Hot Science Cool Talks

UT Environmental Science Institute

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Humanoids of Our Future

Dr. Luis Sentis

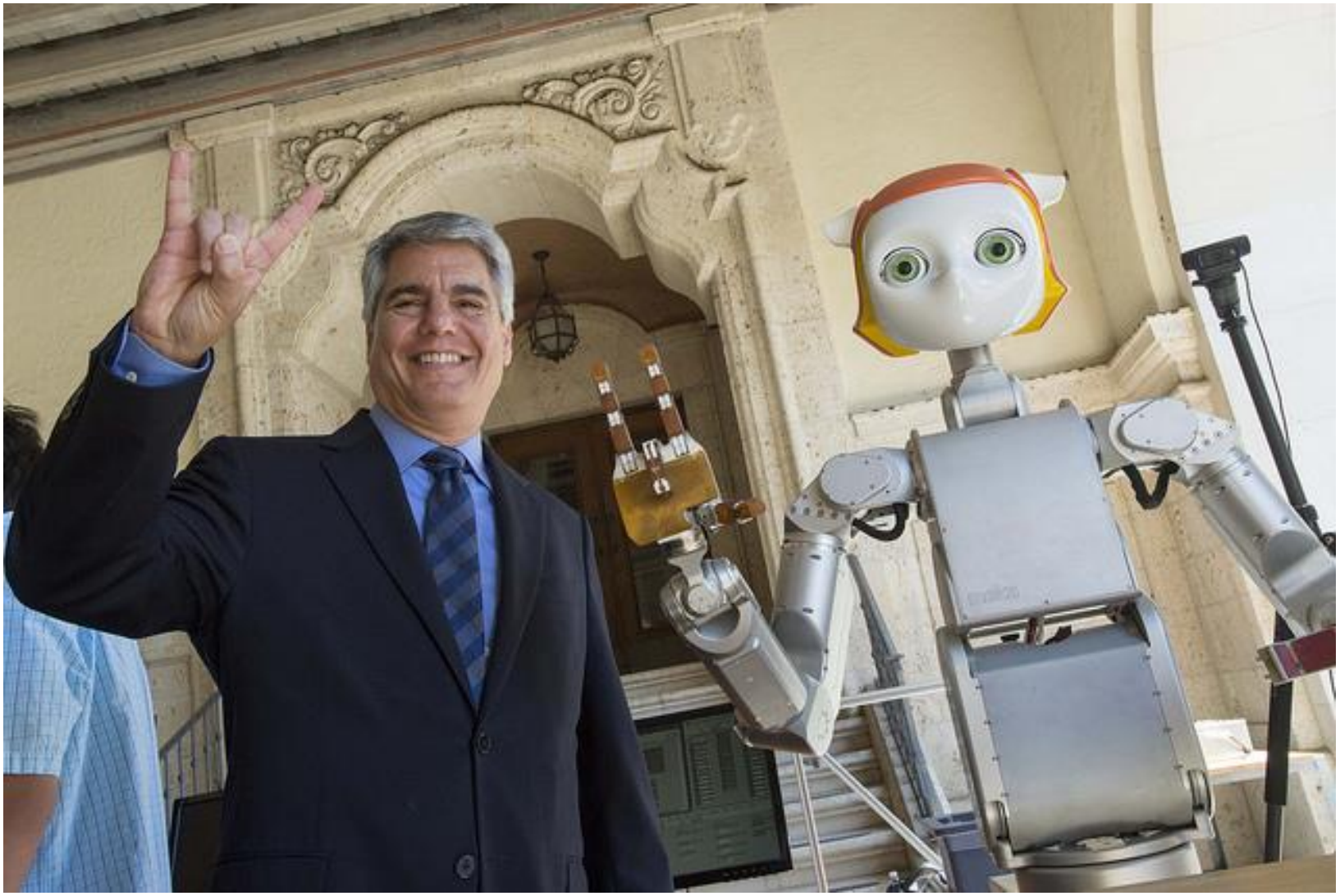
December 4, 2015

THE UNIVERSITY OF TEXAS AT AUSTIN

Hot Science Cool Talks

HUMANOIDS OF THE FUTURE

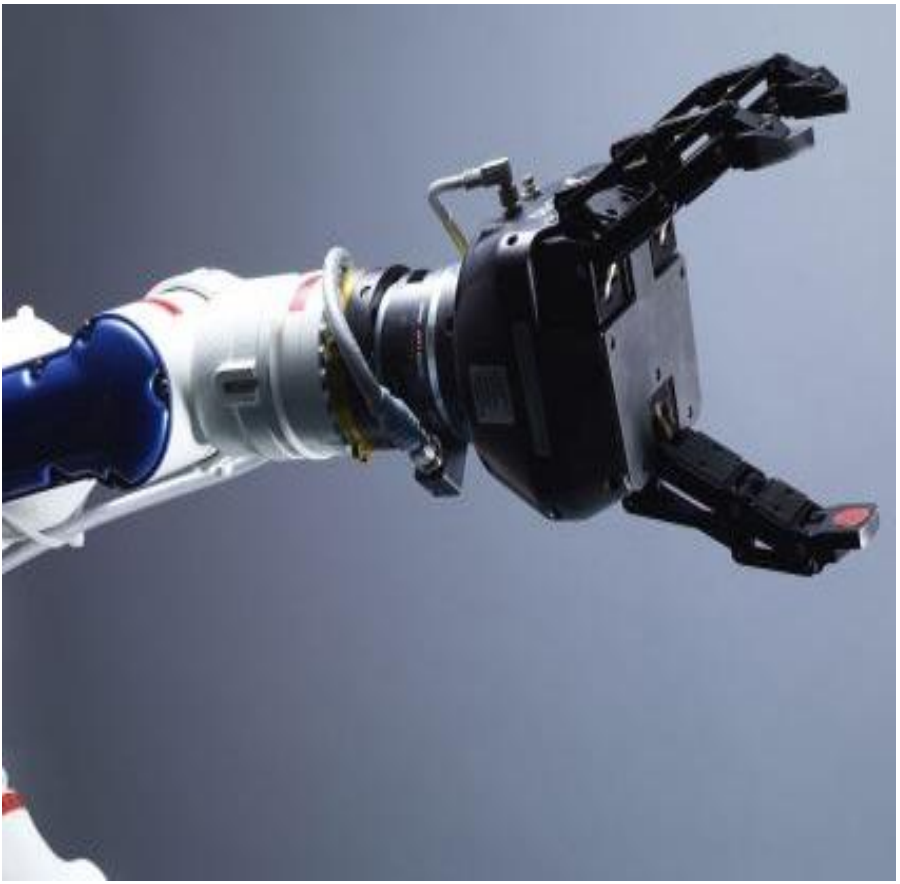
Luis Sentis
Assistant Professor at UT Austin
Head of the Human-Centered Robotics Lab
Scientific Advisor of Apptronik, Inc.



Why do we build humanoid robots?

Assessment of Disruptive Technologies by 2025 (Global Trends)

According to the ***National Intelligence Council***, six civil technologies offer the potential to enhance or degrade US power over the next fifteen years:



Biogerontechnology

Energy Storage Materials

Biofuels & Bio-Based Chemicals

Clean Coal Technologies

Service Robotics

The Internet of Things

Biogerontechnology and Assistive Technologies (source: Fatronik 2007)

Age	%disabled
60	13%
70	22%
80	42%
90	65%

Blue Sky Studios Movie Robots

Human Centered Robotics: The study of machines and robotic systems…

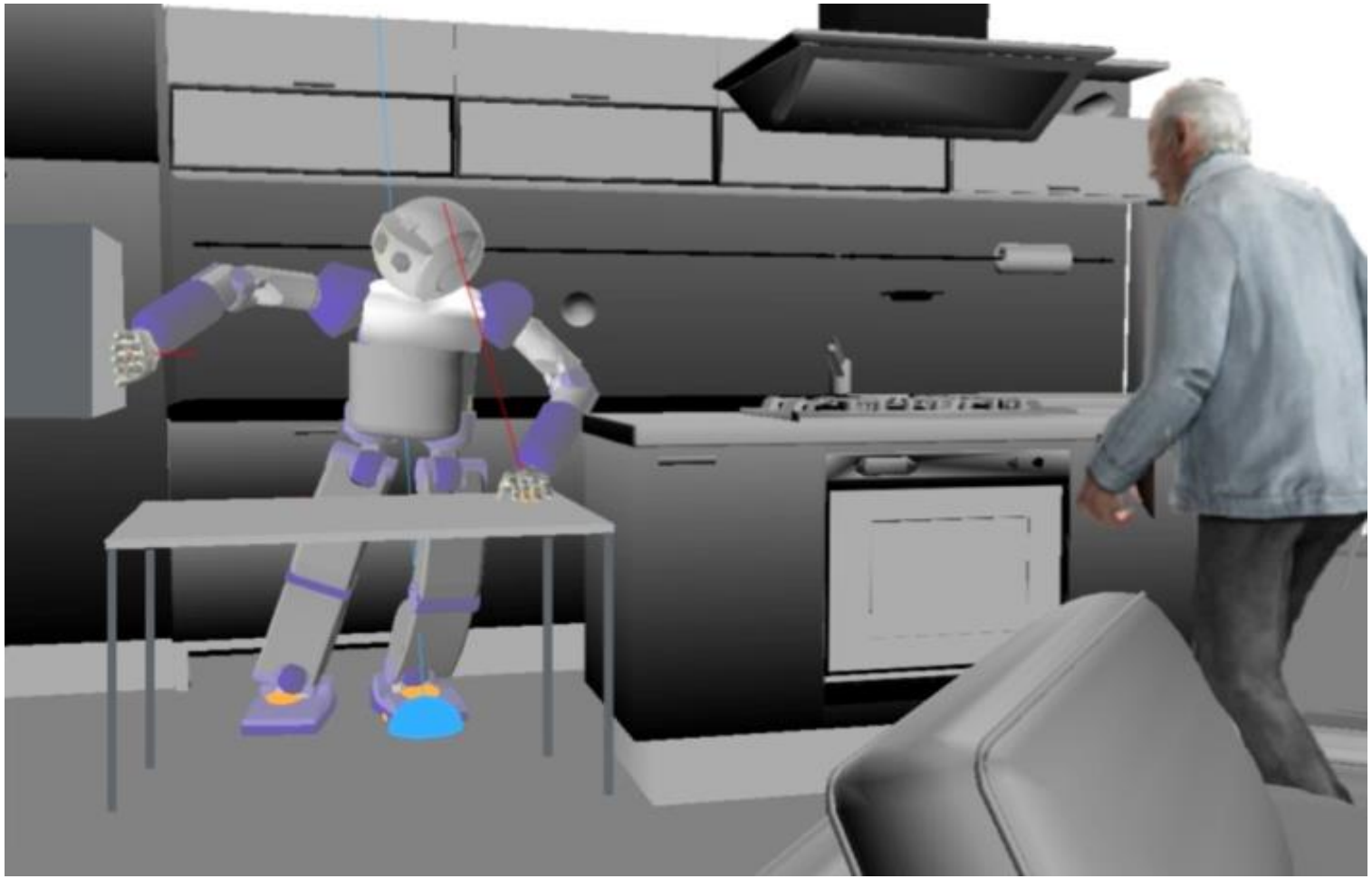
… with high mobility to assist, augment, or represent humans…

… in any way that will increase social comfort, productivity, security and health.

What can humanoid robots do?

How do robots interact with humans?

Home Assistance Robots



Concept art 2009
by Luis Sentis

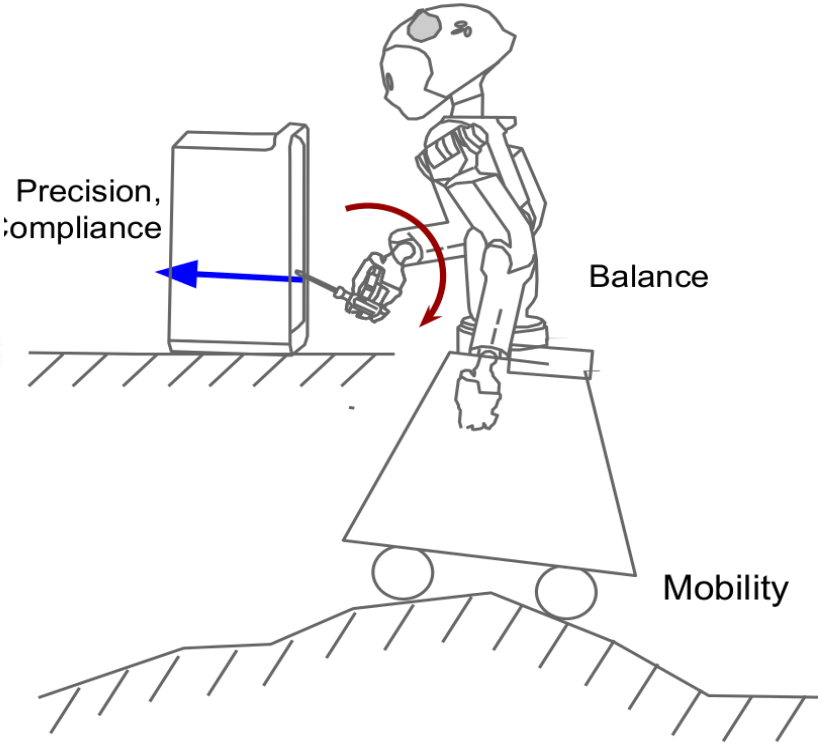
Home Assistance Robots

Legged Robots in the Wild

Concept art 2010
by The Human Centered Robotics Lab and ZPGraphic

Rough Terrain Manipulation Systems

Vecna, Inc. 2011



Concept art 2012

Human-Robot Interaction with the Navy and NASA

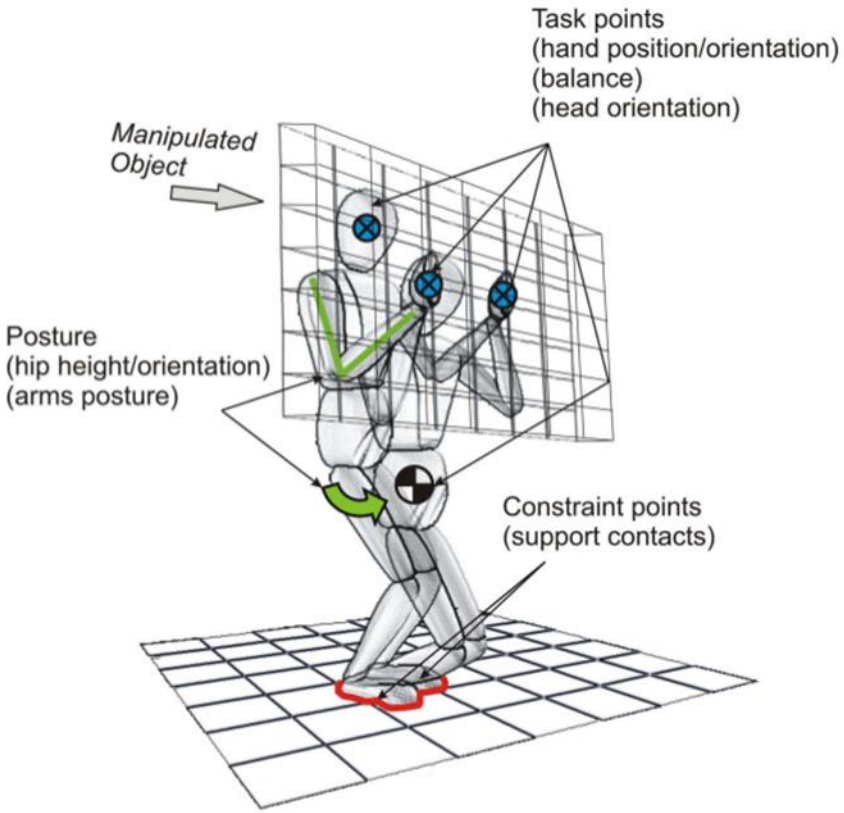
Navy: Vessel firefighting

NASA: Martian operations

Concept art 2014
by The Human Centered Robotics Lab and ZPGraphic

Robots Safely Colliding with Humans

Concept art 2015
by The Human Centered Robotics Lab and ZPGraphic



$A_1 \leftarrow A$ and $b_1 \leftarrow b$

for $i = 1 : n$ do

$$\underset{\mathcal{X}}{\text{minimize}} \quad \pi_i = ||E_i \mathcal{X} - u_i||^2$$

$$\text{subject to} \quad A_i \mathcal{X} = b_i$$

$$G \mathcal{X} \preceq h$$

$$A_{i+1} \leftarrow [A_i^T \; E_i^T]^T$$

$$b_{i+1} \leftarrow [b_i^T \; E_i \mathcal{X}^T]^T$$

end

How do robots mimic humans?

(Or, why you should do your math homework.)

Division 341 –
Cognitive Science &
Human Robot
Interaction Program

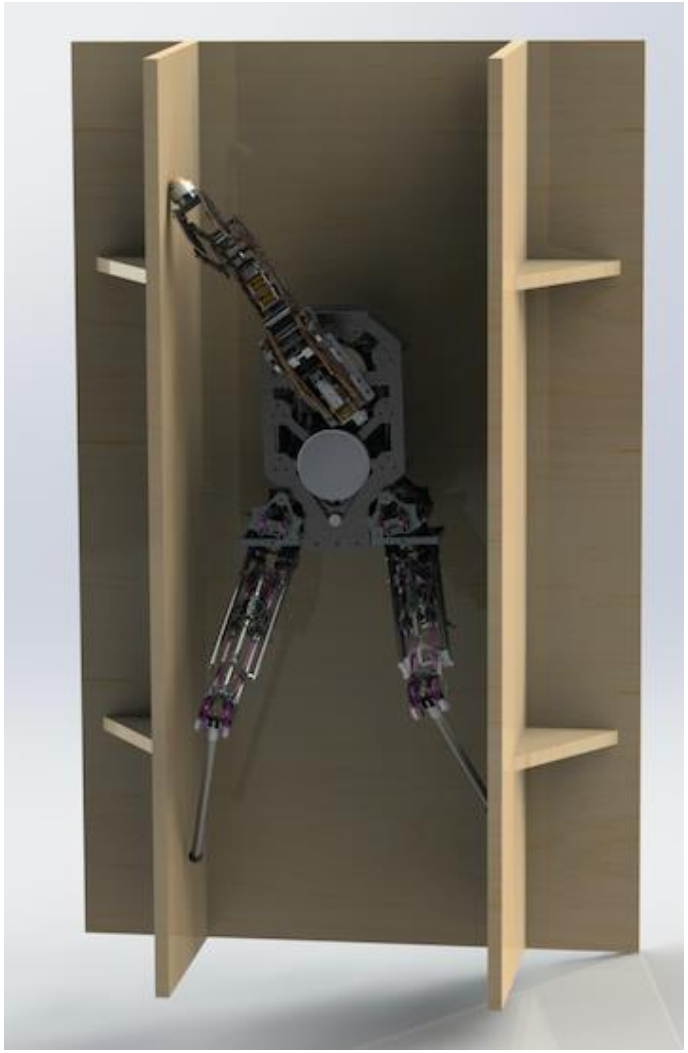
Concept art

Legged Mobility: What's missing?

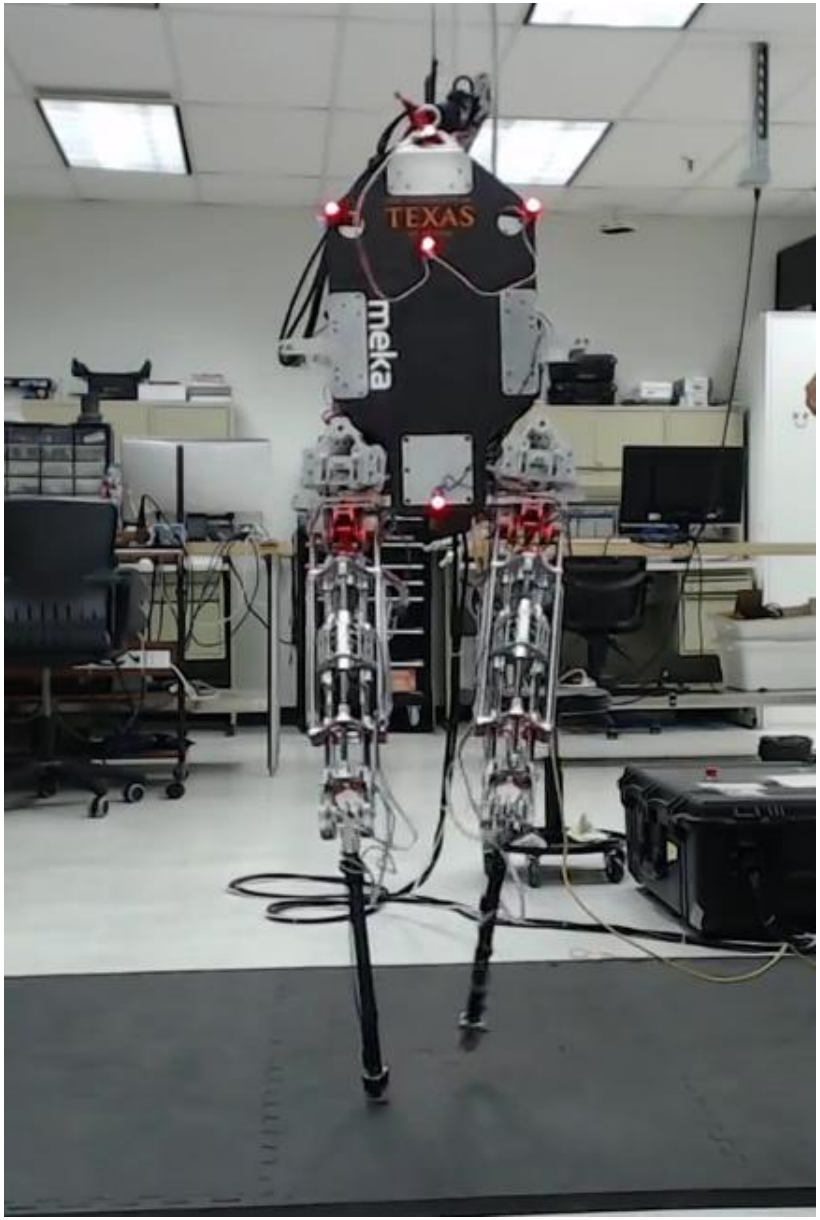
- We lack a basic understanding of general agility.
- We lack a hardware platform to experiment on general agile behaviors.
- We lack realtime plug and play software for humanoid robots.

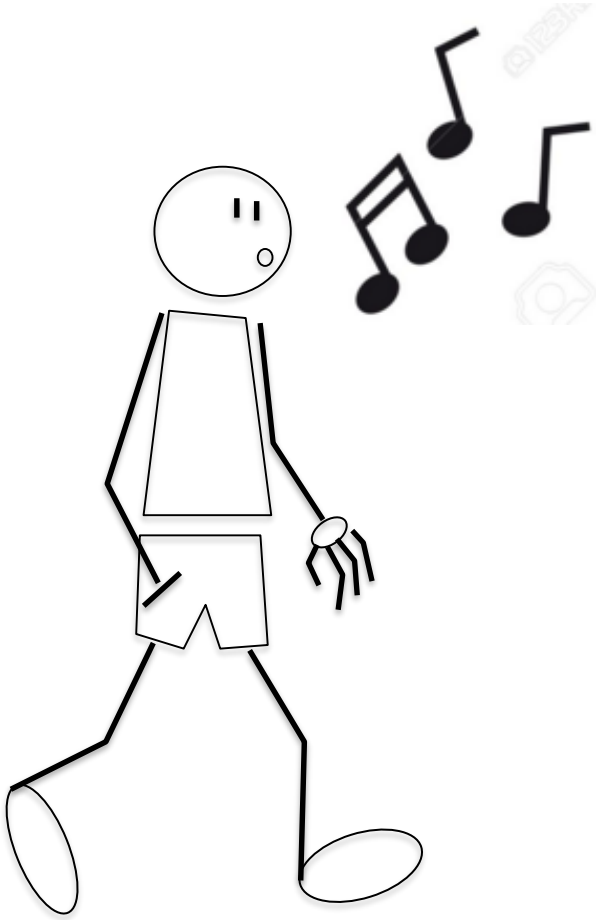
  (*There's no "apps" for this.*)

Scientific Frontiers on Agility



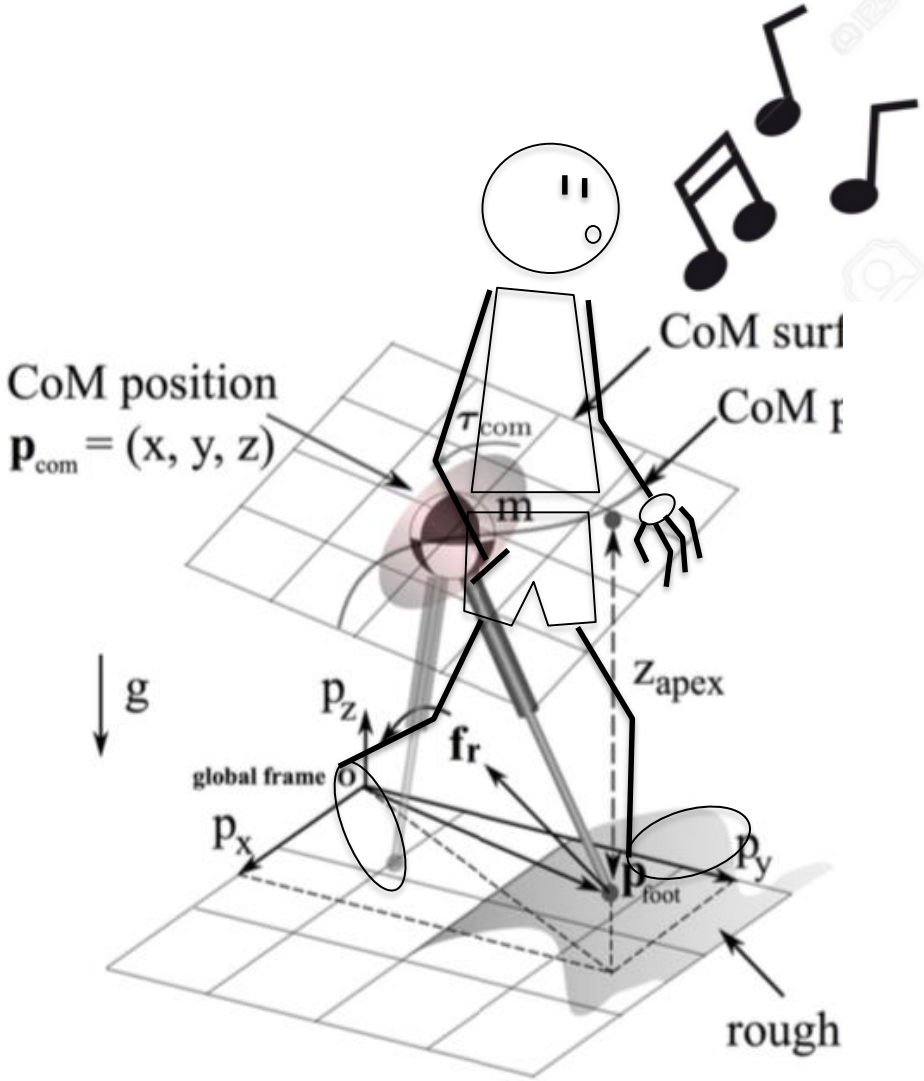
Research Biped Robot

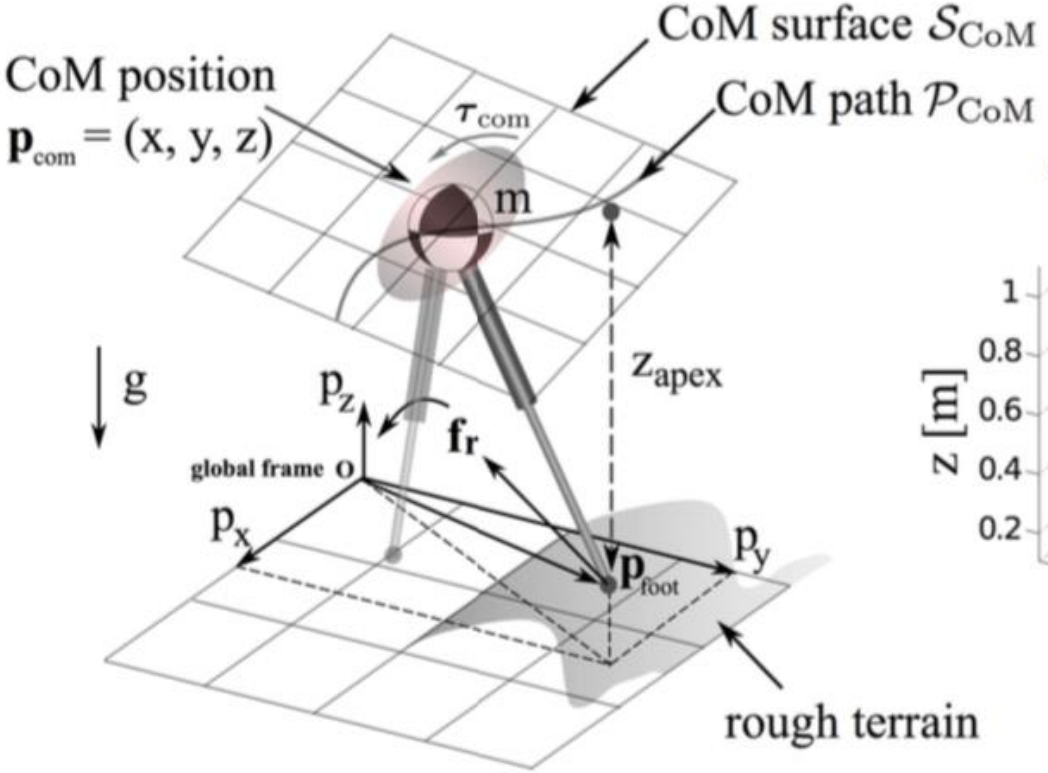


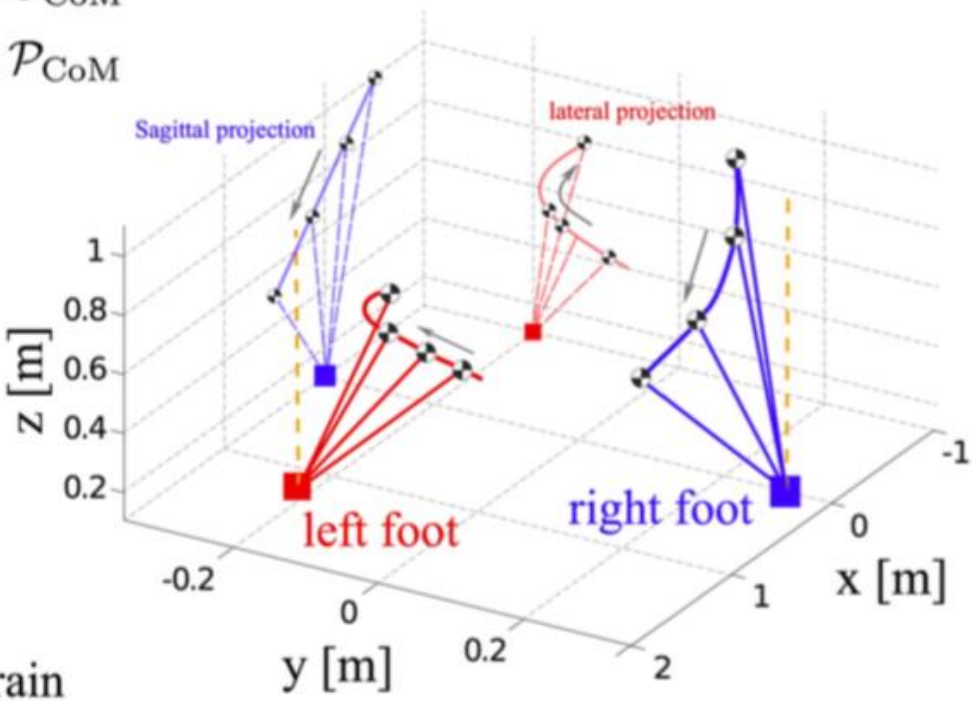


Human Motion Analysis using Inverted Pendulum Dynamics

(Cont'd)

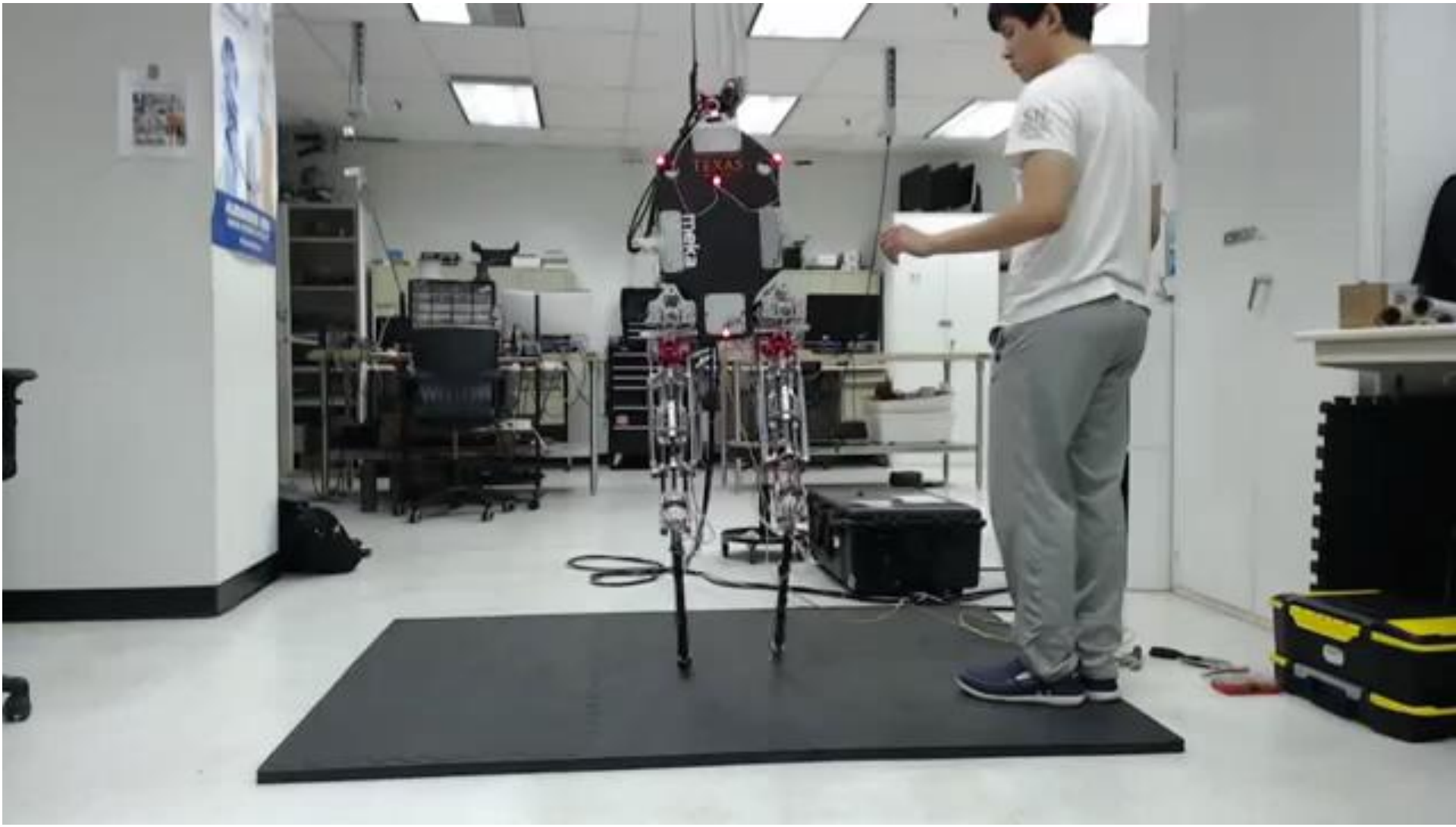

CoM position
$\mathbf{p}_{com} = (x, y, z)$
τ_{com}
m
CoM surf
CoM p
g
p_z
$\mathbf{f_r}$
z_{apex}
global frame
O
p_x
p_y
$\mathbf{p}_{foot}$
rough





$$\ddot{x} = \frac{g + \frac{d^2z}{dx^2}\dot{x}^2}{z - (x - x_p)\frac{dz}{dx}}(x - x_p)$$

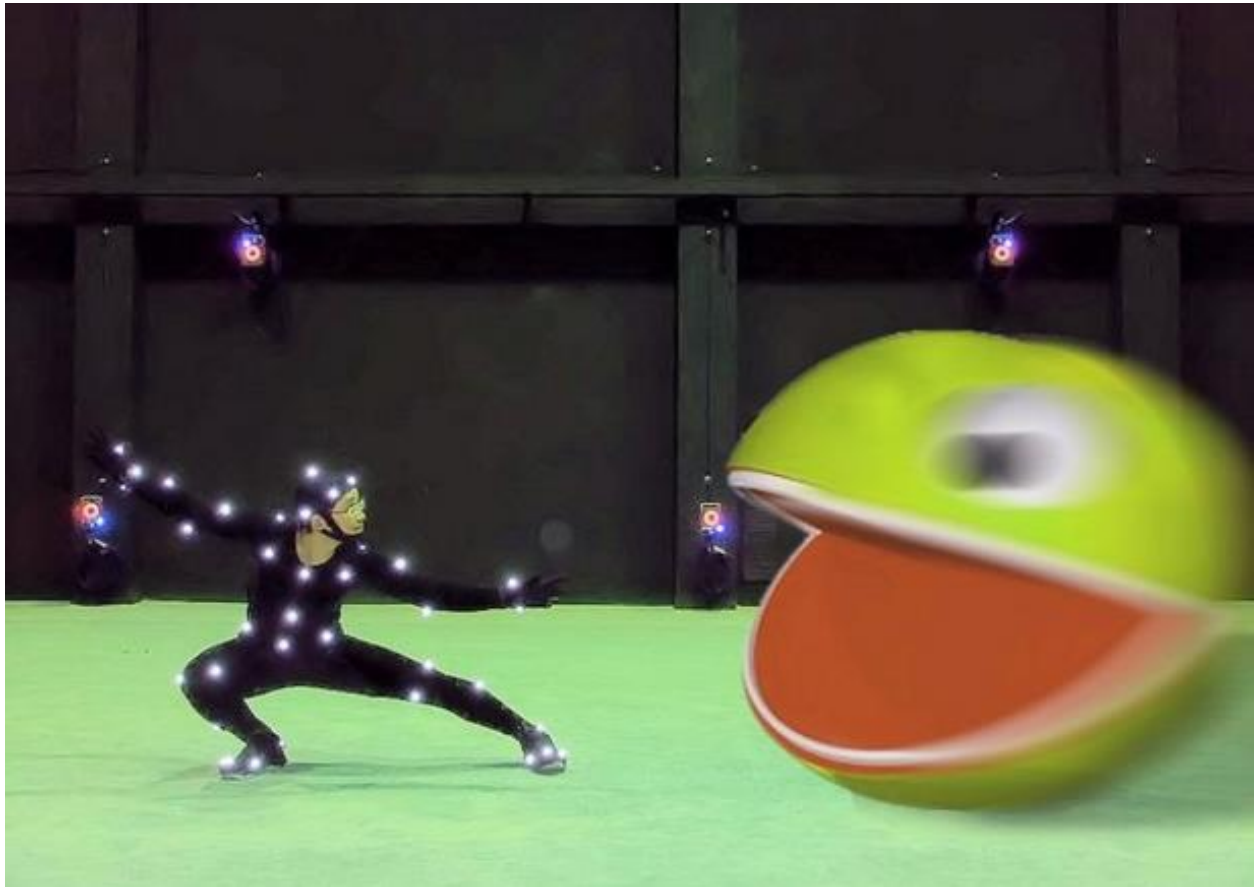
Foot Placement Planner



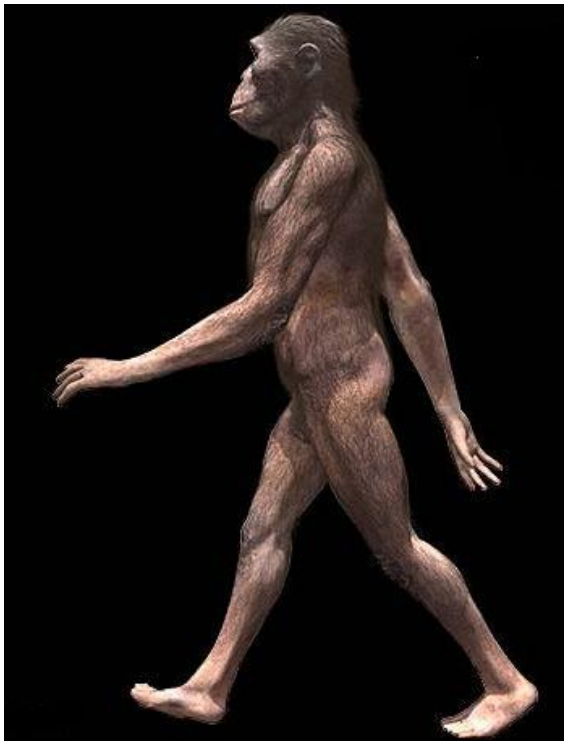
Where is the robot, seriously?

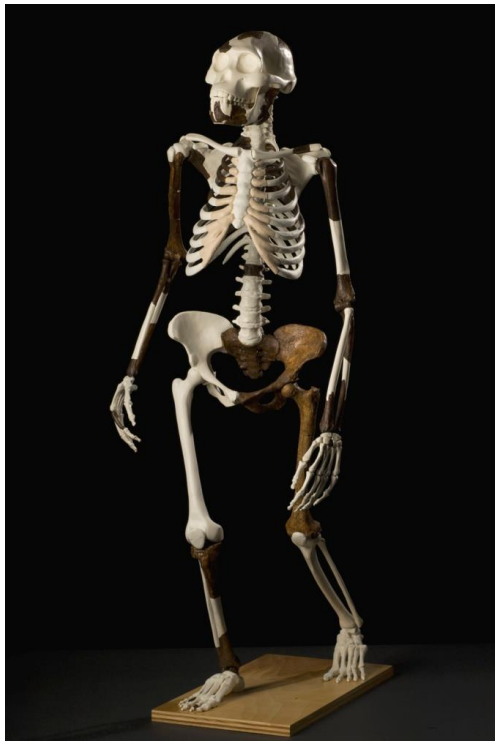
Inertial Measurement Unit

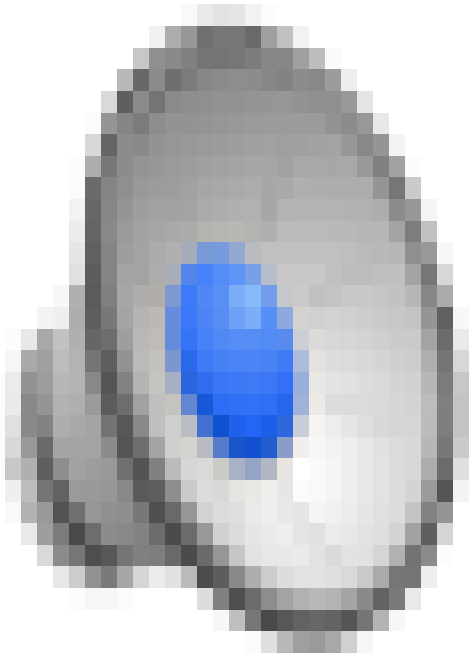
Motion Capture (Cool!)



Complexity of primate motion

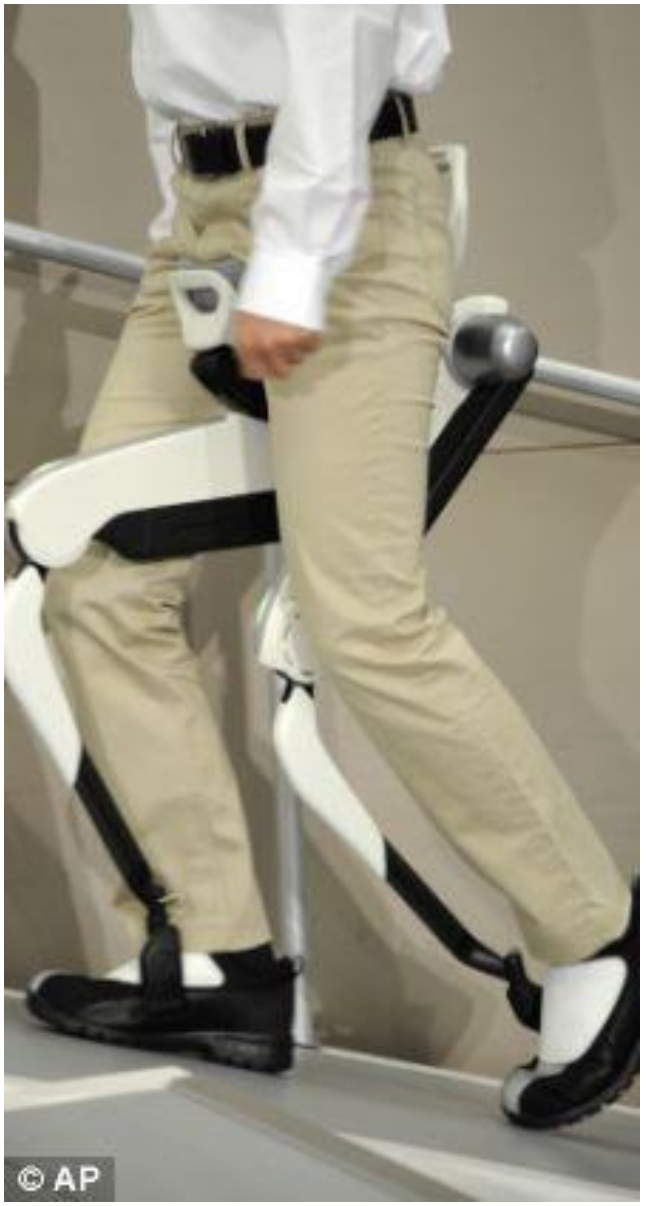


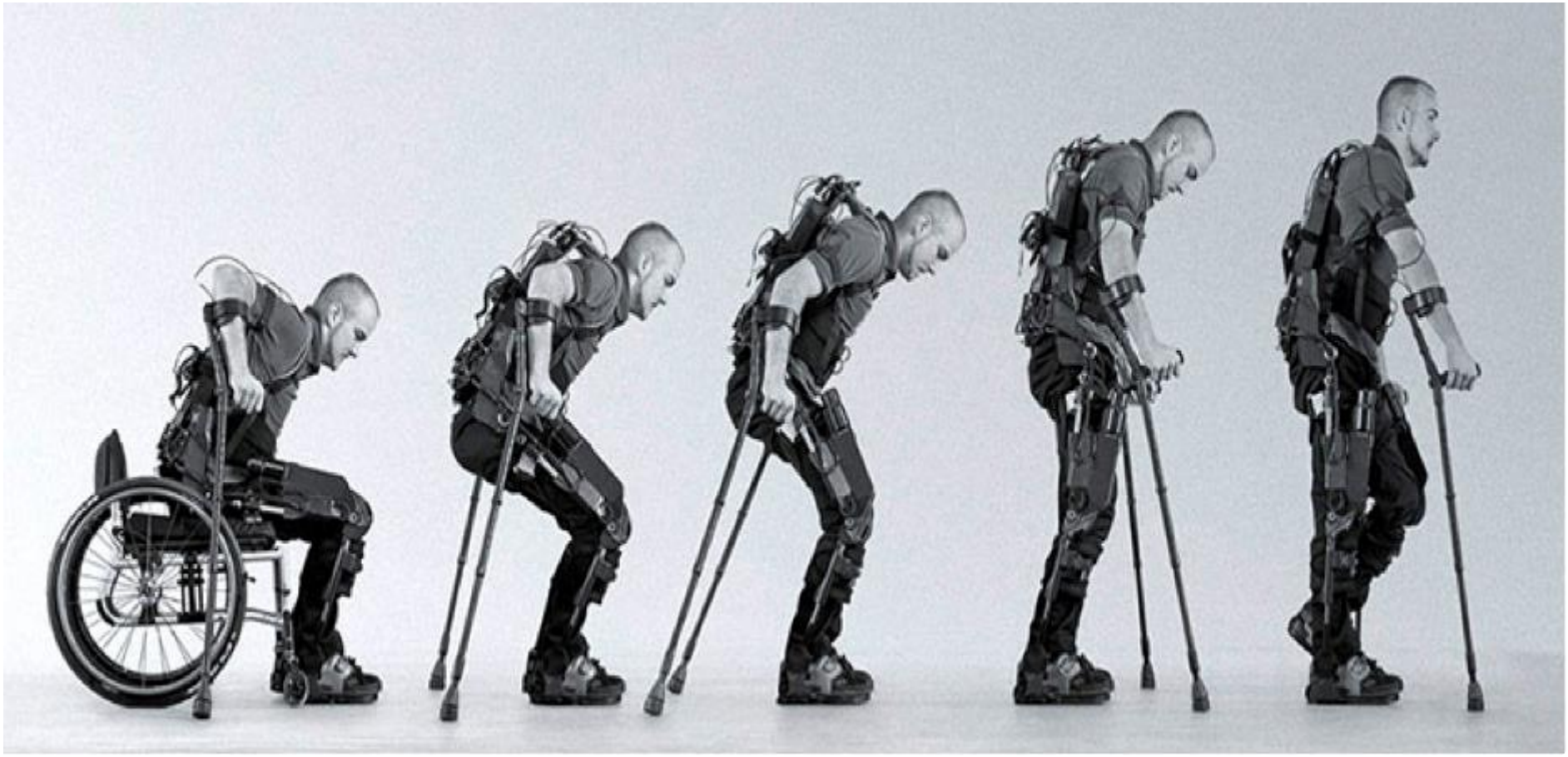




Some Dreams… for the aging population and the young impaired

Honda



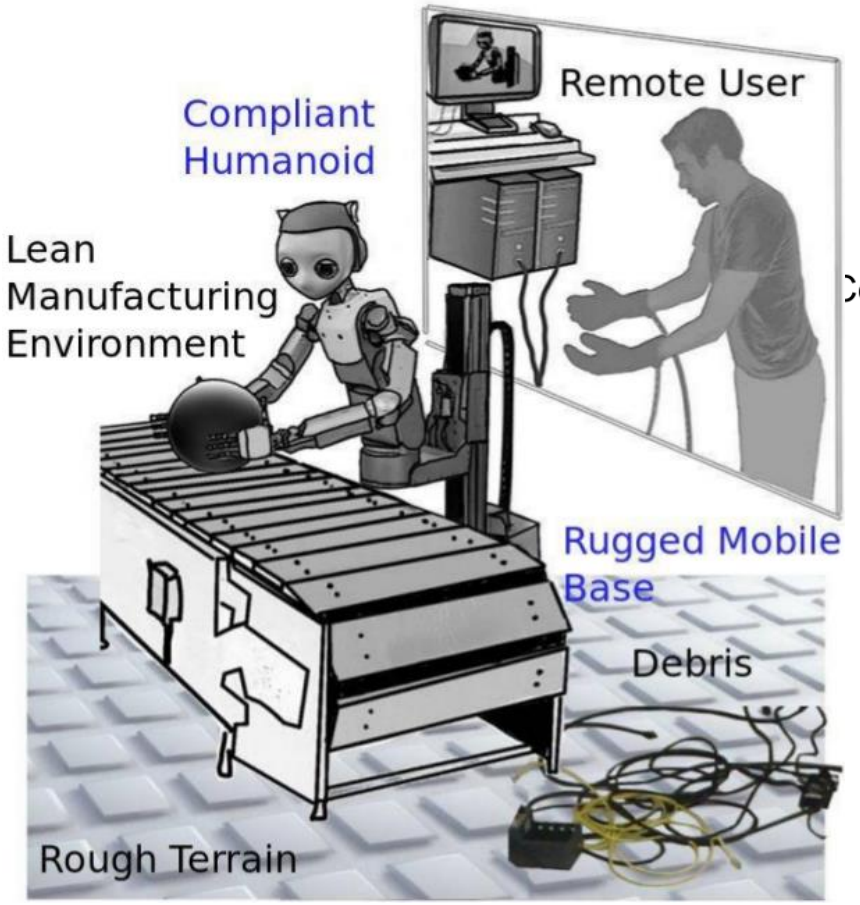


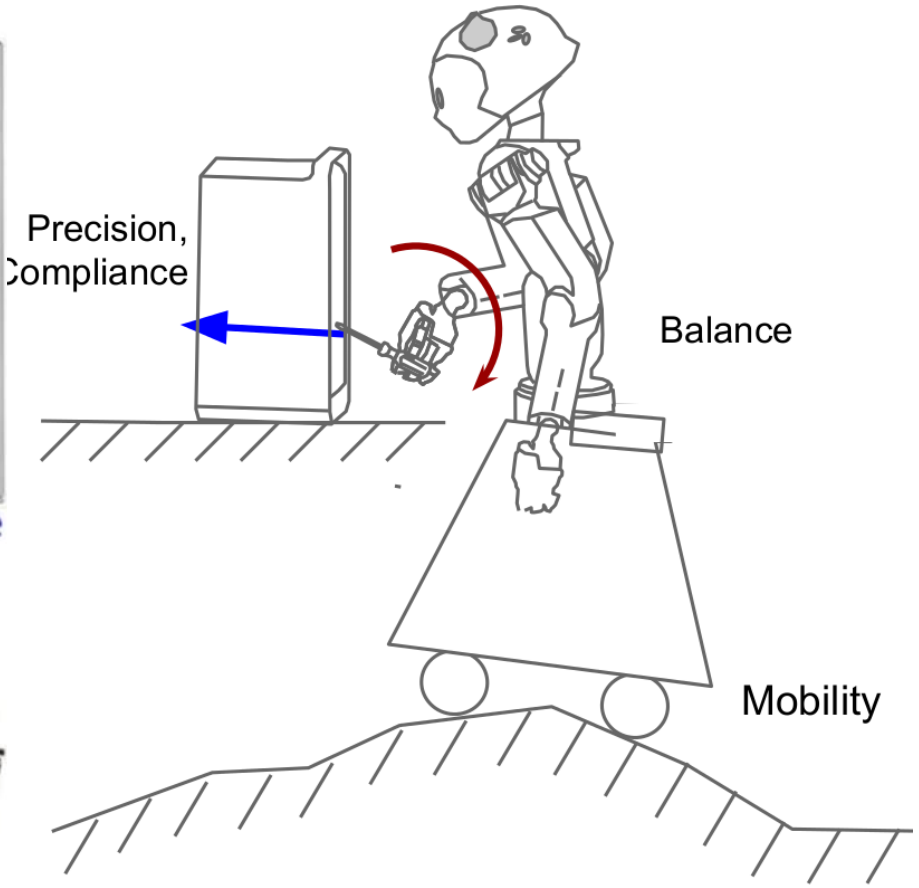
Ekso Bionics

What will humanoid robots in the future be like?

National Robotics Initiative

Mobile robots for manufacturing



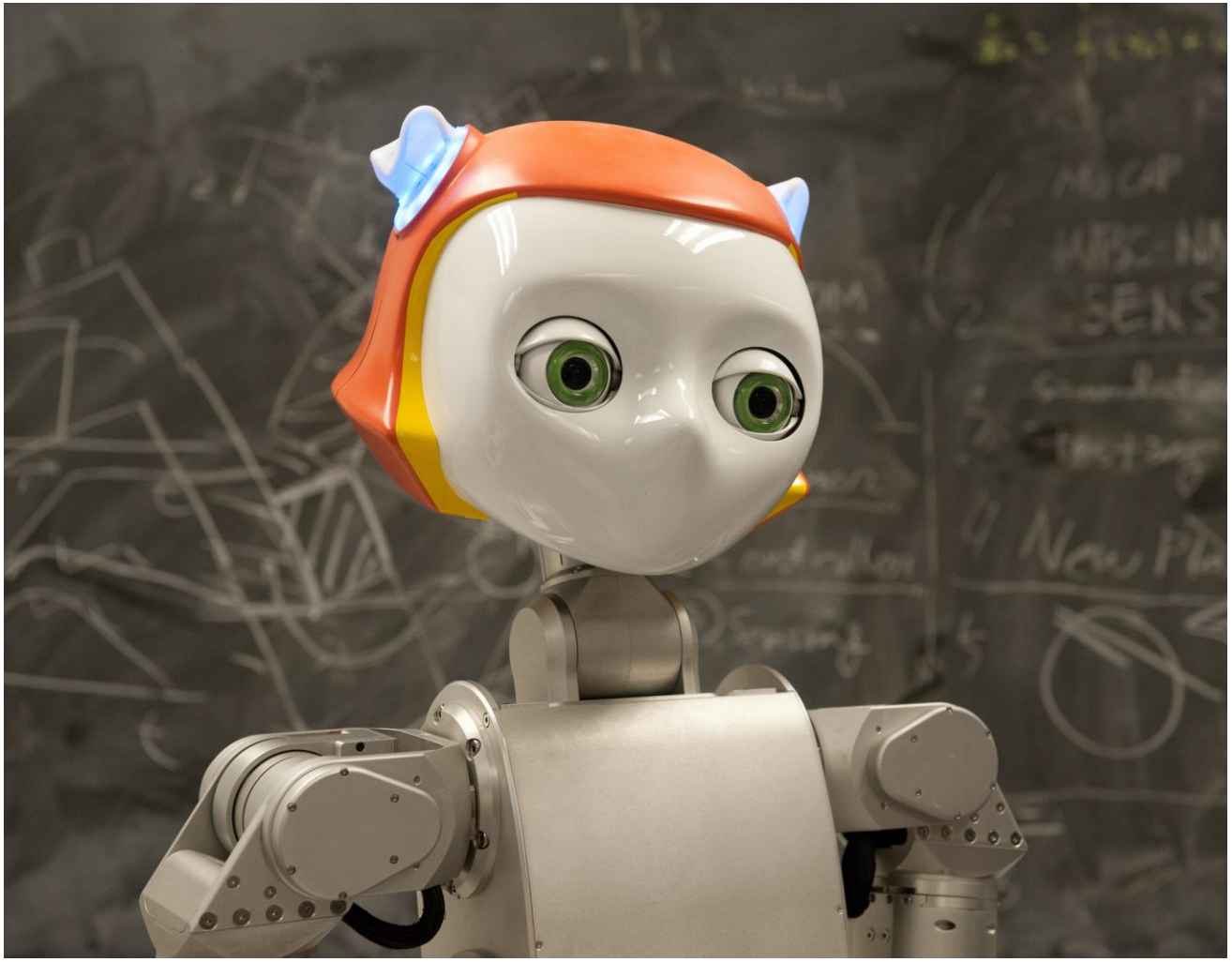


Twists and Turns: Planetary Exploration for NASA

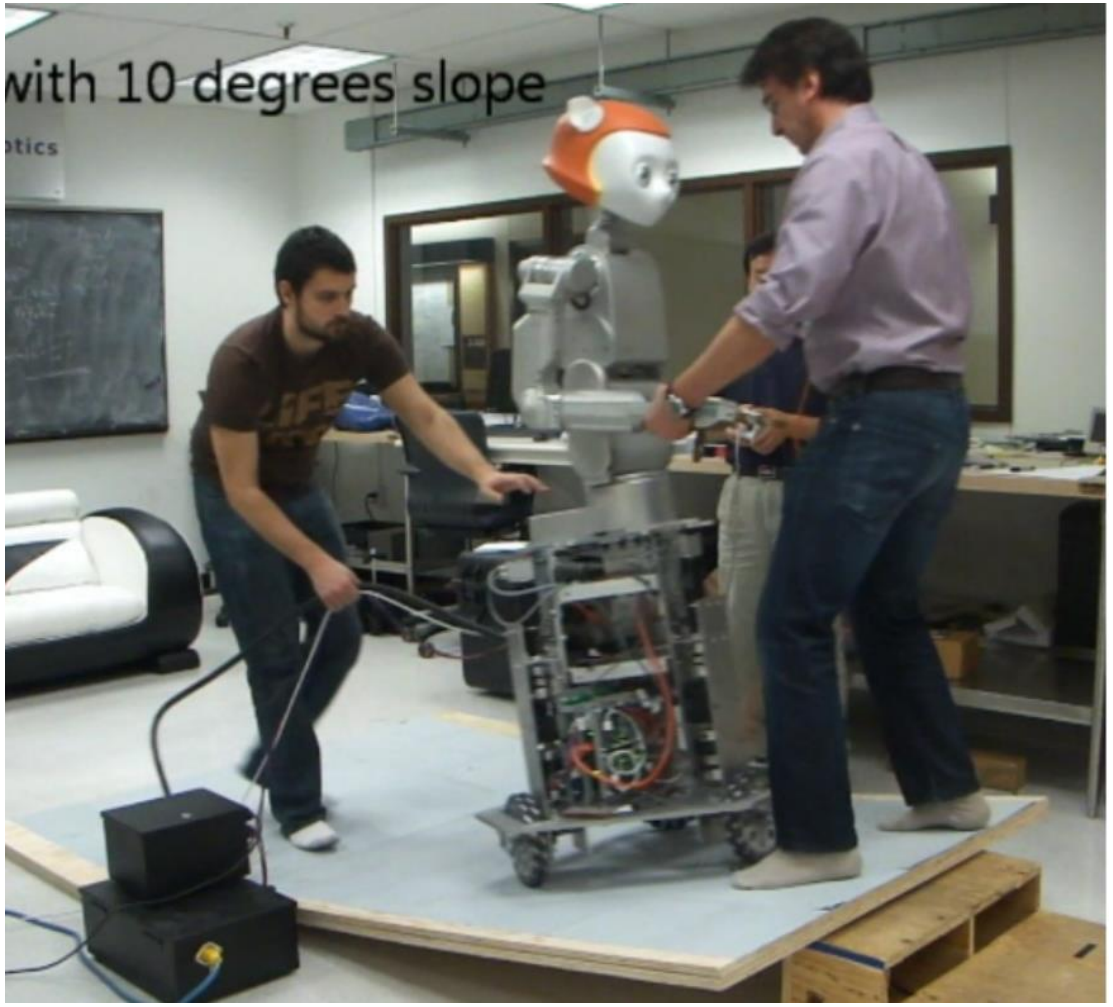
Key Problems

- How will robots interact with humans?
- How do we tell humanoid robots what to do?
- Will robots be able to do things as quickly as humans can?
- Will robots injure humans?

Dreamer's origins and the UT Human Centered Robotics Lab



Human-Robot Interaction at the core



[RSS 2012 Finalist Best Paper Award]
[Autonomous Robots 2013]

How does Dreamer move and interact with humans?

Experiments: Can robots collide safely with humans?

Meanwhile, DARPA's Robotics Challenge Came In

DARPA Inspiration and Goals

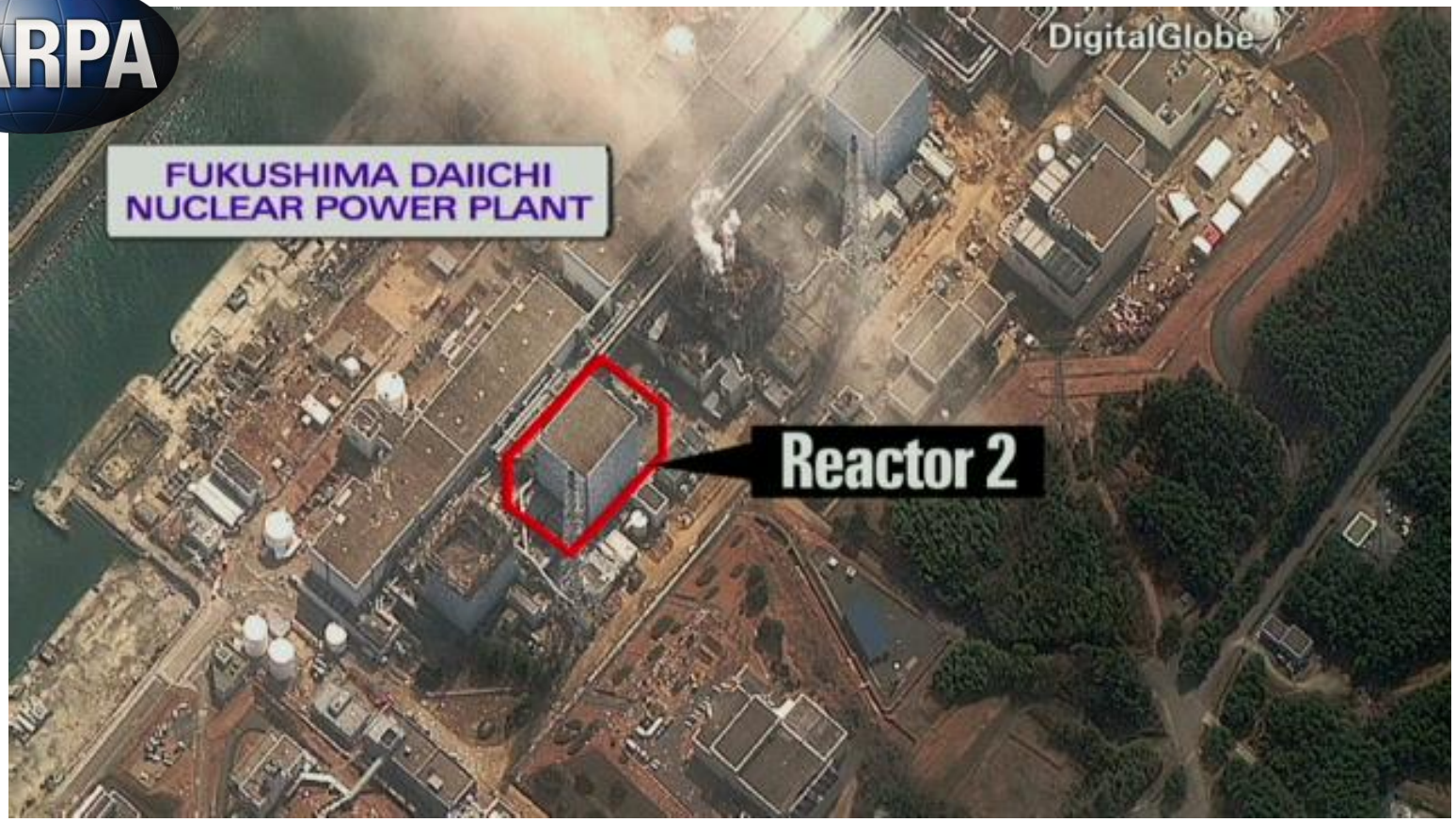
Man-Computer Symbiosis
J. C. R. Licklider (head of DARPA IPTO 1962)
IRE Transactions on Human Factors in Electronics, volume HFE-1, pages 4-11, March 1960

Fukushima - 2011

"... close study of the disaster's first 24 hours, before the cascade of failures carried reactor 1 beyond any hope of salvation, reveals clear inflection points where minor differences would have prevented events from spiraling out of control." *IEEE Spectrum,* November 2011 pg. 36.

