# Curriculum Vitae
## Jesse Hoey

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## Research Interests

My primary research goal is to study principled methods for learning how to act based on visual observations. Research in this area draws upon, and contributes to, computer vision, machine learning, and decision theory. In particular, I study how to learn models of human behaviors in video, how to act based upon the outputs of those models, and how to combine learning and acting in a unified framework. My strengths are in machine learning from visual observations, and in decision making in very large, uncertain environments. My secondary goal is to implement usable systems, and to deploy them in real-world situations in which they can positively contribute to the human condition. In particular, I am interested in building cognitive assistive technologies (CATs) for elderly or disabled persons. Such CATs are pervasive computing systems, and so depend critically on the development of fundamental theories and algorithms which are general and portable across tasks, users and places. This work has allowed me to pursue cross-disciplinary work in computer science, rehabilitation science and medicine.

## Education

**Ph.D. Computer Science**, University of British Columbia, Vancouver, Canada **1997-2004**

**M.Sc. Physics**, University of British Columbia, Vancouver, Canada **1992-1994**

**B.Sc. Physics** (Honours), McGill University, Montreal, Canada **1989-1992**

## Research Experience

**Postdoctoral Fellow, Departments of Occupational Therapy and Computer Science (cross-appointed), University of Toronto** **2004-**
Member: Intelligent Assistive Technology and Systems Laboratory (IATSL).
Supervisors: Dr. Alex Mihailidis and Dr. Craig Boutilier .
Working on the development of intelligent supportive environments for adults. Developing

computer vision and decision theoretic models of human behaviors for use by an intelligent system for helping people with cognitive disabilities perform daily living tasks. Researching approximate planning methods for partially observable Markov decision processes (POMDPs). Developing a wheelchair collision avoidance system using 3D sensors. Developing methods for detecting and preventing unsafe stair use in older adults. Aiding in the development of fall detection and human activity monitoring systems using computer vision.

**Research Assistant, Department of Computer Science ,UBC** **2000-2004**

Member: Laboratory for Computational Intelligence (LCI).
Supervisor: Dr. James J. Little.
Primary project: computer vision analysis of human motion. Developed novel representations of motion in the human face. Built a software system for tracking and analysing human facial expressions in natural interactions.
Secondary project: mobile robotics. Developed software for mobile robots including the lab's robotic waiter, José, and the robotic messenger, HOMER. Developed software for control of IEEE 1394 (firewire) single-lens and stereo digital video cameras. Participated in multiple conference and in-house robotic demonstrations. Assisted junior graduate students in the laboratory. Wrote conference papers and technical reports.
Tertiary project: decision theoretic planning. Investigated compact and approximate representations for planning in Markov decision processes.

**Research Associate, *Computer Vision Driver Analysis* project** **2002-2003**

Nissan Motor Corp. – UBC partnership.
Project supervised by Dr. James J. Little and Dr. Nando de Freitas.
Principal researcher in project to analyse the motions of car drivers. Analysed videos of drivers to find correlations between driver motions and driver workload, car speed, and traffic density. Wrote research proposals, interim reports and a final report. Gave presentations and demonstrations to senior Nissan executives and researchers, in Canada and in Japan.

## Teaching Experience

**Instructor, Department of Computer Science, UBC** **2001, 2002**

Taught two terms of UBC's introductory C++ programming course. Composed and marked quizzes, midterms and final examinations. Supervised six teaching assistants. Organized laboratories and tutorials. Developed online notes and course website. Received excellent student evaluations.

**Teaching Assistant, Department of Computer Science, UBC** **1997-2001**

Teaching assistant for CS124 (introduction to programming – 2 terms), CS126 (introduction to C++ – 2 terms), CS128 (introduction to programming – 3 terms, 1 summer term) and CS216 (intermediate C++ – 1 term). Prepared and taught tutorial and laboratory sessions. Developed an online set of tutorial notes which are extensively used by students and by other teachers. Marked assignments, mid-terms and final examinations. Organized and supervised mid-terms and final examinations. Composed and proofread exams. Received excellent student evaluations.

**Teaching Assistant, Department of Physics, UBC** **1992-1994**
Supervised physics laboratory sessions. Marked laboratory reports. Invigilated mid-terms and final examinations. Received excellent feedback from faculty, students and staff.

## Professional Activities

Reviewer for major computer science journals: IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI) 2004,2005; Computer Vision and Image Understanding Journal 2004; and Image and Vision Computing 2004.

Reviewer for major international conferences in computer vision, computer graphics and artificial intelligence: International Joint Conference on Artificial Intelligence (IJCAI) 2005; Uncertainty in Artificial Intelligence (UAI) 2005,2006; Robotics Science and Systems (RSS) 2005; Mexican Conference on Artificial Intelligence (MICAI) 2005; Graphics Interface (GI) 2004; IEEE International Conference on Computer Vision (CVPR) 2001,2003,2005; International Conference on Pattern Recognition (ICPR) 2001; European Conference on Computer Vision (ECCV) 2002; EuroGraphics 2002; German Conference on Artificial Intelligence (KI) 2002.

Wrote SPUDD, an efficient planning engine based on Markov decision Processes (MDPs) and algebraic decision diagrams (ADDs). Currently maintain the SPUDD website and the SPUDD code, providing a fast and free online MDP solver to the research community.

## Research Grants

Canadian Institute for Health Research **02/2006-02/2007**
co-Investigator: *Development and validation of an automated tool for detecting and preventing unsafe stair use by older adults*
amount: $48,227(CDN)

Precarn-CITO (Communications and Information Technology Ontario) **05/2006-04/2007**
co-Investigator: *Intelligent Haptic Stroke Rehabilitation*
amount: $599,990(CDN)

Nissan Motor Corp., Japan – UBC Computer Science Partnership Grant **05/2001-05/2002**
co-Investigator: *Analysis of driver behavior with computer vision*
amount: $95,275(CDN)

## Research Personnel Trained or Supervised

Dan Gunn, Sunnybrook & Women's Health Center **05/2005-09/2005**
Research Assistant. *The development of an intelligent anti-collision system for a powered wheelchair.*

Jasper Snoek, Dept. of Computer Science, University of Toronto **05/2005-09/2005**
Research Assistant. *The development of an automated tool for detecting unsafe stair use by older adults*

Chris Riddle, Dept. of Occupational Therapy, University of Toronto **04/2005-06/2005**
Research Assistant. *Clinical testing of an automated prompting system for handwashing*

## Scholarships

PRECARN Student Scholarship, IRIS-PRECARN **2002,2003**
*Value: $6,000 (CDN)*

University Graduate Fellowship, University of British Columbia. **2001-2002**
*Value: $16,000 (CDN)*

University Graduate Fellowship, University of British Columbia. **1998-2000**
*Value: $32,000 (CDN)*

NSERC PGS A Scholarship, Government of Canada. **1992-1994**
*Value: $36,000 (CDN)*

## Awards

Canesta$^{TM}$ Vision Contest Grand Prize Winner **2005**
Innovative Application of Canesta's electronic perception technology, *Wheelchair collision obstacle avoidance* ($17,500 USD in-kind and cash prize)

First place, 2001 *Hors D'œuvres Anyone?* Mobile Robot Competition **2001**
Team member, Seattle, WA, August, 2001.

Teaching Assistant Award, Department Computer Science, UBC **1998,1999,2000**
Awarded to departmental teaching assistants for outstanding student evaluations and faculty recommendations.

Horace Watson Medal. McGill University, Montreal, Canada. **1992**
Awarded for highest academic standing in Honours Physics

## Publications

### Refereed Journal Articles

- **Jesse Hoey** and James J. Little. Value-Directed Human Behavior Analysis with Partially Observable Markov Decision Processes. Accepted for publication in *IEEE Transactions on Pattern Analysis and Machine Intelligence* (PAMI), 2006.
- Jen Boger, **Jesse Hoey**, Pascal Poupart, Craig Boutilier, Geoff Fernie, and Alex Mihailidis. A planning system based on Markov decision processes to guide people with dementia through activities of daily living. Accepted for publication in *IEEE Transactions on Information Technology in Biomedecine*, 2005.

### Refereed Conference Articles

- **Jesse Hoey** and Pascal Poupart. Solving POMDPs with Continuous or Large Discrete Observation Spaces. In *Proc. of Intl. Joint Conference on Artificial Intelligence* (IJCAI), Edinburgh, Scotland, July 2005

- Jen Boger, Pascal Poupart, **Jesse Hoey**, Craig Boutilier, Geoff Fernie, and Alex Mihailidis. A Decision-Theoretic Approach to Task Assistance for Persons with Dementia. In *Proc. of Intl. Joint Conference on Artificial Intelligence* (IJCAI), Edinburgh, Scotland, July 2005
- **Jesse Hoey**, Pascal Poupart, Craig Boutilier and Alex Mihailidis. Semi-Supervised Learning of a POMDP model of Patient-Caregiver Interactions. In *Proc. IJCAI Workshop on Modeling others from Observations* (MOO), Edinburgh, Scotland, July 2005
- **Jesse Hoey** and James J. Little. