Humanoids of Our Future

Dr. Luis Sentis
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Hot Science Cool Talks

HUMANOIDs OF THE FUTURE

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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)

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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
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
CoM position $\mathbf{p}_{\text{com}} = (x, y, z)$
\[ \ddot{x} = \frac{g + \frac{d^2 z}{dx^2} \dot{x}^2}{z - (x - x_p) \frac{dz}{dx}} (x - x_p) \]
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
Ekso Bionics
What will humanoid robots in the future be like?
National Robotics Initiative
Mobile robots for manufacturing

- Compliant Humanoid
- Remote User
- Lean Manufacturing Environment
- Rugged Mobile Base
- Debris
- Rough Terrain
- Precision, Compliance
- Balance
- Mobility
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

with 10 degrees slope

[RSS 2012 Finalist Best Paper Award]
[Autonomous Robots 2013]
How does Dreamer move and interact with humans?
Experiments: Can robots collide safely with humans?

Collisions using a Calibrated Testbed
Meanwhile, DARPA’s Robotics Challenge Came In

DARPA Inspiration and Goals

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.

"... 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.
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:


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.