

## LUIS SENTIS, Ph.D.

Assistant Professor  
Mechanical Engineering Department  
The University of Texas at Austin  
204 East Dean Keeton St.  
Austin, TX 78712-1024  
Office phone: (650) 725-6952

Email: [luis.sentis@austin.utexas.edu](mailto:luis.sentis@austin.utexas.edu)  
URL: <http://ai.stanford.edu/~lsentis/>

## EDUCATION

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- Ph.D.** 2007, Electrical Engineering Department, Stanford University  
**M.Sc.** 2000, Electrical Engineering Department, Stanford University  
**B.Sc. (Honors Thesis)** 1996, School of Telecommunications and Electronics Engineering, Polytechnic University of Catalonia, Barcelona, Spain

## ACADEMIC AND PROFESSIONAL APPOINTMENTS

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- 2010 - present Assistant Professor, the University of Texas at Austin  
2007 - 2009 Postdoctoral Research Fellow, Computer Science Department, Stanford University  
2000 - 2007 Research Assistant, Computer Science Department, Stanford University  
2004 Teaching Assistant, Computer Science Department, Stanford University  
1998 - 2000 La Caixa Graduate Fellow, La Caixa Foundation, Stanford University  
1996 - 1998 R&D Control Engineer, Phase 2 Automation, Inc., Silicon Valley, USA

## RESEARCH CONTRIBUTIONS

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**Methodology for compliant control of humanoid robots** operating in highly constrained environments.

**Models for multi-contact behaviors** of legged robots operating in complex 3D environments.

**Embedded control architecture** for the implementation of interactive behaviors in the Honda Asimo humanoid robot, and the Stanford AI robotic platform.

**Direct motion capture tracking algorithm** for extracting human kinematic and dynamic data from motion capture and wearable sensor systems.

## AWARDS

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2010 Grant from Willow Garage on embedded control architecture for personal robots

2008-2009 Grant from The Boeing Company for research on unmanned vehicle coordination

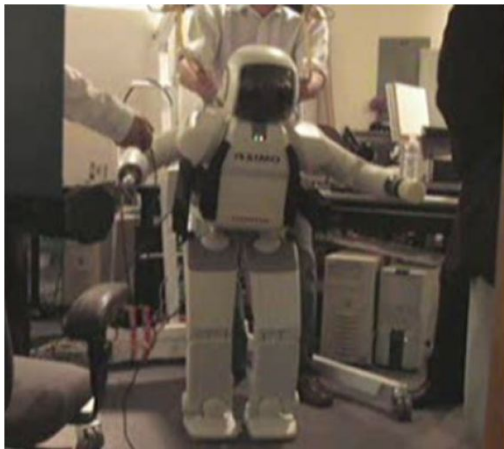
2005 Finalist for Best Student Paper Award, International Conference of Robotics and Automation (ICRA)

1998-2000 La Caixa Foundation Graduate Fellowship, Stanford University

1996 Honors for B.Sc. Thesis, Polytechnic University of Catalonia, Barcelona, Spain

## CURRENT PROJECTS

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Title: Compliant control of humanoid robots.

Goal: To enable humanoid robots to autonomously assist humans in daily chores.

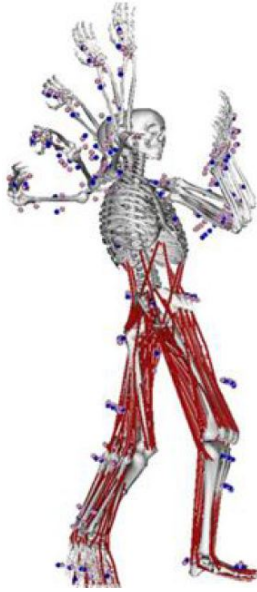
Methods: (1) Compliant control methods for the generation and mapping of advanced human-like skills in highly constrained environments. (2) Multi-contact manipulation and balance stability models. (3) Embedded software control platform for humanoid robots. (4) Artificial Intelligence (AI) methods for semantic and geometric reasoning. (5) Development of manipulation systems incorporating mobile stages equipped with mapping and contact sensors, and distributed computer systems.



Title: Coordination of large-scale multi-robot systems.

Goal: To coordinate operation of a large number of manned and unmanned vehicles.

Methods: (1) Prioritized potential field techniques to implement rich task and formation behaviors. (2) Geometric planners with fast deformation methods to deal with unknown terrain. (3) Control models to deal with network and geographical constraints. (4) Field implementation in air and ground systems.



Title: Analysis and control of human neuromuscular function.

Goal: To enable mobility of impaired human patients.

Methods: (1) Balance and multi-contact postural models to understand physical interactions. (2) Center of mass and posture feedback control methods for muscular activation modulation. (3) Develop wearable sensor systems (such as inertial, pressure, electromyography devices) to gather information on postural status. (4) Development of novel feedback based modulation policies to control Functional Electrical Stimulation (FES) devices for muscle activation. (5) Design and development of exoskeletal actuators to complement the function of FES systems.

## RESEARCH INTERESTS

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- **Models and control of compliant and dynamic legged locomotion**
  - **Goal:** To develop models, control, and planning methods for biped and multi-legged locomotion in both uneven discontinuous or flat surfaces, with special emphasis on compliance and contact planning
  - **Methods:** Hybrid underactuated dynamics, models of compliance and internal forces, analysis of nonlinear dynamics, contact planning
- **Feedback Control of Human Gait Function Using Functional Electrical Stimulation**
  - **Goal:** To generate postural motion and contact patterns for the guidance of neuromuscular function needed to enable assisted postural stance and walk on the disabled
  - **Methods:** Analysis of human kinematics and dynamics using inertial, force, and EMG sensors, models of neuromuscular activity, identification and learning of neural activation patterns, wearable sensor systems, feedback using functional electrical stimulation
- **Multi-Robot Coordination of Unmanned Vehicles under Network and Geographical Constraints**
  - **Goal:** To develop a methodology for the implementation of advanced cooperative skills in multi-robot networks
  - **Methods:** Multi-objective gradient descent, formation primitives, hierarchical control, semantic planning
- **Development of biomechatronic systems**
  - **Goal:** To study and build compliant robotic systems for interactive robotic applications and rehabilitation devices
  - **Methods:** Bionic artificial muscles, spherical actuators, parallel kinematics and dynamics, stiffness control

## COLLABORATORS

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**Stanford School of Medicine**, Prof. Jessica Rose: analysis of neuromuscular function, and Prof. Graham Creasey: orthopedic surgery / implanted functional electrical stimulation (FES) devices

**The Boeing Company**, Arun Ayyagari and Dr. Susan Ying. Large scale coordination of unmanned vehicles

**Laboratoire d'Informatique, de Robotique et de Microelectronique de Montpellier, France**, Prof. Philippe Fraisse: rehabilitation, humanoid robotics

**UC Berkeley CITRIS**, (<http://www.citris-uc.org/>), Prof. Ruzena Bajcsy. Augmented reality.

**Xulu Inc.**, 3D social networks, (<http://www.xulu.com/>), Nanci Solomon: CEO, James Solomon: Chairman. 3D social networks.

**Willow Garage Inc.**, personal robotics, (<http://www.willowgarage.com/>), Eric Berger: Co-director, and Dr. Kurt Konoldige: Senior Scientist. Personal robotics.

## FUNDING

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Proposed and obtained with Prof. Oussama Khatib a \$350,000 grant from **The Boeing Company** for the development of control, planning, and behavioral methods for multi-vehicle coordination, 2008-2010

Proposed and obtained with Prof. Oussama Khatib and Dr. Roland Philippsen a \$100,000 grant from **Willow Garage Inc.** for the development of an embedded controller for personal robotics, 2010, (collaboration committed, award's amount pending)

Participated on developing an **NIH ARRA proposal** with Prof. Jessica Rose from Stanford Medical School on Artificial Walking Technologies for FES Assisted Gait in Cerebral Palsy, 2010-2012, (award pending)

Developing a proposal with **Xulu Inc.** on the development of human motion controllers for augmented reality applications, 2010, (terms under development)

## PUBLICATIONS (Number of Google citations on main publications: 200)

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Website: <http://ai.stanford.edu/~lsentis/files/publications.html>

### Peer Reviewed Journal Publications and Book Chapters:

1. **Luis Sentis**, Jaeheung Park, Oussama Khatib, "Compliant Control of Multi-Contact and Center of Mass Behaviors in Humanoid Robots", *IEEE Transactions in Robotics*, (accepted, in press 2010).
2. **Luis Sentis**, chapter title: "Compliant Control of Whole-Body Multi-Contact Behaviors in Humanoid Robots", book name: "Motion Planning for Humanoid Robots", *Springer Global Editorial*, *Invited Book Chapter*, (in press 2009)
3. Oussama Khatib, Emel Demircan, Vincent DeSapio, **Luis Sentis**, Thor Besier, Scott Delp, "Task-based methods for the reconstruction and analysis of human motion", *Journal of Biomechanics* (in press), 2009.

4. **Luis Sentis** and Oussama Khatib, "Synthesis of whole-body behaviors through hierarchical control of behavioral primitives", *International Journal of Humanoid Robotics*, 2(4):505-518, December 2005. [Google citations: 76]
5. Oussama Khatib, **Luis Sentis**, Jae-Heung Park, James Warren, "Whole Body Dynamic Behavior and Control of Human-Like Robots", *International Journal of Humanoid Robotics*, 1(1): 1-15, March 2004. [Google citations: 73]
6. Oussama Khatib, Oliver Brock, K.C. Chang, Diego Ruspini, **Luis Sentis**, Sriram Viji, "Human-Centered Robotics and Interactive Haptic Simulation" *International Journal of Robotics Research*, 23(2):167, February 2004. [ Google citations: 40]
7. Oussama Khatib, Oliver Brock, Kyong-Sok Chang, François Conti, Diego Ruspini, and **Luis Sentis**. "Robotics and Interactive Simulation", *Communications of the ACM*, 45(3): 46-51, March 2002. [Google citations: 38]
8. Santiago Silvestre, **Luis Sentis**, and Luis Castañer, "A Fast Low-Cost Solar Cell Spectral Response Measurement System with Accuracy Indicator", *IEEE Transactions on Instrumentation and Measurement*, 48(5): 944-948, October 1999.

#### **Peer Reviewed Conference Publications:**

1. **Luis Sentis**, Jaeheung Park, Oussama Khatib, "Modeling and Control of Multi-Contact Centers of Pressure and Internal Forces in Humanoid Robots", *IEEE International Conference on Intelligent Robots and Systems (IROS)*, St. Louis, 2009.
2. **Luis Sentis**, Mike Mintz, Arun Ayyagari, Craig Battles, Susan Ying, Oussama Khatib, "Control Methods for Multiple Vehicle Coordination with Network Management Constraints", *The International Symposium of Industrial Electronics (ISIE 2009)*, Seoul, Korea, July 2009.
3. Roland Philippsen, Negin Nejati, **Luis Sentis**, "Bridging the Gap Between Semantic Planning and Continuous Control for Mobile Manipulation Using a Graph-Based World Representation", *International Workshop on Hybrid Control of Autonomous Systems (HYCAS 2009)*, Pasadena, USA, July 2009.
4. Emel Demircan, **Luis Sentis**, Vincent De Sapio, and Oussama Khatib, "Human motion reconstruction by direct control of marker trajectories", *Advances in Robot Kinematics (ARK)*, Springer, 11th International Symposium, Batz-sur-Mer, France, June 2008. [Google citations: 9]
5. Oussama Khatib, **Luis Sentis**, and Jae-Heung Park, "A Unified Framework for Whole-Body Humanoid Robot Control With Multiple Constraints and Contacts", *Springer Tracts in Advanced Robotics - STAR Series, European Robotics Symposium (EURON)*, Prague, Czech Republic, March 2008. [Google citations: 5]
6. **Luis Sentis** and Oussama Khatib, "A Whole-Body Control Framework for Humanoids Operating in Human Environments", *IEEE International Conference in Robotics and Automation*, Orlando, USA, May 2006. [Google citations: 40]
7. **Luis Sentis** and Oussama Khatib, "Control of Free-Floating Humanoid Robots Through Task Prioritization", *Proceedings of the IEEE International Conference in Robotics and Automation*, Barcelona, Spain, April 2005. **Finalist for the Best Student Paper Award.** [Google citations: 22]

8. **Luis Sentis** and Oussama Khatib, “Prioritized multi-objective dynamics and control of robots in human environments”, *IEEE-RAS/RSJ International Conference on Humanoid Robots*, Santa Monica, USA, November 2004. [**Google citations: 22**]
9. Oussama Khatib, James Warren, Vincent De Sapio, **Luis Sentis**, “Human-Like Motion From Physiologically Based Potential Energies”, *Advances in Robot Kinematics*, J. Lenarcic and C. Galletti (Eds.), pp. 149-163, Kluwer Academic Publishers, 2004.
10. Oussama Khatib, Oliver Brock, K.C. Chang, Diego Ruspini, **Luis Sentis**, Sriram Viji, “Robots for the Human and Interactive Simulations”, *Proceedings of the 11th World Congress in Mechanism and Machine Science*, Tianjin, China, 2003.
11. Oussama Khatib, Oliver Brock, Kyong-Sok Chang, Diego Ruspini, **Luis Sentis**, and Sriram Viji, “Human-Centered Robotics and Interactive Haptic Simulation”, *Robotics Research, the Tenth International Symposium (ISRR’2001)*, Lorne, Victoria, Australia, Nov, 2001, Springer-Verlag, 2002. [**Google citations: 31**]
12. Oussama Katib, Oliver Brock, Kyong-Sok Chang, Diego Ruspini, **Luis Sentis**, “Efficient algorithms for robots with human-like structures and interactive haptic simulation”, *Advances in Robot Kinematics: Theory and Applications*, Eds, Lenarcic, J. and Thomas, F., Kluwer Academic Publishers 2002, pp. 89-98.

## SEMINARS

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1. SEMINAR: *Synthesis of Whole-Body Skills for Human Environments*, **The University of Tokyo**, Tokyo, Japan, July 2009.
2. SEMINAR: *Synthesis of Whole-Body Skills for Human Environments*, **Advanced Telecommunications Research Institute (ATR)**, Seika City, Japan, July 2009.
3. INVITED SEMINAR: *Synthesis of Whole-Body Skills in Highly Constrained Environments*, **Willow Garage**, Menlo Park, USA, June 2009.
4. STRATEGIC REVIEW PRESENTATION FOR BOEING’S CTO: *Multi-Vehicle Coordination and Control Under Network and Geographical Constraints (Results 2008-2009)*, **Stanford University**, April 2009.
5. INVITED SEMINAR: *Modeling and Control of Advanced Skills in Mobile Robots and Humanoids*, **University of Texas at Austin, Department of Computer Science**, April 2009.
6. INVITED SEMINAR: *Modeling and control of manipulation, multi-contact and formation behaviors in humanoids and multi-robot systems*, **University of Illinois at Urbana Champaign, Mechanical Science and Engineering Department**, February 2009.
7. GRANT REVIEW PRESENTATION: *Multi-Vehicle Coordination and Control Under Network and Geographical Constraints*, **The Boeing Company**: Network Systems Laboratory, Seattle, February 2009.
8. INVITED SEMINAR: *Analysis and Control of Contact Centers of Pressure and Internal Forces in Humanoid Robots*, **Laboratoire d’Informatique, de Robotique et de Microelectronique de Montpellier, France**, January 2009.

