Berkeley and AI

Artificial Intelligence (AI)

Overview

Work in Artificial Intelligence in the EECS department at Berkeley involves foundational research in core areas of knowledge representation, reasoning, learning, planning, decision-making, vision, robotics, speech and language processing. There are also significant efforts aimed at applying algorithmic advances to applied problems in a range of areas, including bioinformatics, networking and systems, search and information retrieval. There are active collaborations with several groups on campus, including the campus-wide vision sciences group, the information retrieval group at the I-School and the campus-wide computational biology program. There are also connections to a range of research activities in the cognitive sciences, including aspects of psychology, linguistics, and philosophy. Work in this area also involves techniques and tools from statistics, neuroscience, control, optimization, and operations research.Berkeley Artificial Intelligence Research Lab (BAIR).

Topics

- ### Learning and Probabilistic Inference:

  Graphical models. Kernel methods. Nonparametric Bayesian methods. Reinforcement learning. Problem solving, decisions, and games.

- ### Knowledge Representation and Reasoning:

  First order probabilistic logics. Symbolic algebra.

- ### Search and Information Retrieval:

  Collaborative filtering. Information extraction. Image and video search. Intelligent information systems.

- ### Speech and Language:

  Parsing. Machine translation. Speech Recognition. Context Modeling. Dialog Systems.

- ### Vision:

  Object Recognition. Scene Understanding. Human Activity Recognition. Active Vision. Grouping and Figure-Ground. Visual Data Mining.

- ### Robotics:

  Motion Planning, Computational Geometry. Computer assisted surgical and medical analysis, planning, and monitoring. Unmanned Air Vehicles

Research Centers

- Berkeley Artificial Intelligence Research Lab
- Berkeley Laboratory for Information and System Sciences
- Center for Human Compatible Artificial Intelligence
- CITRIS People and Robots
- FHL Vive Center for Enhanced Reality
- International Computer Science Institute
- VeHICaL: Verified Human Interfaces, Control, and Learning for Semi-Autonomous Systems
- Video and Image Processing Lab

Faculty

Primary

- Pieter Abbeel
- Peter Bartlett
- John DeNero
- Anca Dragan
- Alexei (Alyosha) Efros
- Joseph Gonzalez
- Jiantao Jiao
- Michael Jordan
- Daniel Klein
- Sergey Levine
- Michael Lustig
- Yi Ma
- Jitendra Malik (coordinator)
- Gireeja Ranade
- Jaijeet Roychowdhury
- Stuart J. Russell
- S. Shankar Sastry
- Dawn Song
- Martin Wainwright

Secondary

- Venkat Anantharam
- Ruzena Bajcsy
- Alexandre Bayen
- John F. Canny
- Thomas Courtade
- Trevor Darrell
- Laurent El Ghaoui
- Richard J. Fateman
- Jerome A. Feldman
- Gerald Friedland
- Ken Goldberg
- Marti Hearst
- Jennifer Listgarten
- Ren Ng
- Benjamin Recht
- Anant Sahai
- Alberto L. Sangiovanni-Vincentelli
- Somayeh Sojoudi
- Avideh Zakhor

Faculty Awards

- MacArthur Fellow: Dawn Song, 2010.
- Okawa Prize: Avideh Zakhor, 2004.
- National Academy of Sciences (NAS) Member: Jitendra Malik, 2015. Michael Jordan, 2010.
- National Academy of Engineering (NAE) Member: Jitendra Malik, 2011. Michael Jordan, 2010. S. Shankar Sastry, 2001. Alberto L. Sangiovanni-Vincentelli, 1998. Ruzena Bajcsy, 1997.
- American Academy of Arts and Sciences Member: Jitendra Malik, 2013. Michael Jordan, 2010. Ruzena Bajcsy, 2007. S. Shankar Sastry, 2003.
- Berkeley Citation: S. Shankar Sastry, 2018. Jerome A. Feldman, 2009.
- UC Berkeley Distinguished Teaching Award: John DeNero, 2018. Daniel Klein, 2010. Alberto L. Sangiovanni-Vincentelli, 1981.
- Sloan Research Fellow: Anca Dragan, 2018. Ren Ng, 2017. Michael Lustig, 2013. Benjamin Recht, 2011. Pieter Abbeel, 2011. Alexei (Alyosha) Efros, 2008. Dawn Song, 2007. Daniel Klein, 2007. Martin Wainwright, 2005.

Related Courses

- CS 188. Introduction to Artificial Intelligence
- CS 189/289A. Introduction to Machine Learning
- CS C280. Computer Vision
- CS C281A. Statistical Learning Theory
- CS C281B. Advanced Topics in Learning and Decision Making
- CS 287. Advanced Robotics
- EE 290P. Advanced Topics in Electrical Engineering: Advanced Topics in Bioelectronics

Courses Offered

- CS 188. Introduction to Artificial Intelligence
- CS 189/289A. Introduction to Machine Learning
- CS C280. Computer Vision
- CS C281A. Statistical Learning Theory
- CS C281B. Advanced Topics in Learning and Decision Making
- CS 287. Advanced Robotics
- EE 290P. Advanced Topics in Electrical Engineering: Advanced Topics in Bioelectronics

CS 188. Introduction to Artificial Intelligence

Catalog Description: Ideas and techniques underlying the design of intelligent computer systems. Topics include search, game playing, knowledge representation, inference, planning, reasoning under uncertainty, machine learning, robotics, perception, and language understanding.

