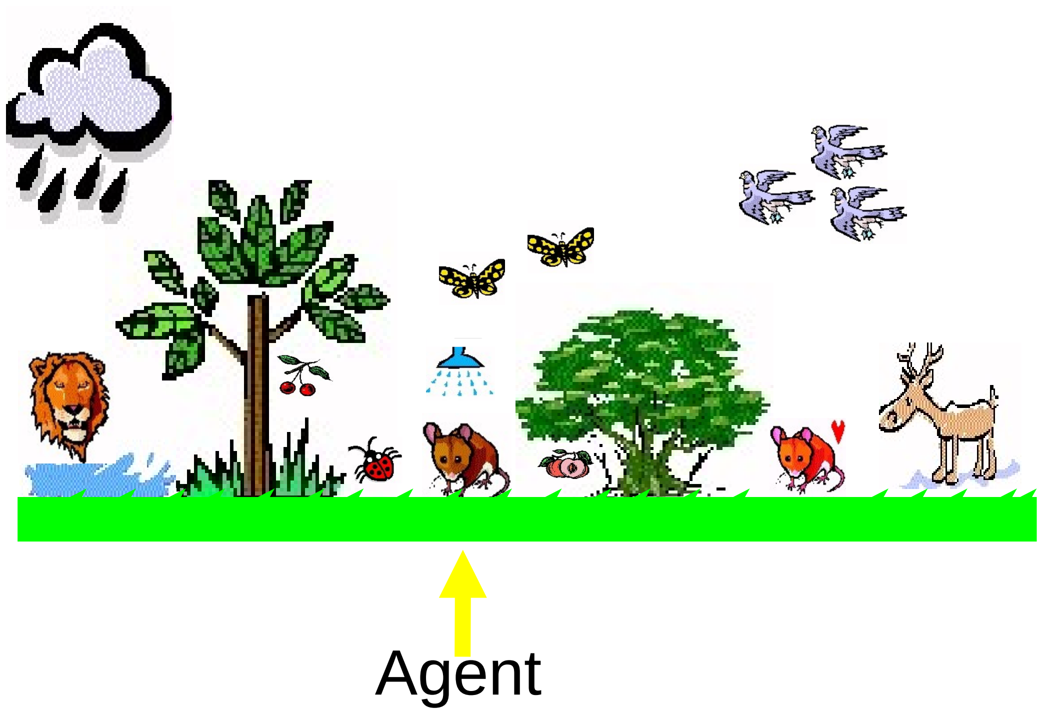
- Embodiment
  - knowledge is implicit in the fact that we have a body
    - embodiment is a foundation for brain development
- Intelligence develops through interaction with environment
  - Situated in a specific environment
  - Environment is its best model

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

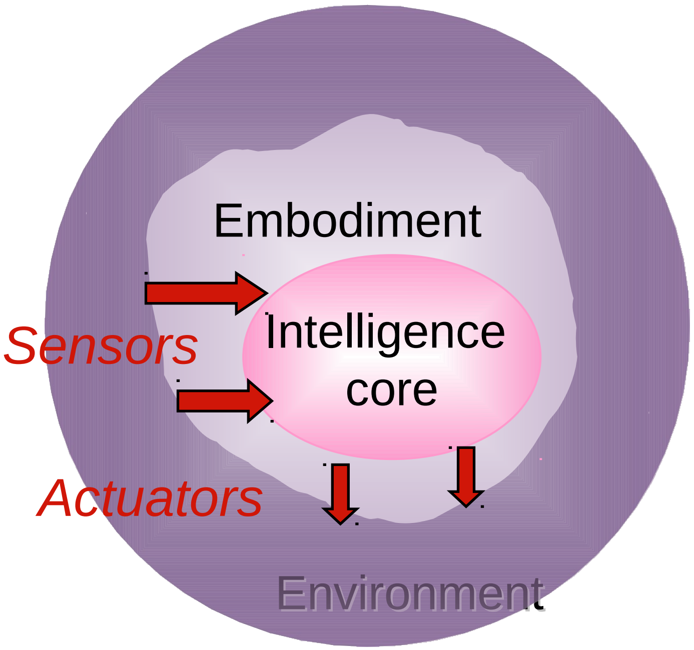
Embodied AI



Drawing by Ciarán O’Leary- Dublin Institute of Technology

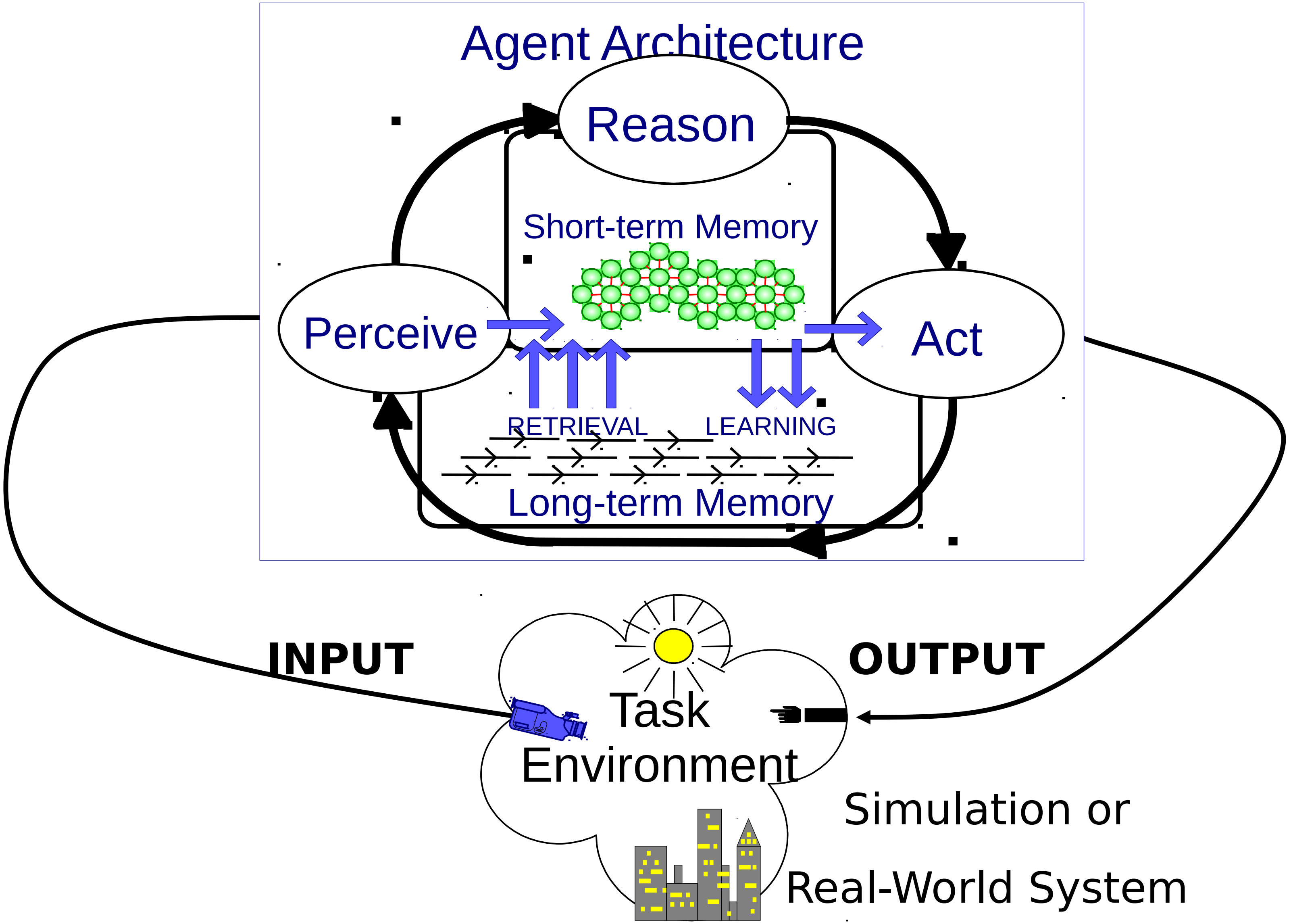
Embodied AI

“**Embodiment of a mind** is a mechanism **under the control of the intelligence core** that contains **sensors and actuators** connected to the core through **communication channels.**”



Drawing and quote by Janusz Starzyk
EECS, Ohio University

Embodied AI



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

Embodiment in Humans

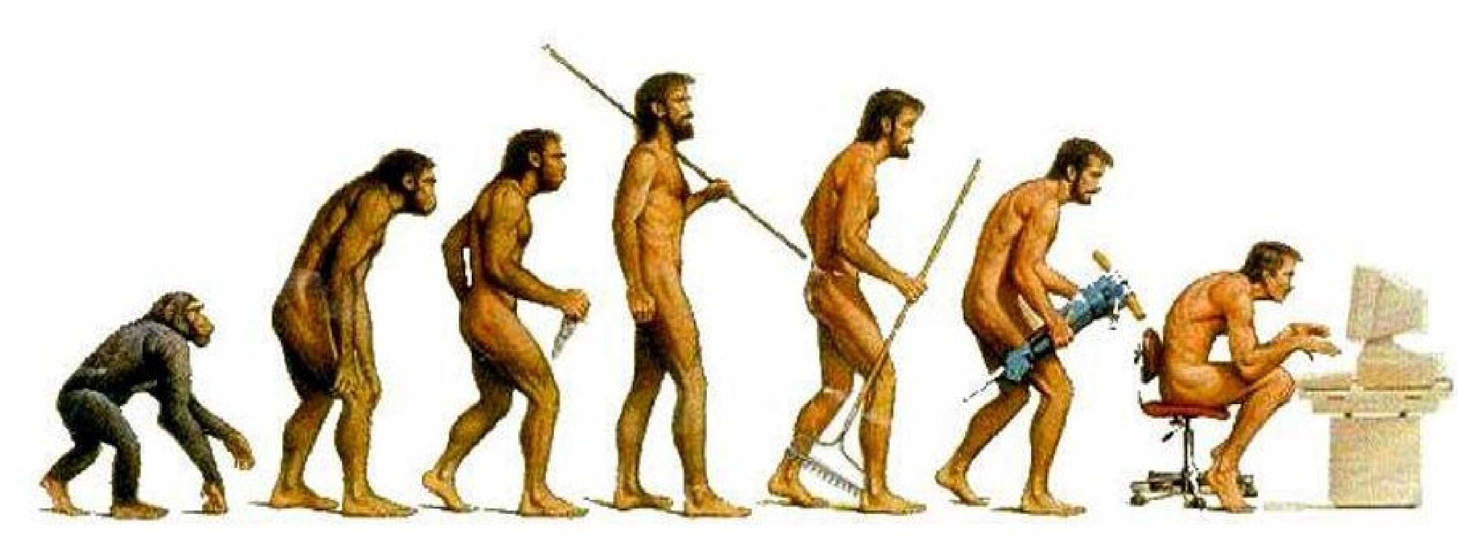
Embodiment in Humans

https://anagnk.files.wordpress.com/2013/03/fetal-growth.jpg

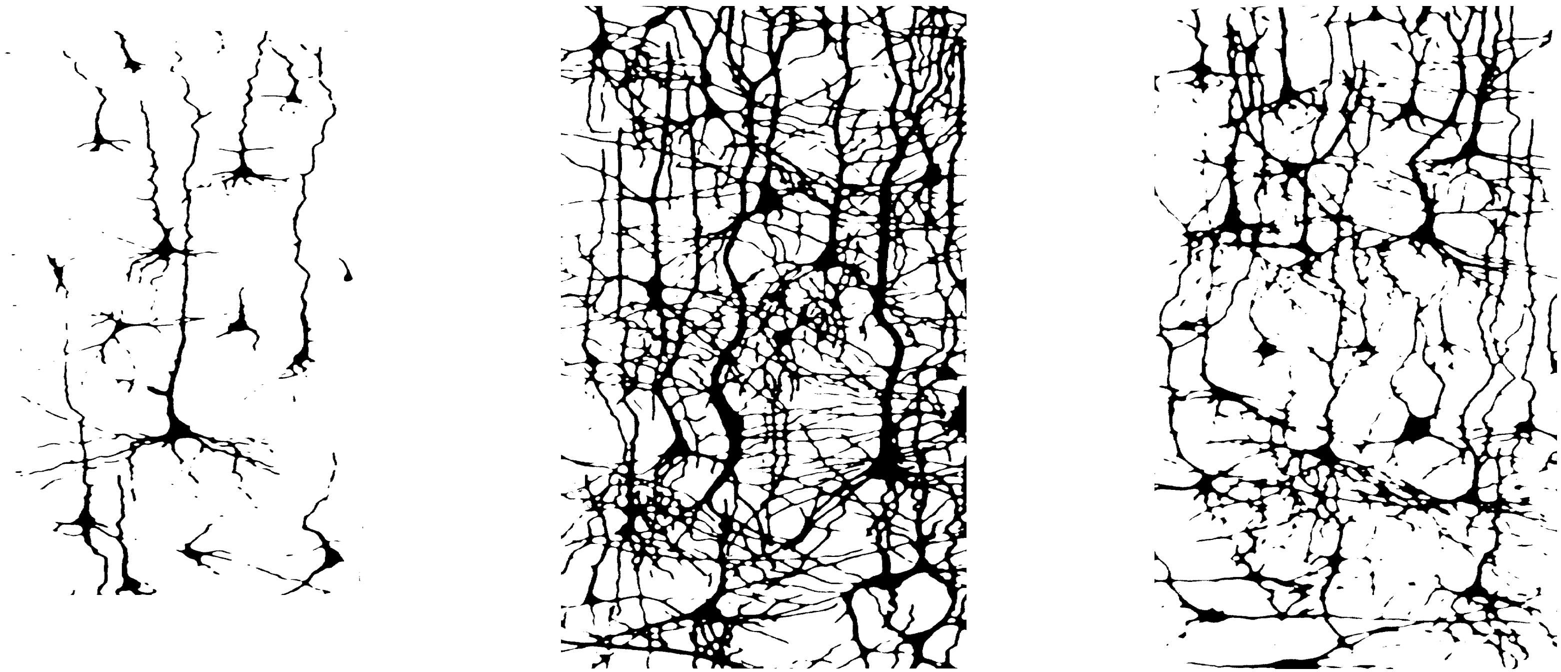
Embodiment in Humans

Source: Getty Images

Embodiment in Humans



Embodiment in Humans



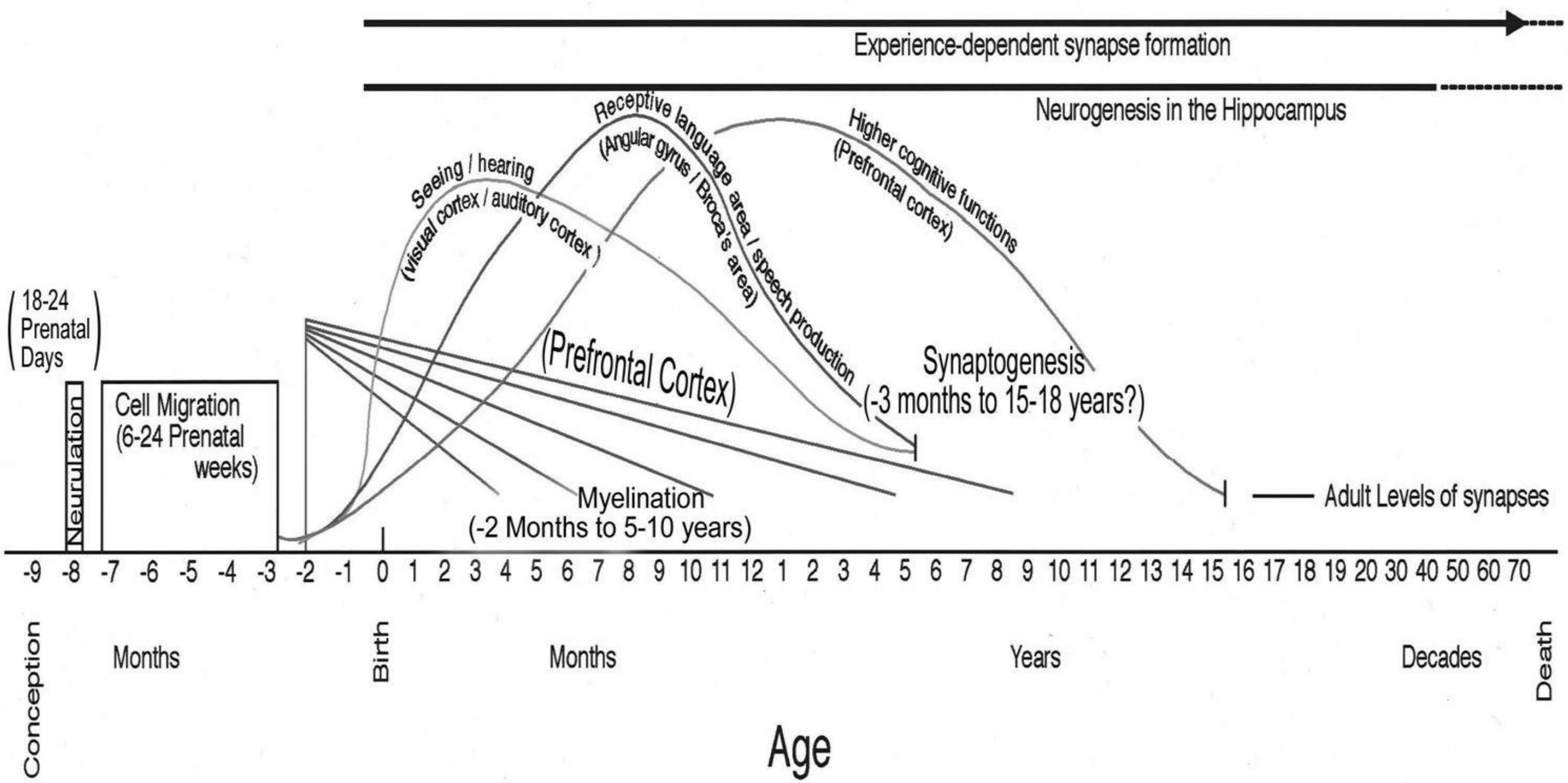
Human Brain at Birth

6 Years Old

14 Years Old