9. INVITED WORKSHOP TALK: *Control of Humanoid Robots*, **Workshop on Cognitive Animation, (CogAnim 2008)**, Yosemite National Park, USA, June 2008.
10. INVITED WORKSHOP TALK: *Task-Based Control Methods for Humanoid Systems*, *Neural Information Processing Systems Conference*, **Neural Information Processing Systems Conference (NIPS 2007)**, Whistler, Canada, December 2007.
11. INVITED WORKSHOP TALK: *Synthesis and control of whole-body behaviors in humanoid systems*, **IEEE-RAS International Conference on Humanoid Robots (Humanoids 2007)**, Pittsburgh, USA, December 2007.
12. INVITED SEMINAR: *Robotic Methods for the Synthesis, Reconstruction, and Analysis of Human Motion*, **Bioengineering Department, Stanford University**, November 2007.
13. SEMINAR: *Computational Tools for Human Motion Analysis*, **Laboratoire d'Informatique, de Robotique et de Microelectronique de Montpellier, France**, July 2007.
14. INVITED WORKSHOP TALK: *Realtime Control of Humanoid Robots*, **IEEE International Conference of Robotics and Automation (ICRA 2007)**, Rome, Italy, May 2007.
15. INVITED WORKSHOP TALK: *On Autonomous Robot Motion*, **IEEE International Conference of Robotics and Automation (ICRA 2006)**, Orlando, USA, May 2006.
16. INVITED SEMINAR: *Control of Mobile Robots*, **Mechanical Engineering Department, The University of Texas at Austin**, July 2006.
17. INVITED SEMINAR: *Torque Control Strategies for Humanoid Robots*, **Carnegie Mellon University (CMU)**, May 2006.
18. INVITED SESSION OPENING TALK: *Humanoid Robots Session*, **5<sup>th</sup> Japan-American Frontiers of Engineering Symposium (JAFOE 2005)**, National Academy of Engineering, San Jose, USA, November 2005.
19. SEMINAR: *Control of Humanoid Robots*, **Advanced Telecommunications Research Institute (ATR)**, Kyoto, Japan, July 2005.
20. INVITED SEMINAR: *Robotic Methods for the Analysis of Human Motion*, **Bioengineering Department, Stanford University**, February 2004.
21. SEMINAR: *Control of Mobile Robots*, **Department of Mathematics and Computer Science, The Weizmann Institute Of Science, Rehovot, Israel**, May 2003.
22. FUND-RAISING TALKS: *Overview of Robotics Research at Stanford*, **The Jonsson Family (Co-Founders of Texas Instruments), Artificial Intelligence Laboratory, Stanford University**, February 2004 and February 2003.
23. INVITED SEMINAR/LECTURE: *Robotics Manipulation Methods*, **Computer Science Department, Polytechnic University of Valencia, Spain**, May 2001.
24. INVITED SEMINAR/LECTURE: *Robotic Manipulation Methods*, **Computer Science Department, University of Murcia, Spain**, May 2001.
25. INVITED SEMINAR: *Control of Mobile Robots*, **Honda Research Institute, Mountain View, USA**, April 2001.

## **PROFESSIONAL CAREER**

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1. **Assistant Professor**  
**Mechanical Engineering Department** **2010-present**  
**The University of Texas at Austin**
  - Laboratory of Human-Centered Robotics
  - Teaching course: Topics in Human-Centered Robotics
  
2. **Postdoctoral Research Fellow** **2007-2009**  
**Robotics and Artificial Intelligence Laboratory**  
**Computer Science Department** **Stanford University**
  
3. **Graduate Research Assistant** **2000-2007**  
**Robotics and Artificial Intelligence Laboratory**  
**Computer Science Department** **Stanford University**
  
4. **La Caixa Fellow** **1998-1999**  
**Department of Electrical Engineering** **Stanford University**
  
5. **R&D Control Engineer** **1996-1998**  
**Phase 2 Automation** **Sillicon Valley, USA**
  
6. **Undergraduate Research Assistant** **1995-1996**  
**Laboratory of Solid State Electronics**  
**Polytechnic University of Catalonia** **Barcelona, Spain**

## **PROFESSIONAL SOCIETIES**

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- Institute of Electrical and Electronics Engineers, Member (IEEE)
- Association for the Advancement of Artificial Intelligence, Member (AAAI)