1. Target disaster response in dangerous environments, and important DoD capability for HADR (Humanitarian Assistance and Disaster Relief) missions
2. Advance supervised autonomy, mobility, manipulation, and energetic efficiency.
3. Catalyze the robotics industry by developing a validated, real-time, operator-interactive simulator.
4. Welcome a wide range of international contributors including traditional and non-traditional DARPA performers from a variety of fields.

Meanwhile, DARPA's Robotics Challenge came in…



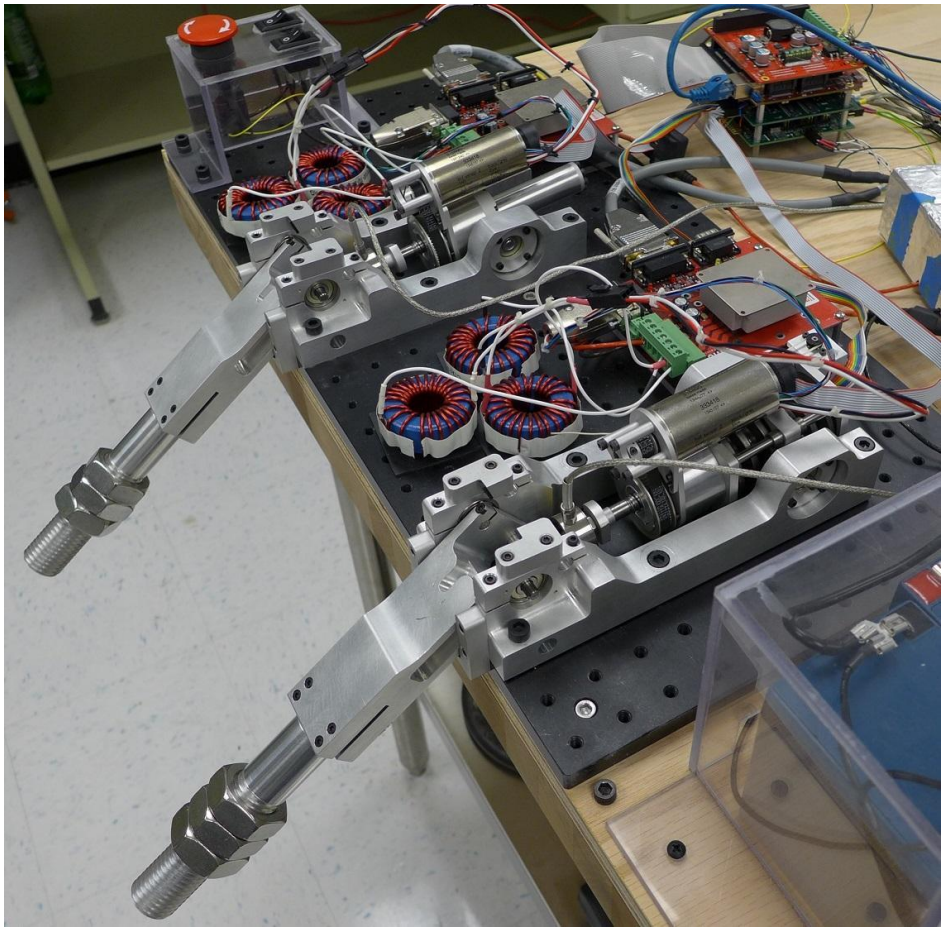
Robotics could have helped keep the situation from spiraling out of control.

Our lab teamed up with NASA on Building Valkyrie

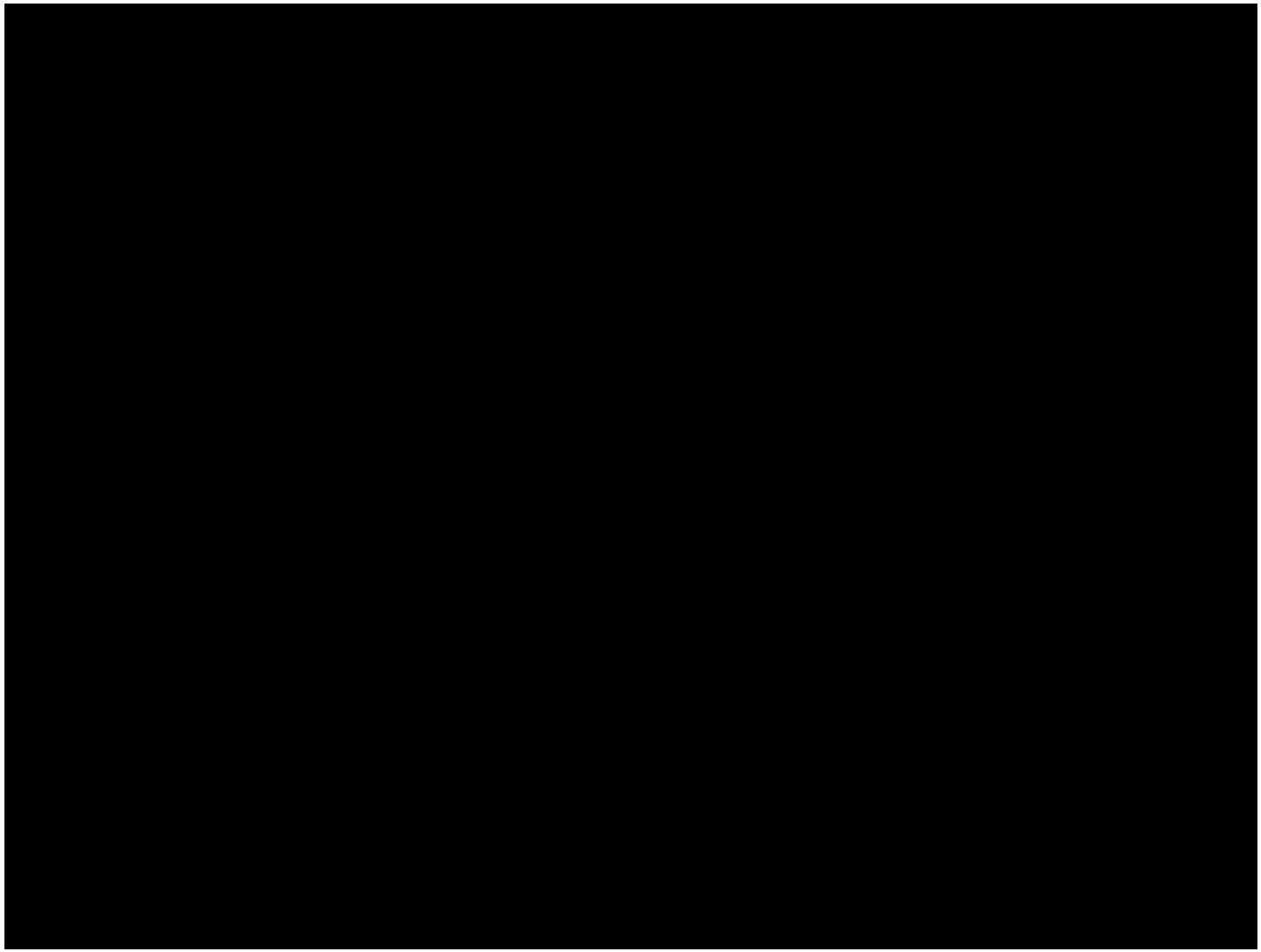
Valkyrie can mimic humans

Locked in the Apollo Lander Room

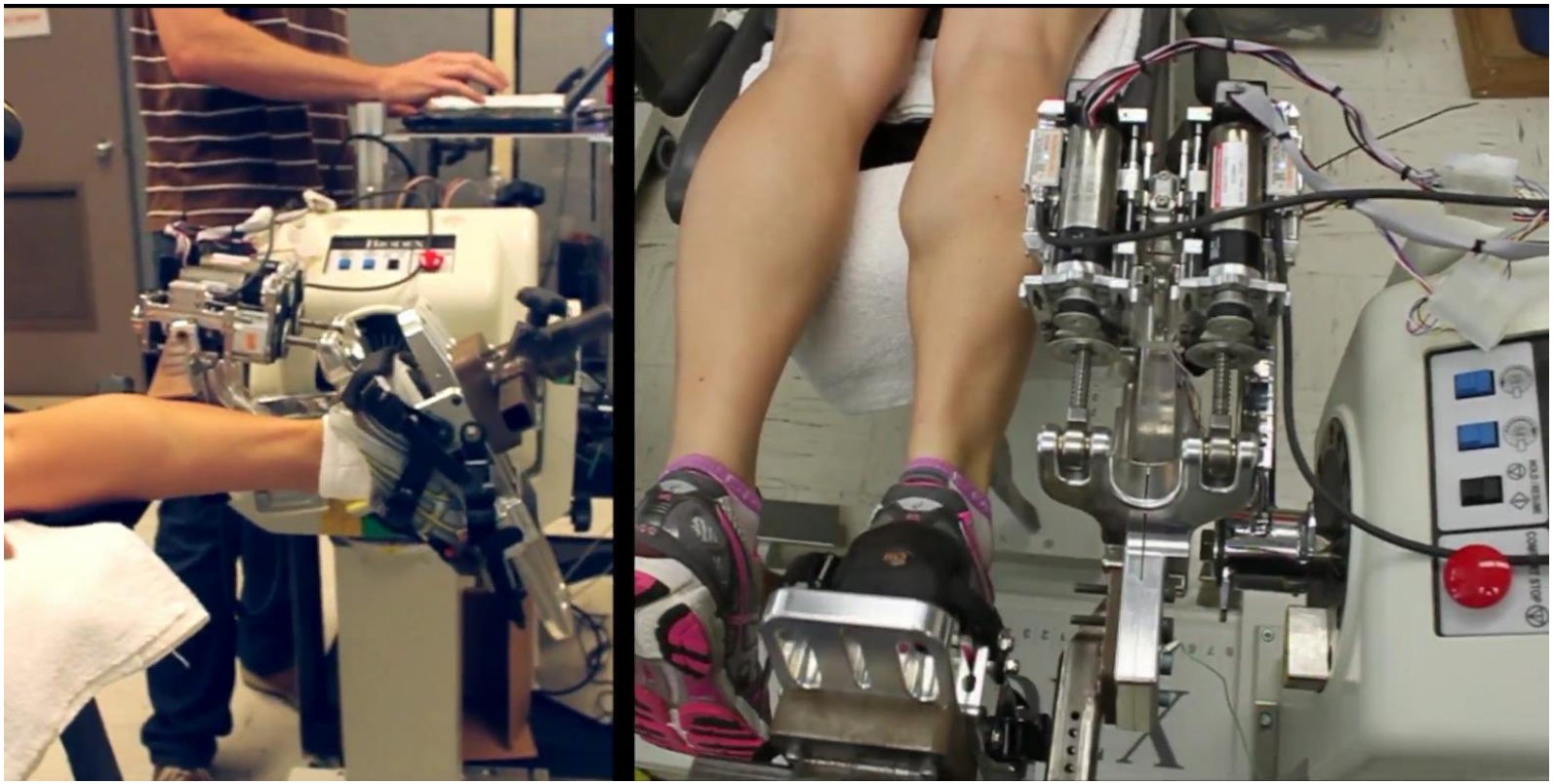
Students Developed Mechanics



Mechanics for Valkyrie

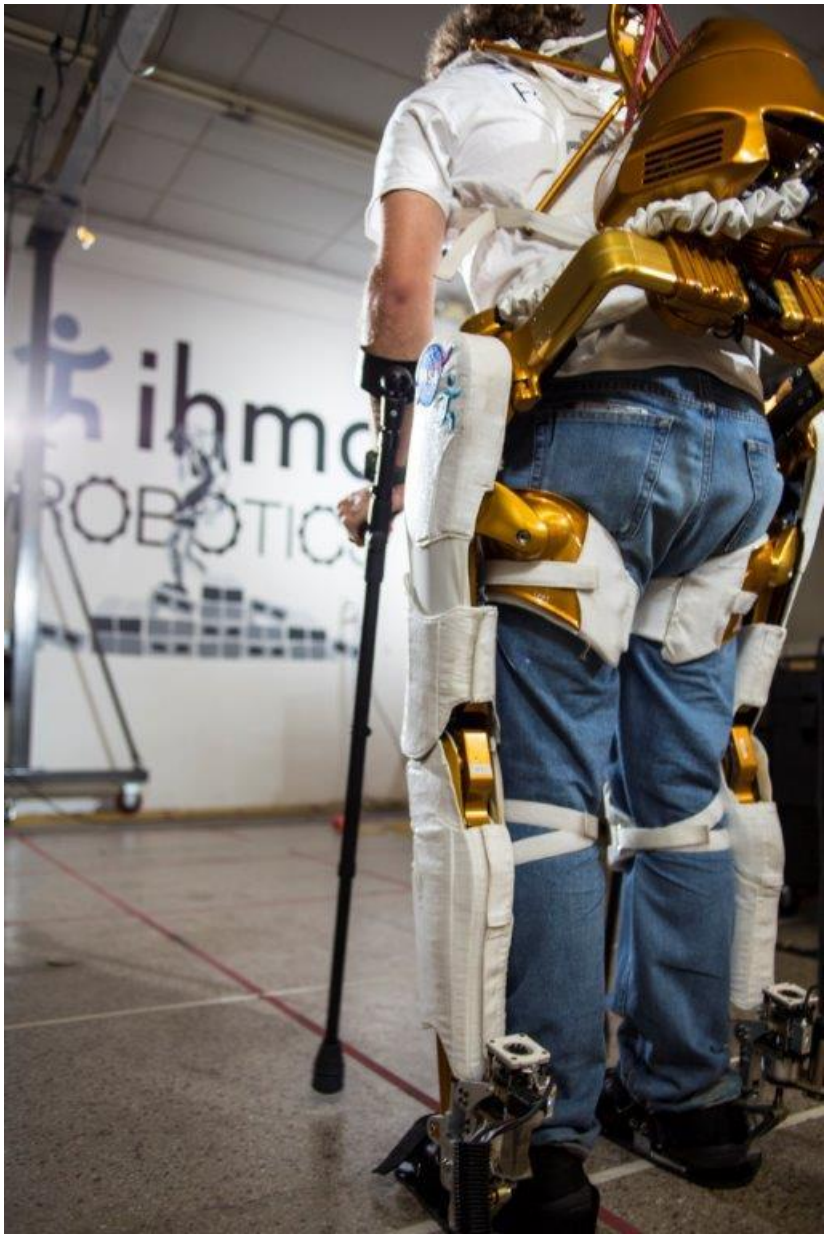


… and went to places



IHMC Rehabilitation System

… that taught us real-world needs



IHMC/NASA X2 Mina Exo

We made our dreams true at NASA

We felt like controlling Mars robots

We felt like controlling Mars robots

Valkyrie is a success today!

One very successful robot – Now at Google

Innovation in Human-Centered Robots

The Rise of Practical Humanoid Robots

- Recent events:

- Strong, ***reliable***, ***safe***, and size of a grown-up:

Honda Asimo (2000)

AIST HRP4 (2010)

SARCOS Primus (2011)

SCHAFT (2013)

NASA Valkyrie (2013)

Sandia Nat. Lab WANDERER (2015)

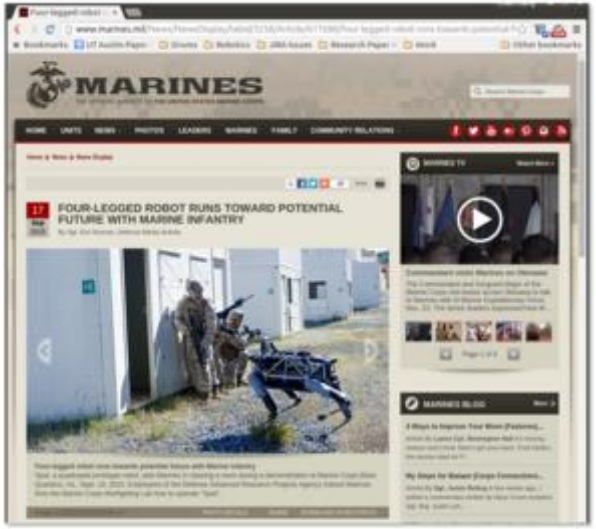
IIT Walkman (2015)

Boston Dynamics Atlas 2 (2015)

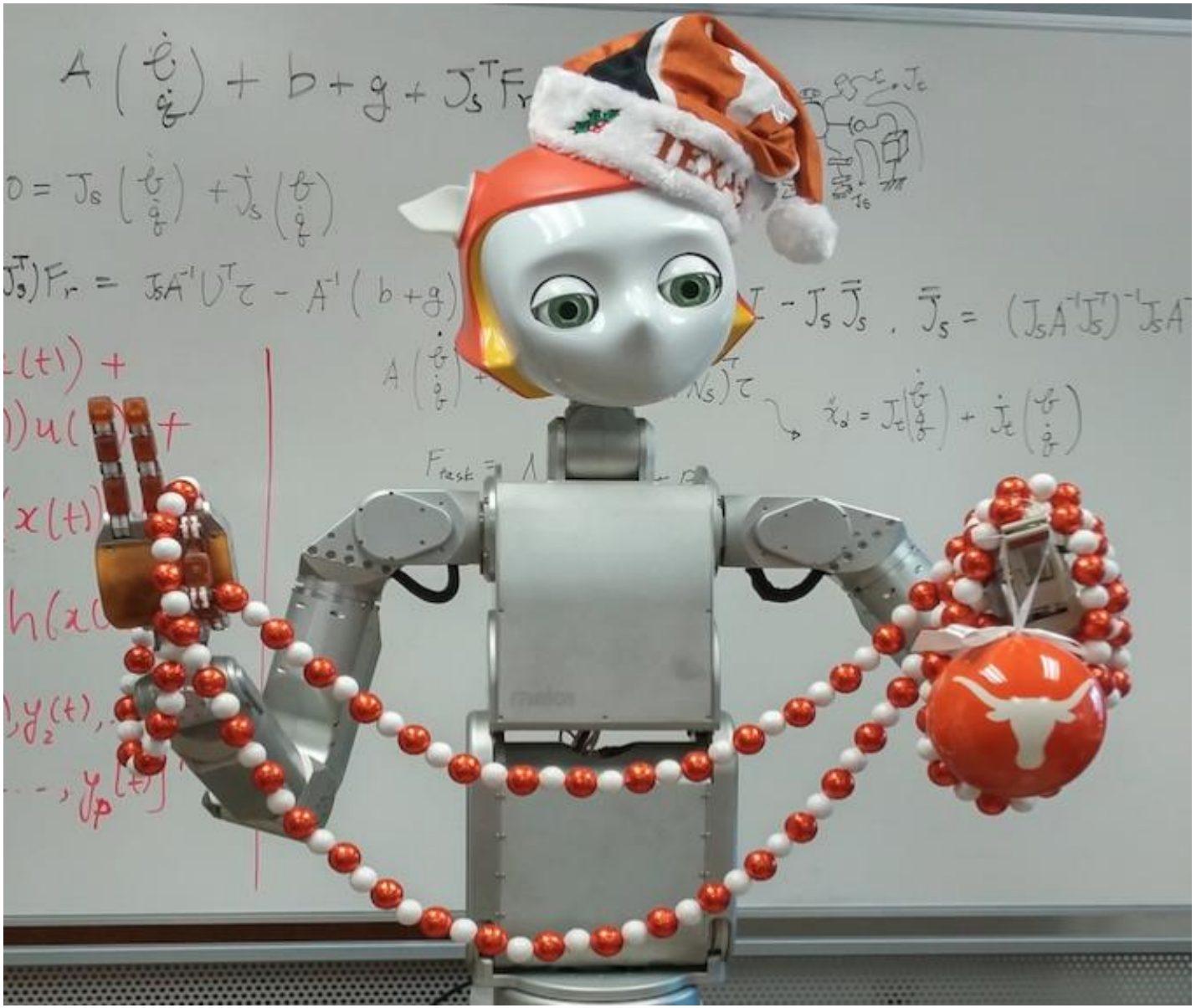
KAIST HRC-HUBO (2015)

Vision: Quantum Leap to Practicality

- Versatile, safe, and reliable human-centered robots
- Next-generation robots with class-leading actuators
- Integrating agility, manipulation, sensing, and awareness
- Demand: SOCOM, NASA, Navy, Marine Corps, DoE



THe EnD



Dr. Luis Sentis

Dr. Luis Sentis is the director of the UT Human Centered Robotics Lab. He has worked on several humanoid robots, and is the creator of the robot Dreamer, which appeared in the movie *Transformers Age of Extinction* with Mark Walhberg.

Dr. Sentis is an Assistant Professor in the Department of Mechanical Engineering at the University of Texas at Austin since 2010.