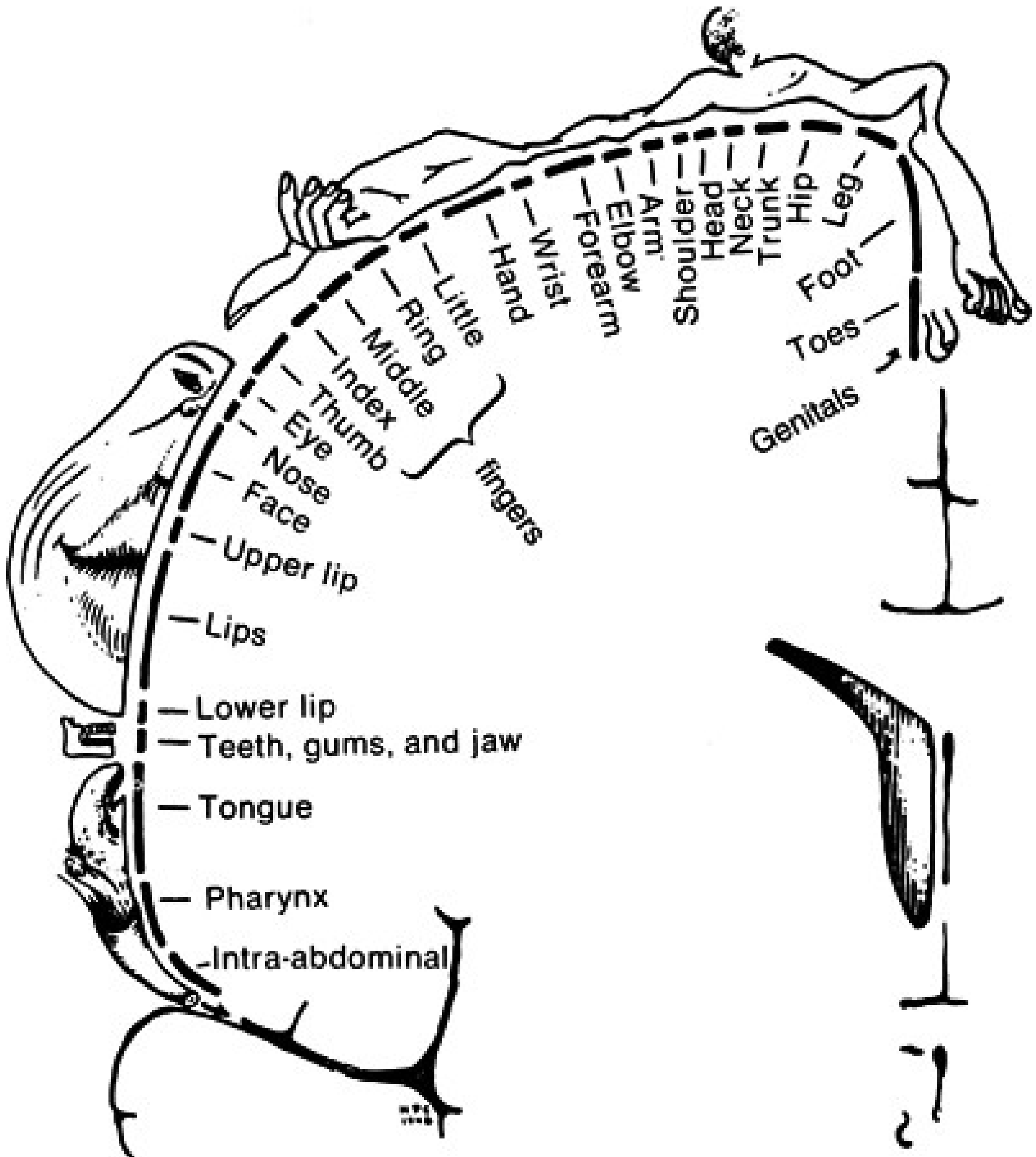
<u>Rethinking the Brain</u>, **Families and Work Institute, Rima Shore, 1997.**

Synaptic Density over Time

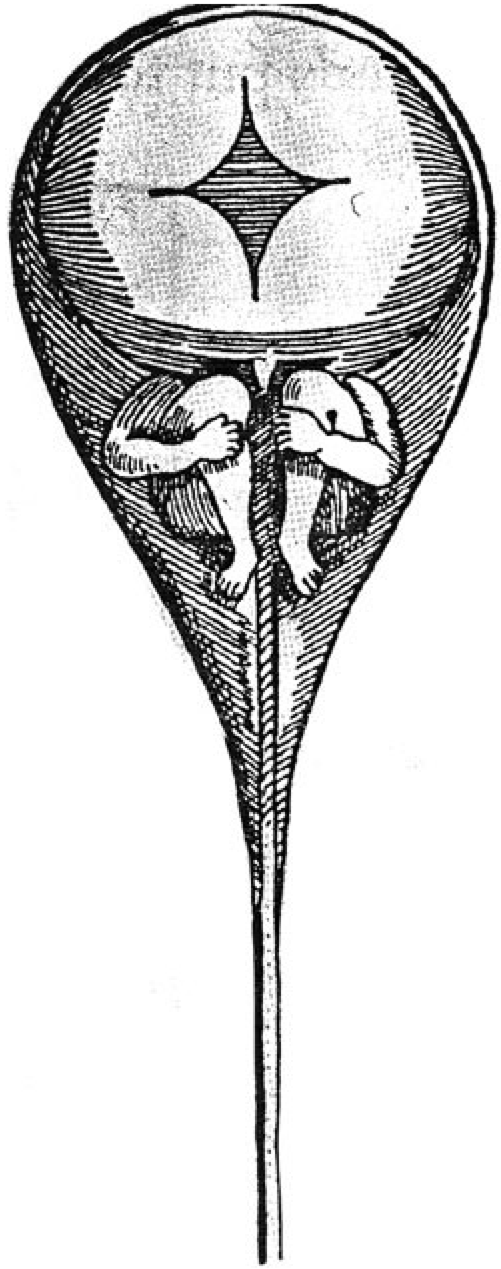


Thompson, R. A., & Nelson, C. A. (2001). Developmental science and the media: Early brain development. *American Psychologist, 56(1),* 5-15.

Penfield (a.k.a. Sensory) Homunculus



And its 3D analog



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?

- Do human bodies change in addition to just growing up?

Adaptive Body Representation

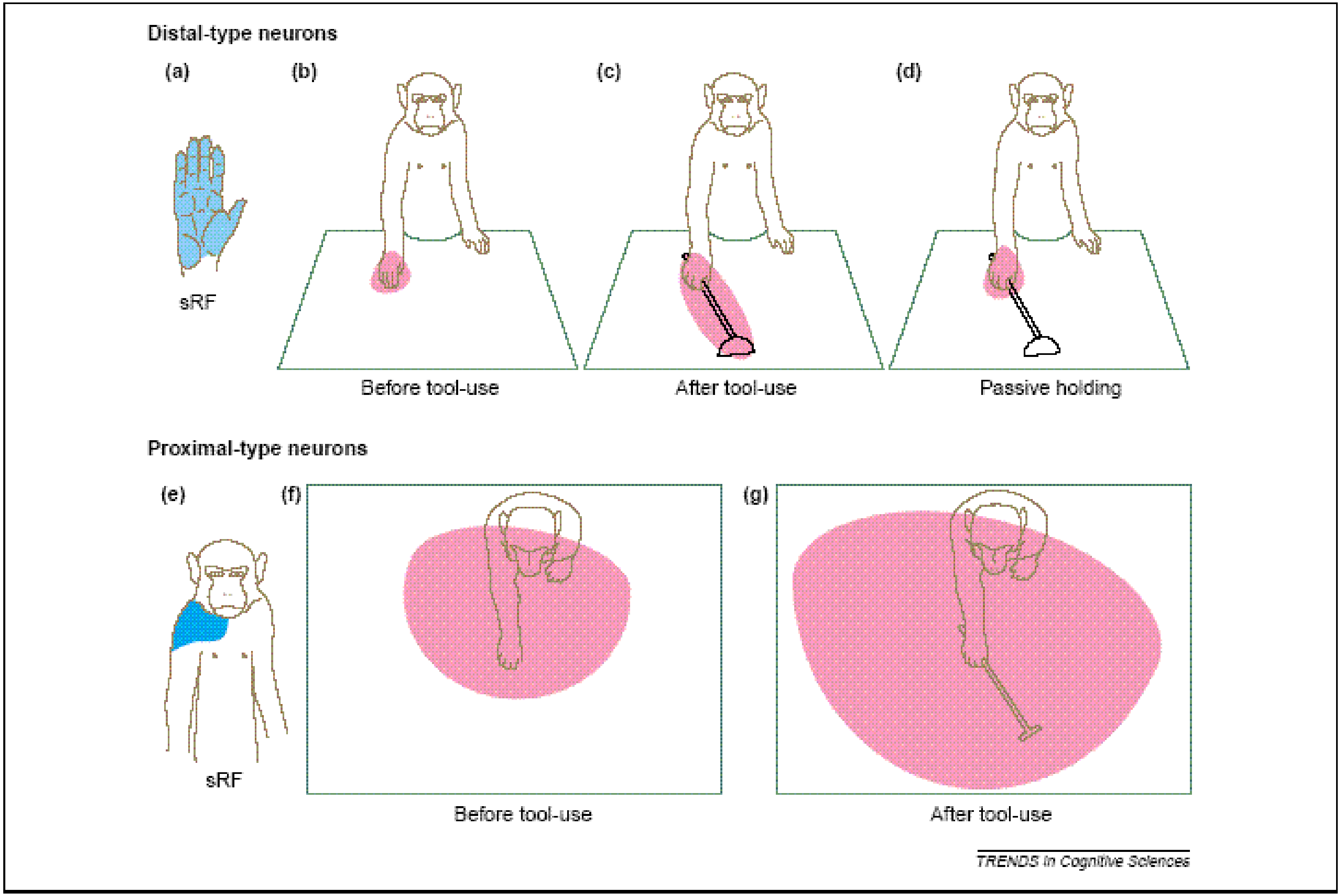
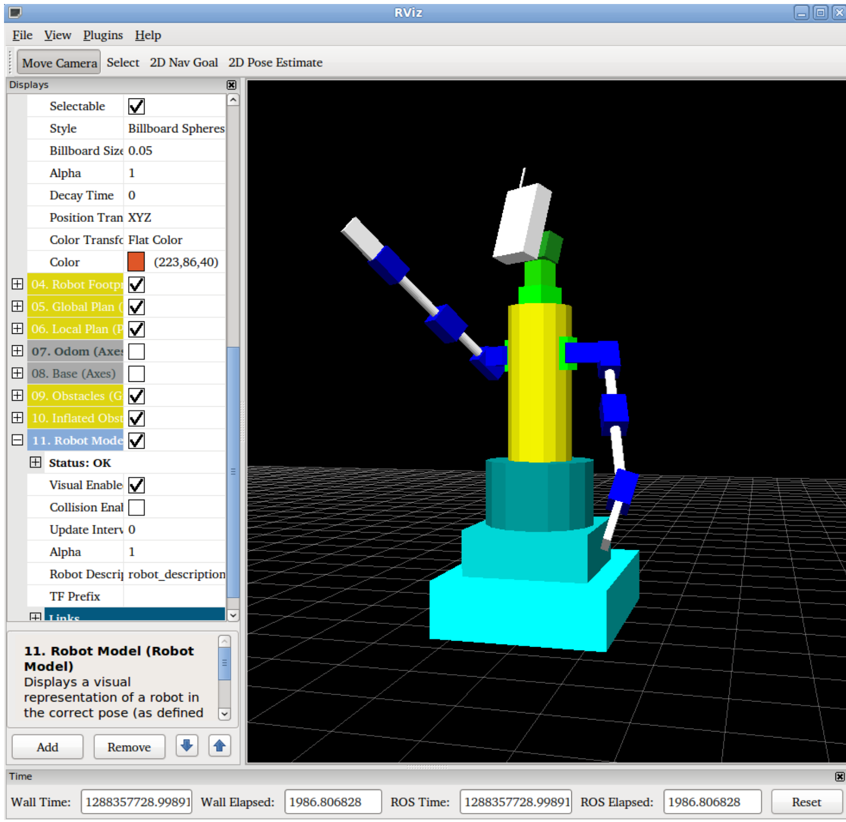
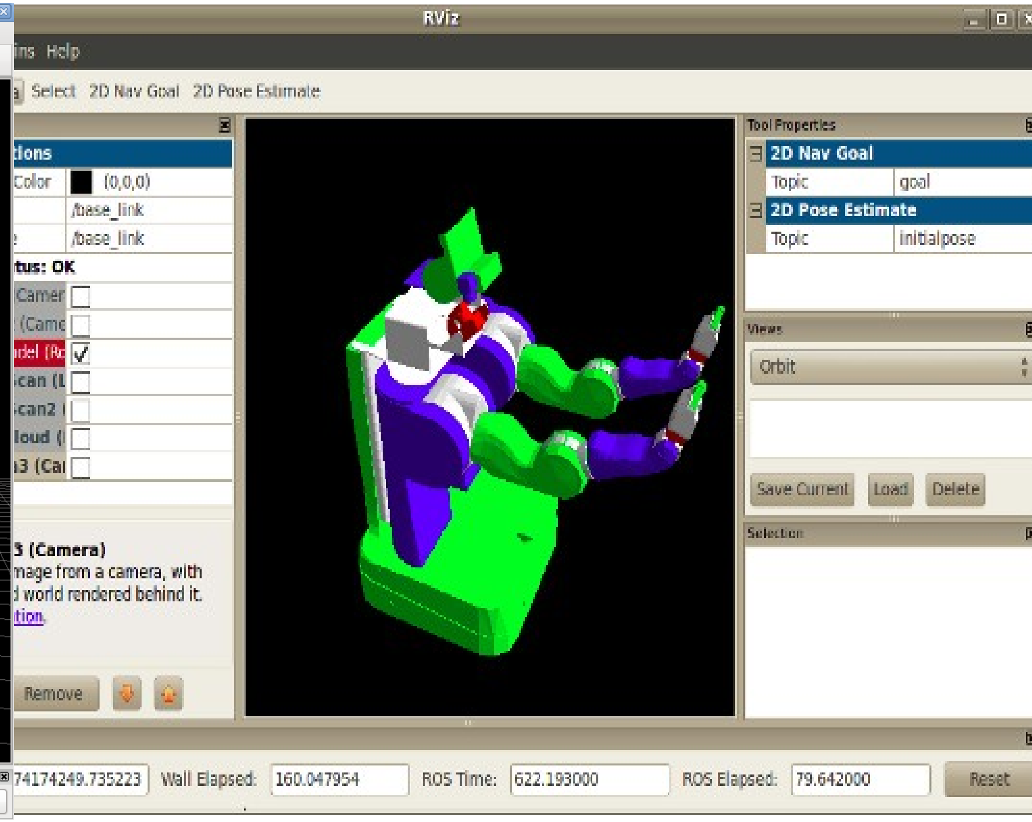