Units: 4.0

Prerequisites: Computer Science 61A; Computer Science 61B; Computer Science 70.

Formats:
Fall: 3.0 hours of lecture and 1.0 hours of discussion per week
Spring: 3.0 hours of lecture and 1.0 hours of discussion per week
Summer: 6.0 hours of lecture and 2.0 hours of discussion per week

Grading basis: letter

Final exam status: Written final exam conducted during the scheduled final exam period

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Class Schedule (Spring 2019):
MoWe 5:00PM - 6:29PM, Wheeler 150 – Aditya Balachandar Baradwaj, Sergey Levine, Stuart Russell

Class homepage on inst.eecs

General Catalog listing

Department Notes:

Course objectives: An introduction to the full range of topics studied in artificial intelligence, with emphasis on the "core competences" of intelligent systems - problem solving, reasoning, decision making, and learning - and on the logical and probabilistic foundations of these activities.

Topics covered:

- history
- intelligent agents
- uninformed search
- informed search
- constraint satisfaction
- game-playing
- logical agents
- propositional logic
- first-order logic
- inference in first-order logic
- resolution, logic programming
- planning, plan execution
- uncertainty, probability theory, probabilistic inference
- Bayesian networks and associated inference algorithms
- optimal decisions under uncertainty
- optimal sequential decisions, Markov decision processes
- learning agents
- inductive learning, decision trees
- neural networks
- Bayesian learning
- natural language processing
- perception/vision
- robotics
- philosophical foundations

Related Areas:

- Artificial Intelligence (AI)

CS 189. Introduction to Machine Learning

Catalog Description: Theoretical foundations, algorithms, methodologies, and applications for machine learning. Topics may include supervised methods for regression and classication (linear models, trees, neural networks, ensemble methods, instance-based methods); generative and discriminative probabilistic models; Bayesian parametric learning; density estimation and clustering; Bayesian networks; time series models; dimensionality reduction; programming projects covering a variety of real-world applications.

Units: 4.0

Prerequisites: Mathematics 53 and 54; Computer Science 70 or consent of instructor.

Credit Restrictions: Students will receive no credit for Comp Sci 189 after taking Comp Sci 289A.

Formats:
Fall: 3.0 hours of lecture and 1.0 hours of discussion per week
Spring: 3.0 hours of lecture and 1.0 hours of discussion per week
Summer: 6.0 hours of lecture and 2.0 hours of discussion per week

Grading basis: letter

Final exam status: Written final exam conducted during the scheduled final exam period

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Class Schedule (Spring 2019):
MoWe 6:30PM - 7:59PM, Wheeler 150 – Jonathan Shewchuk

Spring 2019 class homepage on bCourses

Class homepage on inst.eecs

General Catalog listing

Related Areas:

- Artificial Intelligence (AI)

CS C280. Computer Vision

Catalog Description: Paradigms for computational vision. Relation to human visual perception. Mathematical techniques for representing and reasoning, with curves, surfaces and volumes. Illumination and reflectance models. Color perception. Image segmentation and aggregation. Methods for bottom-up three dimensional shape recovery: Line drawing analysis, stereo, shading, motion, texture. Use of object models for prediction and recognition.

Units: 3.0

Prerequisites: Knowledge of linear algebra and calculus. Mathematics 1A-1B, 53, 54 or equivalent.

Formats:
Fall: 3 hours of lecture per week
Spring: 3 hours of lecture per week

Grading basis: letter

Final exam status: Written final exam conducted during the scheduled final exam period

Also listed as: VIS SCI C280

Class Schedule (Spring 2019):
WeFr 10:00AM - 11:29AM, Soda 306 – Alexei Efros, Jitendra Malik, Stella Yu

Class homepage on inst.eecs

General Catalog listing

Department Notes: Course Homepage: http://www.eecs.berkeley.edu/~trevor/CS280.html

Related Areas:

- Artificial Intelligence (AI)
- Biosystems & Computational Biology (BIO)
- Graphics (GR)

CS C281A. Statistical Learning Theory

Catalog Description: Classification regression, clustering, dimensionality, reduction, and density estimation. Mixture models, hierarchical models, factorial models, hidden Markov, and state space models, Markov properties, and recursive algorithms for general probabilistic inference nonparametric methods including decision trees, kernal methods, neural networks, and wavelets. Ensemble methods.

Units: 3.0

Formats:
Fall: 3 hours of lecture per week
Spring: 3 hours of lecture per week

Grading basis: letter

Final exam status: No final exam

Also listed as: STAT C241A

Class homepage on inst.eecs

General Catalog listing

Related Areas:

- Artificial Intelligence (AI)
- Biosystems & Computational Biology (BIO)

CS C281B. Advanced Topics in Learning and Decision Making

Catalog Description: Recent topics include: Graphical models and approximate inference algorithms. Markov chain Monte Carlo, mean field and probability propagation methods. Model selection and stochastic realization. Bayesian information theoretic and structural risk minimization approaches. Markov decision processes and partially observable Markov decision processes. Reinforcement learning.

Units: 3.0

Formats:
Fall: 3 hours of lecture per week
Spring: 3 hours of lecture per week

Grading basis: letter

Final exam status: No final exam

Also listed as: STAT C241B

Class homepage on inst.eecs

General Catalog listing

Related Areas:

- Artificial Intelligence (AI)

CS 287. Advanced Robotics

Catalog Description: Advanced topics related to current research in algorithms and artificial intelligence for robotics. Planning, control, and estimation for realistic robot systems, taking into account: dynamic constraints, control and sensing uncertainty, and non-holonomic motion constraints.

Units: 3.0

Prerequisites: Instructor consent for undergraduate and masters students.

Class homepage on inst.eecs

General Catalog listing

Department Notes: Over the past ten years advances in optimization, in probabilistic reasoning, and in machine learning have had a large impact in robotics, with many of the current state-of-the-art algorithms heavily relying on these tools. At the same time these three tools have wide applicability in many other fields. The current curriculum of CS287 is centered around these three tools---making it both a treatment of these tools (in the context of a specific application domain, namely robotics), as well as a treatment of the state of the art in (algorithmic) robotics. Problem sets are a mix of mathematical/algorithmic questions and programming problems. There is a substantial final project. NOTE: This course is about algorithms for robotics, and does *not* cover hardware aspects. PREREQS: Familiarity with mathematical proofs, probability, algorithms, linear algebra; ability to implement algorithmic ideas in code. EE125: is not a pre-req for CS287. EE125 covers a different aspect of robotics. MOST RECENT OFFERING WEBPAGE: http://people.eecs.berkeley.edu/~pabbeel/

Related Areas:

- Artificial Intelligence (AI)
- Control, Intelligent Systems, and Robotics (CIR)

EE 290P. Advanced Topics in Electrical Engineering: Advanced Topics in Bioelectronics

Catalog Description: The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.

Units: 1-3

Prerequisites: Consent of instructor.

Formats:
Fall: 1-3 hours of lecture per week
Spring: 1-3 hours of lecture per week

Grading basis: letter

Final exam status: No final exam

Also listed as: EL ENG 290P

Class homepage on inst.eecs

General Catalog listing

Related Areas:

- Artificial Intelligence (AI)
- Biosystems & Computational Biology (BIO)

Video and Image Processing Lab

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Video and Image Processing (VIP) Lab, founded in 1988, is engaged in research related to theories, algorithms, and applications of signal, image and video processing.

Of particular emphasis in recent years is

- Multimedia Networking, both wireless and wireline
- 3D model construction for large scale environments: indoor and outdoor modeling, visualization, rendering

- Applications of image processing techniques to semiconductor manufacturing: optical proximity correction; direct write maskless lithography

For more information about our current research projects, see our Research page.

The VIP Lab is located in 307 Cory Hall.

In the News

October 3, 2018 - Cruise Tech Talk: Fast, photorealistic, 3D mapping of urban environments

May 18, 2017 - The Mercury News: "Avideh Zakhor:the brains behind Google Earth and Street View"

February 19, 2017 - bigthink: "Smart Tech: Phones, Drones, and Interior Mapping"

October 29, 2015 - KQED: "Mapping Your World with a Backpack"

KQED feature on the 3D mapping project

June 8, 2015 - Berkeley Engineering: "The Mapping Backpack"

Berkeley engineering discuss our energy audit research.

June 4, 2015 - BBC Arabic: "Backpack Device Performs Three-Dimensional Scanning for any Building Design"

Our lab was visited by BBC Arabic to look at our backpack scanning system.

February 26, 2015 - Voice of America: "New Tool Maps Buildings' Energy Efficiency"

Voice of America shows off our latest backpack hardware at the ARPA-E summit.

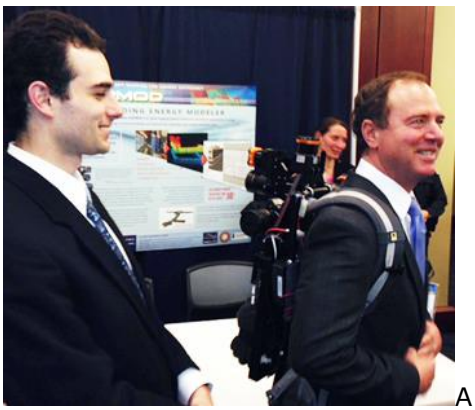
February 12, 2015 - BERC: "Berkeley Based Startups Win Big at ARPA-E"

Indoor Reality was among three winners of a start-up pitch competition to a panel of four investors.

February 11, 2015 - Avideh Zakhor Featured in ARPA-E Inspiring Innovators Showcase

November 13, 2014 - SWARM Lab Seminar: "Professor Zakhor's talk on image based localization"

February 28, 2014 - U.C. Berkeley NewsCenter: "Berkeley Team Takes its Energy Innovation to Capitol Hill"


A public affairs story of our visit to a Capitol Tech Showcase, held by ARPA-E.

February 26, 2014 - Energy Manager Today: Backpack Creates Thermal Maps

Energy Manager today ran a story about our latest backpack system.

February 26, 2014 - KTVU News Segment on 3D Mapping Backpack

The Channel 2 News ran a segment for our indoor modeling project.

February 26, 2014 - EnergyWire: "All-Seeing Backpack Homes in on Energy Waste"


EnergyWire article by David Ferris, E&E reporter

February 25, 2014 - LBNL Newsletter on RAPMOD at ARPA-E Tech Showcase

 Lawrence Berkeley Lab's monthly newsletter showcased us presenting our latest hardware for our indoor modeling project.

December 10, 2013 - FierceWirelessTech: "UC Berkeley Pursues Indoor Positioning Via Smartphone Photos"

This article showcases our research in positioning systems using just smartphone cameras.

August 29, 2012 - A Backpack for BIM

GeoDataPoint report by Christine Grahl

April 22, 2011 - Chevrolet Cruze-arati Video Segment

Veronica Belmont filmed a segment for Chevrolet covering our indoor modeling project.

March 7, 2011 - Technology Review: "Turning Augment Reality into an Open Standard"

Technology Review interviewed Professor Zakhor for an article on augmented reality. For more about our image-based localization for augmented reality project, click here.

January 2011 - Photonics Spectra: "3-D Interior Modeling: A Virtual Walk on the Inside"

Photonics Spectra published an article about our indoor modeling project.

November, 2010 - Professor Zakhor's speech at Caltech's EE department centennial

Video

October 8, 2010 - North Gate Radio (KALX) Interview: "Laser Backpack: One-on-One with Avideh Zakhor"

Professor Zakhor was interviewed by Alexa Vaughn of KALX about the lab's work in indoor modeling and 4D capture.
Audio Segment 1, Segment 2 (MP3)

September 30, 2010 - SIGNAL Magazine: "Laser Backpack Prototype Maps Inside Buildings"

SIGNAL Magazine published an article about our indoor modeling project.

September 7, 2010 - Air Force News: "Portable Laser Backpack Revolutionizes 3D Mapping"

The Air Force Office of Scientific Research (AFOSR) published an article about our indoor modeling project.

August 12, 2010 - Daily Californian: "New Backpack Makes 3D Maps of Buildings"

The Daily Californian published an article about our indoor modeling project.

August 8, 2010 - Indoor Modeling on ABC 7 News

Recently, our indoor modeling project was profiled by Richard Hart of ABC 7 News (KGO)! To learn more about our work in indoor modeling, see our project page.

November 2009 - Google Launches City Models With Detailed Building Facades

Lab alum Christian Frueh writes about the highly detailed 3D building facades added to select cities in Google Earth. This technology is based off research performed in our lab for the City Modeling project.

August 2007 - Air Force News: "3-D models of urban environments to aid military efforts"

The Air Force Materiel Command published an article about our City Modeling project, which is funded by the Air Force Office of Scientific Research.

June 2007 - Google Licenses Our 3D City Modeling Software!

Google has licensed the 3D city modeling software we developed with the City Modeling project, which provides a fully automated, fast, scalable data acquisition system and post-processing package for building photo-realistic 3D models of urban environments.

January 2006 - Red Herring: "Video Search's Buried Treasure"

Red Herring published an article about our work in video search and retrieval. For more information, see our publications on the topic.

May 2005 - R&D Magazine: "3D Modeling On-The-Go"

R&D Magazine wrote an article about our work on our City Modeling project.

May 2005 - Future Tense Radio Interview: "3D Mapping For War Planning and Starbucks Finding"

Professor Zakhor is interviewed by the American Public Media radio program, Future Tense, discussing urban mapping and its uses. For more information about our work, see our City Modeling project page.

April 2005 - The Hungry Mind: "Prof. Avideh Zakhor on being a science nerd in Iran, why Larry Summers made her mad, and what the heck a 4D model is"

Professor Zakhor is interviewed. Projects mentioned in this interview: City Modeling, Video Compression.

February 2004 - Daily Californian: "3-D City Modeling System Unveiled"

The Daily Californian covers our City Modeling project in this article.

Publications

Page links

Patents

- **Optical Proximity Correction Using Regression**, A. Gu, P. Gao and A. Zakhor, U.S. Patent No. 8,201,110 issued on June 12, 2012.
- **Dictionary Generation Method for Video and Image Compression**, A. Zakhor and P. Schmid, U.S. Patent No. 7,003,039, Issue Date: February 21, 2006.
- **Optimization of Streaming Data Throughput in Unreliable Networks**, M. Chen and A. Zakhor, U.S. Patent Serial No. 1114788, filed June 2005.
- **Method and Apparatus for Compression of Low Bit Rate Video Signals**, A. Zakhor and R. Neff, U.S. Patent No. 5,699,121, Issue Date: December 16, 1997.
- **Phase Shifting Mask Design for Optical Lithography Step of Integrated Circuit Fabrication**, A. Zakhor, Y. Liu, and A. Neureuther, U.S. Patent No. 5,326,659, Issue Date: July 5, 1994.
- **Optimal Decoding for Data Acquisition Applications of Sigma Delta Modulators**, A. Zakhor and S. Hein, U.S. Patent No. 5,164,727, Issue Date: November 17, 1992.
- **Method of Canceling Ghosts from NMR Signals**, A. Zakhor and R. Rzedzian, U.S. Patent No. 5,089,778, Issue Date: February 18, 1992.
- **Method for Reconstructing MRI Signals Resulting from Time-Varying Gradients**, A. Zakhor and R. Rzedzian, U.S. Patent No. 4,982,162, Issue Date: January 1, 1991.

Books

- W. Wei and A. Zakhor, *Multipath Video Communication in Wireless Ad Hoc Networks*, VDM Verlag, May 2008, ISBN-10: 3639020367. [Book Info]
- M. Chen and A. Zakhor, *A General Framework for Flow Control in Wireless Networks*, VDM Verlag, May 2008, ISBN-10: 3836492091. [Book Info]
- S. Hein and A. Zakhor, *Sigma Delta Modulators: Nonlinear Decoding Algorithms and Stability Analysis*, Kluwer Academic Publishers, 1993, ISBN 0-7923-9309-0.

Book Chapters

- E. Tzeng, A. Zhai, M. Clements, R. Townshend, and A. Zakhor, **"User-Driven Geolocation of Untagged Desert Imagery Using Digital Elevation Models."** *Visual Analysis and Geo-Localization of Large Scale Imagery*. edited by A. Hakeem, R. Szeliski, M. Shah, L. Van Gool, A. Zamir, Springer 2015. [Adobe PDF]
- E. Turner and A. Zakhor, **"Multistory Floor Plan Generation and Room Labeling of Building Interiors from Laser Range Data"**, to appear in *Communications in Computer and Information Science*. edited by Simone Barbosa et al, Springer 2014.[Adobe PDF]
- J. Liang, N. Corso, E. Turner, and A. Zakhor, **"Image-Based Positioning of Mobile Devices in Indoor Environments"**, appeared in *Multimodal Location Estimation of Videos and Images*. edited by Jaeyoung Choi and Gerald Friedland, Springer 2014. [Adobe PDF]
- W. Wei and A. Zakhor, **"Multipath Unicast and Multicast Video Communication over Wireless Ad Hoc Networks"** to appear in *Broadband Mobile Multimedia: Techniques and Applications*, Auerbach Publications, CRC Press, edited by Yan Zhang, Shiwen Mao, Laurence T. Yang, and Thomas M. Chen, 2007. [Adobe PDF]
- A. Zakhor and C. Frueh, **"Automatic 3D Modeling of Cities with Multimodal Air and Ground Sensors"** in *Multimodal Surveillance, Sensors, Algorithms and Systems*, Z. Zhu and T. S. Huang, Editors, Artech House, 2007, Chapter 15, pp. 339 - 362. ***(Best paper award for 2007 IEEE Workshop on Multimodal Sentient Computing: Sensors, Algorithms, and Systems, in conjunction with CVPR 2007.)*** [Adobe PDF]
- V. Dai and A. Zakhor, **"Lossless Compression of VLSI Layout Image Data"** to appear in Document and Image Compression, edited by M. Barni, 2006, pp. 413 - 426, CRC press. [Adobe PDF]
- N. Cobb and A. Zakhor, **"Fast Sparse Aerial Image Calculation for OPC"** in *15th Annual Symposium on Photomask Technology and Management*, G.V. Shelden and J.N. Wiley, eds, Proc. SPIE 2621, pp. 534-545 (Dec. 1995), reprinted in Selected Papers on *Resolution Enhancement Techniques in Optical Lithography*, F.M. Schellenberg,ed. (SPIE Milestone Series Vol. MS 178, SPIE Press, Bellingham, WA, 2004), pp. 805-816.

- S. Cheung, and A. Zakhor, **"Efficient video similarity measurement using video signatures"** in *Handbook of Video Databases*, edited by B. Furht and O. Marques, CRC Press, Boca Raton, Florida, 2003, pp. 679-710.
- A. Zakhor, S. Lin, and F. Eskafi, **"A new class of B/W halftoning algorithms"** in *Selected Papers in Digital Halftoning*, edited by J. P. Allebach, SPIE Optical Engineering Press, Volume MS 154, 1999, pp. 499-508.
- R. Neff, and A. Zakhor, **"Very Low Bit Rate Video Coding Based on Matching Pursuits"** in *Wavelet Image and Video Compression*, edited by P. N. Topiwala, Kluwer Academic Publishers, 1998, Chapter 22, pp. 361-382.
- O. Al-Shaykh, R. Neff, D. Taubman, and A. Zakhor, **"Video Sequence Compression,"** chapter in *The Digital Signal Processing Handbook*, edited by V.K. Madisetti and D.B. Williams, CRC/IEEE Press, 1998, ISBN 0-8493-8572-5.
- D. Taubman, E. Chang, and A. Zakhor, **"Exploiting Directionality in 2-D and 3-D Subband Coding with Applications to Scalable Multirate Video Coding,"** a chapter in *Advances in Image Processing and Machine Vision*, pp. 681-743, edited by J. Sanz, Springer Verlag, 1996.
- R. R. Rinaldoand A. Zakhor, **"Fractal Approximation of Images,"** a chapter in *Control and Dynamic Systems*, vol. 67, pp. 91-142, edited by C. T. Leondes, Academic Press, 1994.
- A. Zakhor and F. Lari, **"Edge Based 3-D Camera Motion Estimation with Application to Video Coding,"** chapter in *Motion Analysis and Image Sequence Processing*, pp. 89-124, edited by M. I. Sezanand R. L. Lagendijk, Kluwer Academic Publishers, 1993, ISBN 0-7923-9329-5.

Journal Papers

- E. Turner, P. Cheng, and A. Zakhor, **"Fast, Automated, Scalable Generation of Textured 3D Models of Indoor Environments,"** *IEEE Journal on Selected Topics in Signal Processing*, Volume 9, No. 3, pp. 409-421, April 2015, [Adobe PDF]
- N. Corso and A. Zakhor, **"Indoor Localization Algorithms for an Ambulatory Human Operated 3D Mobile Mapping System,"** *Remote Sensing 2013*, vol. 5, no. 12, pp. 6611-6646, Oct. 2013, [Adobe PDF]
- R. Garcia and A. Zakhor, **"Consistent Stereo-Assisted Absolute Phase Unwrapping Methods for Structured Light Systems,"** *IEEE Journal on Selected Topics in Signal Processing*, vol. 6, no. 5, pp. 411-424, Sept. 2012, [Adobe PDF]
- A. Abate, M. Chen, Y. Wang, A. Zakhor, and S. Sastry. **"Design and Analysis of a Flow Control Scheme over Wireless Networks,"** accepted in *International Journal of Robust and Nonlinear Control*,(2011), [Adobe PDF]
- V. Dai, A. Zakhor, and G. Cramer. **"Full-chip characterization of compression algorithms for direct-write maskless lithography systems,"** *Journal of Micro/Nanolithography, MEMS, and MOEMS (JM3)*, Vol. 9 (1), 013055 (2010), [Adobe PDF]
- W. Wei and A. Zakhor, **"Interference Aware Multi-Path Selection for Video Streaming in Wireless Ad Hoc Networks,"***IEEE Transactions on Circuits and Systems for Video Technology*, Volume 10, No. 2, pp. 165-178, February 2009. [Adobe PDF]
- A. Gu and A. Zakhor, **"Lossless Compression Algorithms for Hierarchical IC Layout,"** accepted for publication in *IEEE Transactions on Semiconductor Manufacturing,* Volume 21, No. 2, pp 285-296, May 2008. [Adobe PDF]
- A. Gu and A. Zakhor, **"Optical Proximity Correction with Linear Regression,"** *IEEE Transactions on Semiconductor Manufacturing,* Volume 21, Number 2, pp 263 - 271, May 2008. ***(2008 Best Paper Award)*** [Adobe PDF]
- J. Secord and A. Zakhor, **"Tree Detection in Urban Regions Using Aerial LiDAR and Image Data",** *IEEE Geoscience and Remote Sensing Letters (GRSL)*, Vol. 4, No. 2, pp. 196-200, April 2007. [Adobe PDF]
- H. Liu, V. Dai, A. Zakhor and B. Nikolic, **"Reduced Complexity Compression Algorithms for Direct-Write Maskless Lithography Systems,"** *SPIE Journal of Microlithography, MEMS, and MOEMS (JM3)*, Vol. 6, 013007, Feb. 2, 2007. [Adobe PDF]
- W. Wei and A. Zakhor, **"Multiple Tree Video Multicast over Wireless Ad Hoc Networks,"** *IEEE Transactions on Circuits, Systems and Video Technology*, Vol. 17, No. 1, Jan. 2007, pp. 2-15. [Adobe PDF]