Figure 1. Changes in bimodal receptive field properties following tool-use. The somatosensory receptive fields (sRF) of cells in this region were identified by light touches, passive manipulation of joints or active hand-use. The visual RF (vRF) was defined as the area in which cellular responses were evoked by visual probes (the most effective ones being those moving towards the sRF). (a) sRF (blue area) of the 'distal type' bimodal neurons and their vRF (pink areas) (b) before tool-use, (c) immediately after tool-use, and (d) when just passively grabbing the rake. (e) sRF (blue area) of 'proximal type' bimodal neurons, and their vRF (pink areas) (f) before and (g) immediately after tool-use.

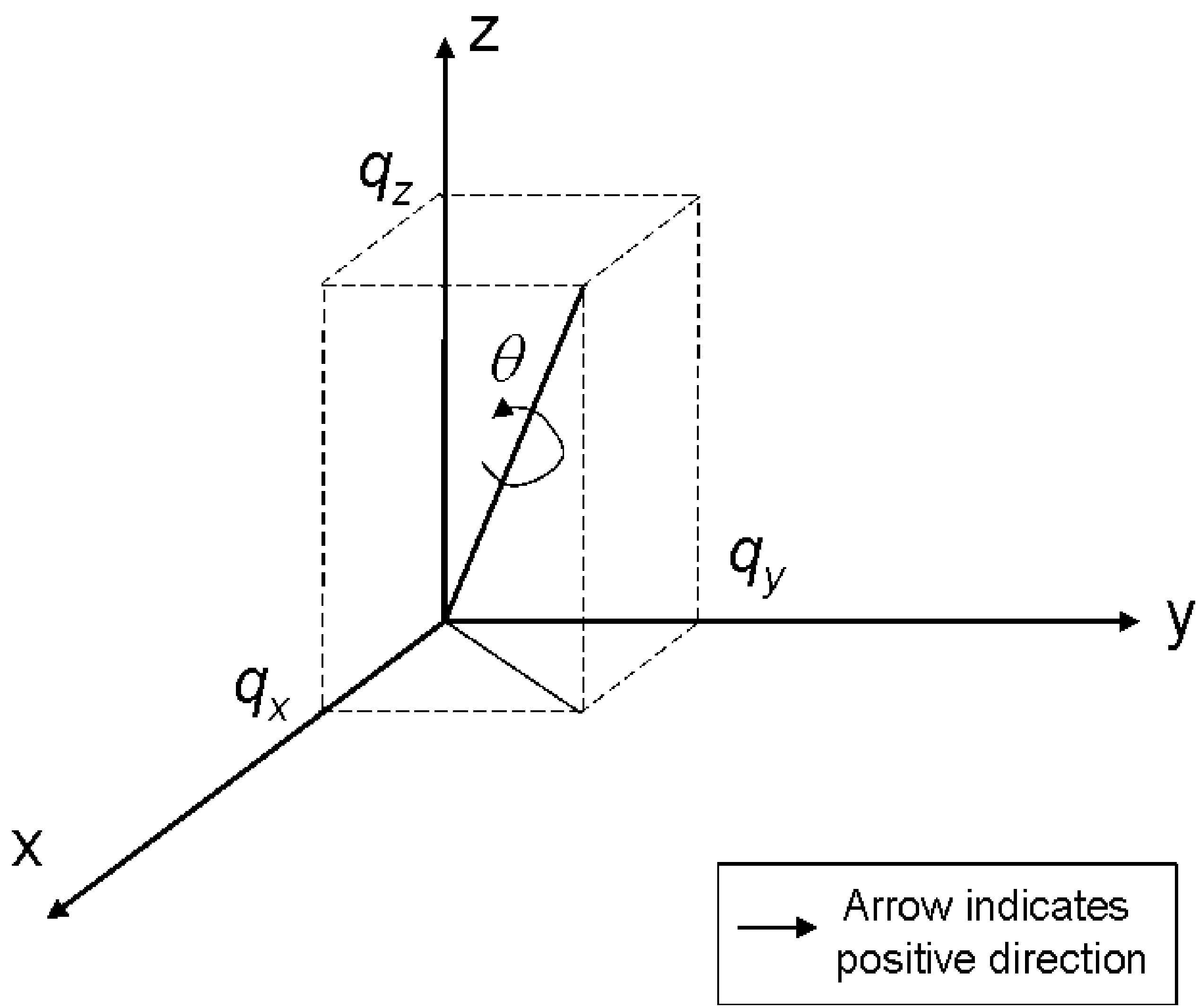
Robot Bodies in ROS



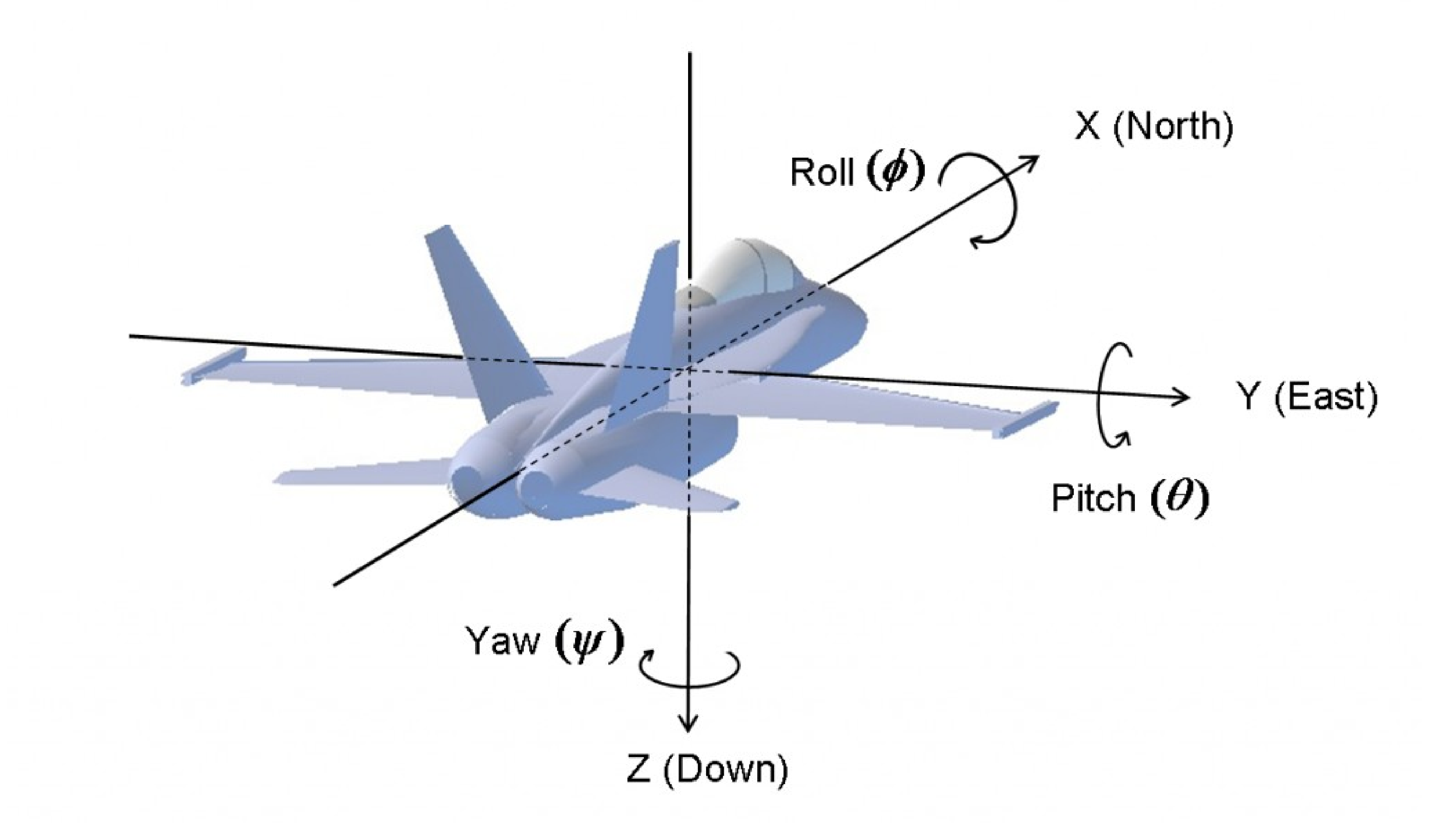


Position and Orientation in 3D

Quaternions

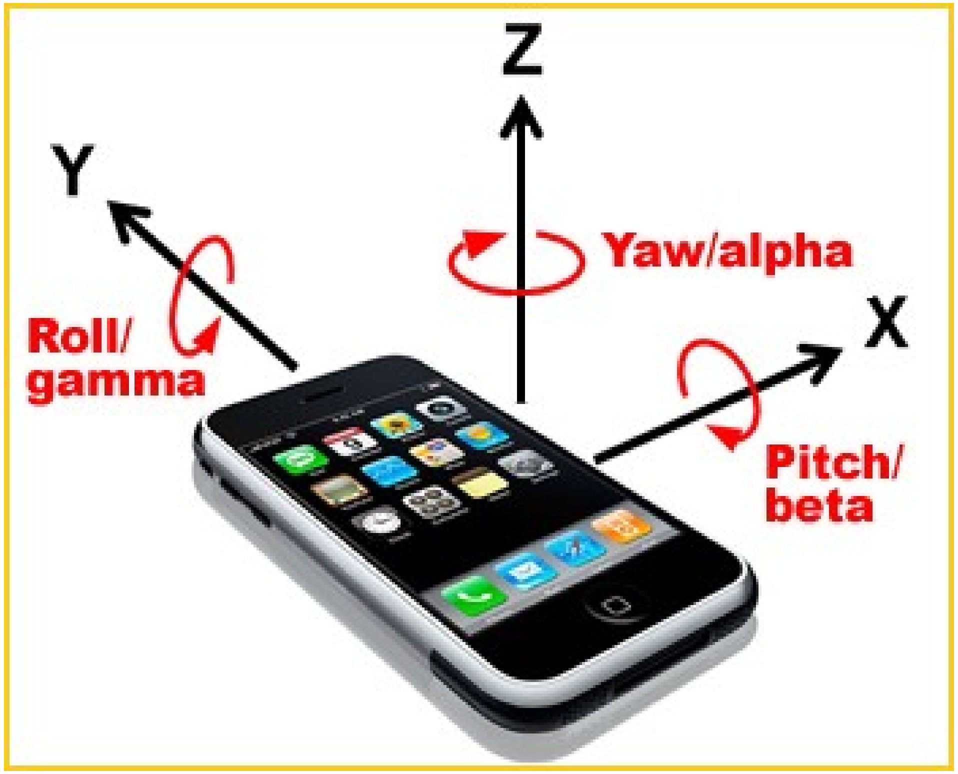


Roll – Pitch – Yaw

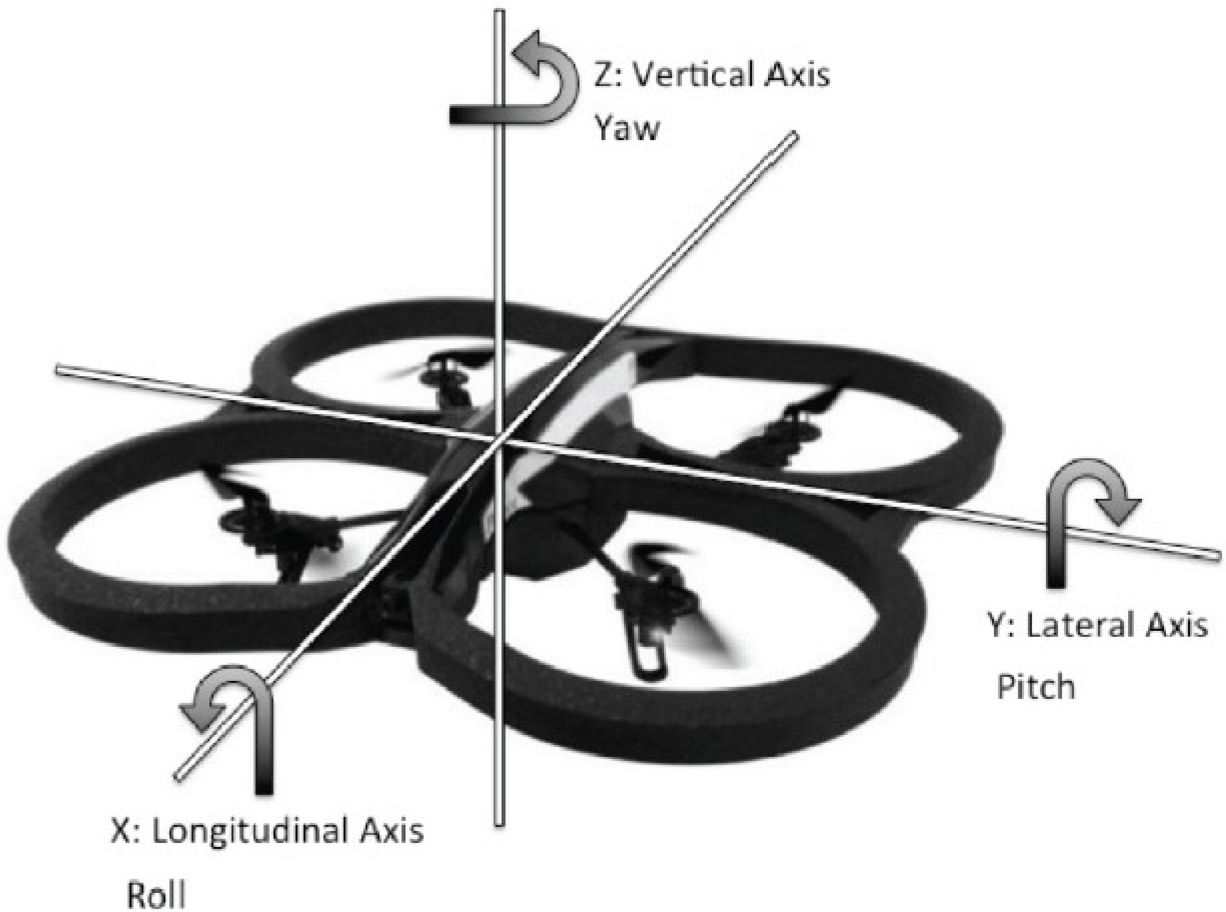


[http://www.chrobotics.com/library/understanding-quaternions]

Roll – Pitch – Yaw



Roll – Pitch – Yaw



Converting between Quaternions and RPY

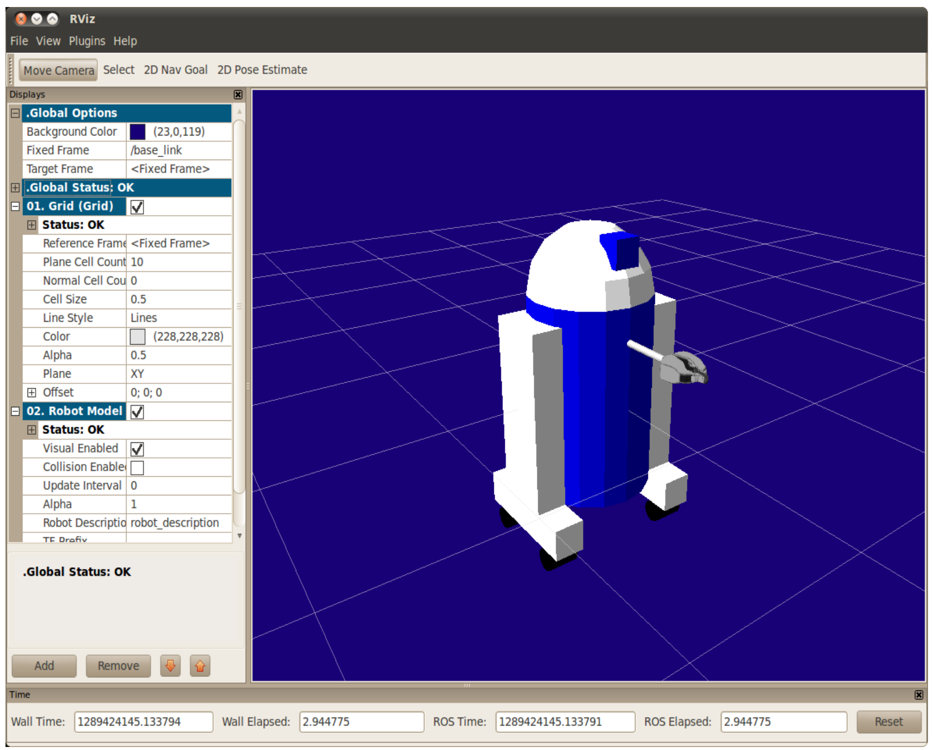
$$\begin{bmatrix}\phi\\ \theta\\ \psi\end{bmatrix} = \begin{bmatrix}\arctan\frac{2(q_0 q_1 + q_2 q_3)}{1-2(q_1^2+q_2^2)}\\ \arcsin(2(q_0 q_2 - q_3 q_1))\\ \arctan\frac{2(q_0 q_3 + q_1 q_2)}{1-2(q_2^2+q_3^2)}\end{bmatrix}$$

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

Pose Tutorial using rviz

URDF Tutorial

- http://wiki.ros.org/urdf/Tutorials



Homework 5

Prerequisites:

- URDF tutorials 3.1 – 3.3
- (Optional) TF tutorials in C++ and URDF tutorials 2.1 – 2.5

Homework 5

- Part 1: Building your own robot
  - Must have at least 6 joints
- Part 2: Robot training session
  - Look for signup sheet in Announcements
  - Each session will last up to 1 hour involving 1 mentor and 4-5 students
  - 6 to 8 sessions will be schedule throughout next week
- Officially out tomorrow

Homework 4: Q&A / Help

THE END