- M. Chen and A. Zakhor, **"Multiple TFRC Connections Based Rate Control for Wireless Networks,"** *IEEE Trans. on Multimedia*, Vol. 8 , No. 5, Oct. 2006, pp. 1045-1062. ***(2009 Best paper award from IEEE Transactions on Multimedia)***[Adobe PDF]
- V. Dai and A. Zakhor, **"Lossless Compression of VLSI Layout Image Data,"** *IEEE Trans. on Image Processing*, Vol. 15, Issue 9, Sept. 2006 , pp. 2522-2530 [Adobe PDF]
- S. H. Kang and A. Zakhor, **"Effective Bandwidth Based Scheduling for Streaming Multimedia",** *IEEE Transactions on Multimedia*, Vol. 7, No. 6, December 2005, pp. 1139-1148. [Adobe PDF]
- M. Chen and A. Zakhor, **"Rate Control for Streaming Video over Wireless,"** *IEEE Wireless Communications*, Vol. 12, Issue 4, Aug. 2005, pp. 32-41 *(invited paper)* [Adobe PDF]
- P. Mehra, C. D. Vleeschouwer, and A. Zakhor, **"Receiver-Driven Bandwidth Sharing for TCP and its Application to Video Streaming,"** *IEEE Transactions on Multimedia*, Vol. 7, No. 4, August 2005, pp. 740-752. [Adobe PDF]
- S. Cheung, and A. Zakhor, **"Fast Similarity Search and Clustering of Video Sequences on the World-Wide-Web,"** *IEEE Transactions on Multimedia*, Vol. 7, No. 3, June 2005, pp. 524-537. [Adobe PDF]
- C. Früh, S. Jain, and A. Zakhor, **"Data Processing Algorithms for Generating Textured 3D Building Facade Meshes from Laser Scans and Camera Images,"** *International Journal of Computer Vision*, Vol. 61 No.2, Feb. 2005, pp. 159-184.[Adobe PDF]
- C. Früh and A. Zakhor, **"An Automated Method for Large-Scale, Ground-Based City Model Acquisition**" in *International Journal of Computer Vision*, Vol. 60, No. 1, October 2004, pp. 5 - 24. [Adobe PDF]
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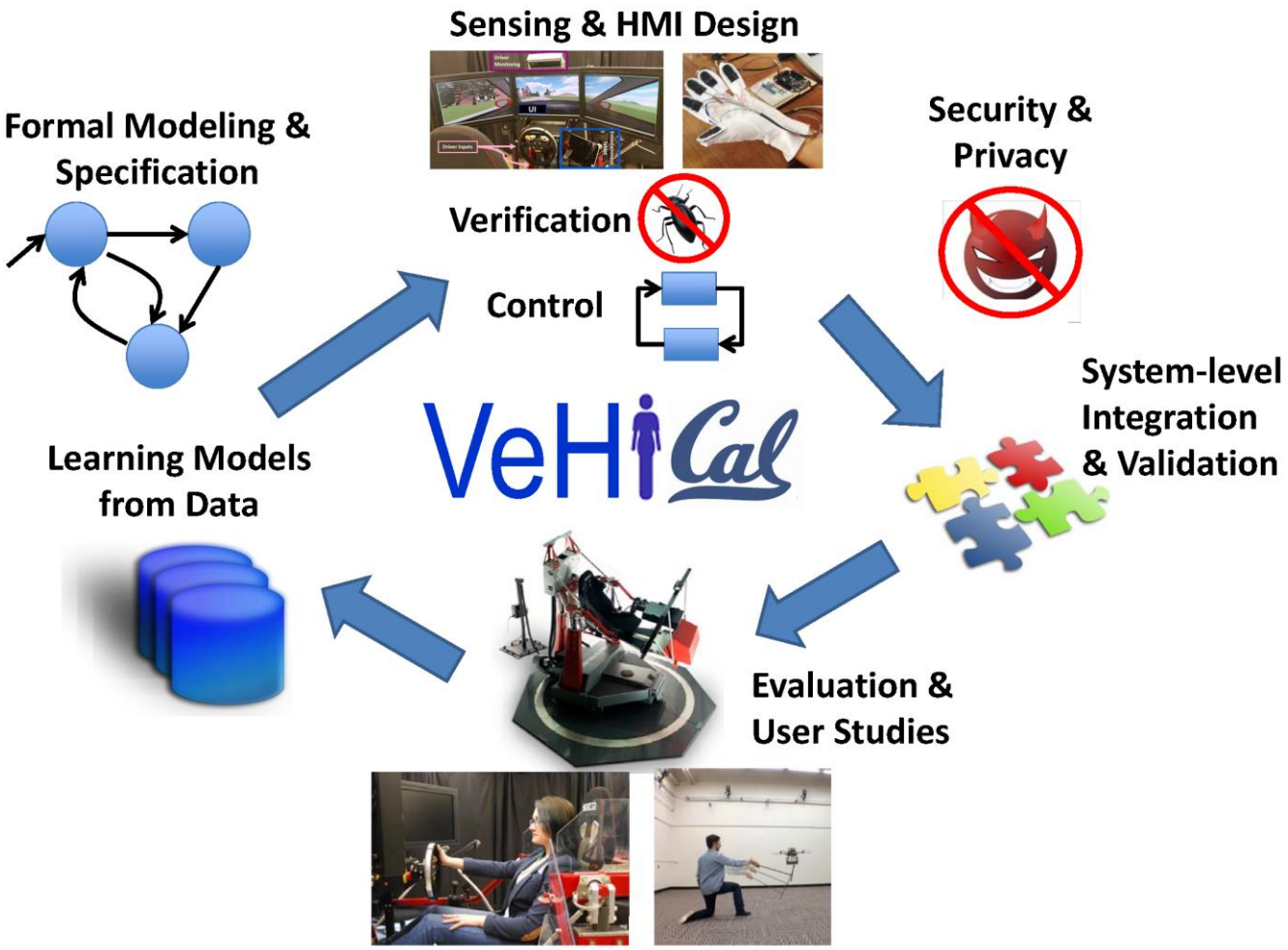
Verified Human Interfaces, Control, and Learning for Semi-Autonomous Systems

About

VeHICaL is an NSF Cyber-Physical Systems (CPS) Frontier project that is developing the foundations of verified co-design of interfaces and control for human cyber-physical systems (h-CPS) --- cyber-physical systems that operate in concert with human operators. VeHICaL aims to bring a formal approach to designing both interfaces and control for h-CPS, with provable guarantees. The VeHICaL approach is bringing a conceptual shift of focus away from separately addressing the design of control systems and human-machine interaction and towards the joint co-design of human interfaces and control using common modeling formalisms and requirements on the entire system. This co-design approach is making novel intellectual contributions to the areas of formal methods, control theory, sensing and perception, cognitive science, security and privacy, and human-machine interfaces.

The foundational work being pursued in the VeHICaL project is being validated in two application domains: semi-autonomous ground vehicles that interact with human drivers, and semi-autonomous aerial vehicles (drones) that interact with human operators.

Overview of the VeHICaL Approach



People

Principal Investigators

University of California, Berkeley

-  Ruzena Bajcsy
-  S. Shankar Sastry

-  Thomas Griffiths
-  Sanjit Seshia
  Lead PI
-  Björn Hartmann
-  Claire Tomlin

News

- Sept 6, 2016: NSF awards $13 million toward research in cyber-physical systems
- Sept 12, 2016: Multi-campus project pioneers self-driving car, drone research

Events

- Sept 27, 2016: VeHICaL Project Kickoff Meeting: Agenda
- Oct 31, 2016: NSF CPS PI Meeting: Overview Presentation (PDF)
- May 9, 2017: VeHICaL industry workshop
- Sept 19, 2017: VeHICaL Workshop

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Keywords

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

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- Big Data
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- Networking and Security
- Research Initiatives
- Speech
- Usable Security and Privacy
- Vision

Projects

- AI
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INTERNATIONAL COMPUTER SCIENCE INSTITUTE

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AI Projects

Preserving Unwritten Languages

In this project, researchers at ICSI are collaborating with Notre Dame to preserve unwritten languages in danger of disappearing. They are recording speech in a variety of genres and styles using mobile technologies. To enable productive linguistic and language-technology research in the future, they are adding respeaking, in which native speakers listen and repeat each phrase slowly and carefully, as well as oral translation, in which bilingual speakers of the language translate the recordings phrase by phrase into a widely used language such as English.

- Read moreabout Preserving Unwritten Languages

Extracting Event Attributes from Unstructured Textual Data for Persistent Situational Awareness

In this collaborative project with Decisive Analytics Corporation (DAC), FrameNet researchers are developing semantic frames for representing the attributes of complex events, which permit more fine-grained analysis than other event recognition frameworks. The researchers are developing event recognition methods focused on organizations and how they plan and carry out actions. These methods are broadly applicable to actions planned and carried out by all types of organizations, such as corporations, government agencies, military units, and insurgent groups.

- Read moreabout Extracting Event Attributes from Unstructured Textual Data for Persistent Situational Awareness

MetaNet: A Multilingual Metaphor Repository

Researchers from ICSI, UC San Diego, University of Southern California, and UC Merced are building a system capable of understanding metaphors used in American English, Iranian Persian, Russian as spoken in Russia, and Mexican Spanish. The team includes computer scientists, linguists, psychologists, and cognitive scientists.

- Read moreabout MetaNet: A Multilingual Metaphor Repository

California Connects

California Connects is a state-level program administered by the Foundation for California Community Colleges that seeks to advance digital opportunity for underserved communities by promoting and enabling digital competency. Among other services, the program provides laptops to community college students, who in return teach people in their communities how to use computers and the Internet. The program also provides free classes in low-income Central Valley communities. The California Connects team at ICSI provides research support for the initiative, evaluating the program's structure and effectiveness in the context of its target population and making recommendations for its future.

- Read moreabout California Connects

BFOIT

BFOIT (the Berkeley Foundation for Opportunities in Information Technology) supports historically underrepresented ethnic minorities and women in their desire to become leaders in the fields of computer science, engineering, and information technology. The intent is to provide youth with knowledge, resources, practical programming skills, and guidance in their pursuit of higher education and production of technology. For more information, visit the BFOIT Web site.

- Read moreabout BFOIT

Color, Language, and Thought

In 1978 The World Color Survey (WCS) collected color naming data in 110 unwritten languages from around the world. The ICSI WCS staff (Paul Kay and Richard Cook of ICSI, Terry Regier of University of Chicago) put these data into a single database, available to the scientific community. Several outside laboratories have already used this database for studies.

- Read moreabout Color, Language, and Thought

NTL

The NTL (Neural Theory of Language) project of the AI Group works in collaboration with other units on the UC Berkeley campus and elsewhere. It combines basic research in several disciplines with applications to natural language understanding systems. Basic efforts include studies in the computational, linguistic, neurobiological, and cognitive bases for language and thought. This research continues to yield a variety of theoretical and practical findings.

- Read moreabout NTL

FrameNet

The FrameNet project is building a semantically-rich lexicon of English and a corresponding set of annotated texts, based on more than 600 semantic frames and 130,000 sentences. Comparable FrameNet projects are underway for Spanish, German, and other languages. By providing a layered semantic representation of text, FrameNet delivers a key component of next-generation question answering, machine translation, and other natural language processing applications. Learn more on the FrameNet Web site.

- Read moreabout FrameNet

AI

The questions studied in Artificial Intelligence Group (AI) are of enormous practical and scientific importance and have proven to be quite difficult for conventional programming techniques. Human brains evolved to excel at tasks such as vision, motor control, speech, and language understanding, and are much better at these than artificial systems. The AI Group effort is exploring how computational models and techniques based on natural intelligence can prove useful

in applications tasks. The ICSI project differs from most others in its emphasis on structured networks, strong methods that exploit scientific knowledge, and extensive interaction with other computer science techniques and theory.

In particular, the AI Group continues its long-term study of language, learning, and connectionist neural modeling. The scientific goal of this effort is to understand how people learn and use language. The applied goal is to develop systems that support human centered computing through natural language and other intelligent systems.

Natural language understanding is a core activity of the AI Group. Three main efforts comprise this work: FrameNet, a project to build and exploit a machine-readable lexicon with detailed semantic descriptions of a substantial portion of the English vocabulary; the Neural Theory of Language (NTL), which uses computational models and simulations of language and learning to answer basic questions about the production and use of natural language; and Language Communication with Automomous Systems (LCAS), which explores "full path" language understanding with advanced systems like robots and automomous vehicles.

Professor Jerry Feldman is the AI Group leader.
Read about specific projects of the AI Group.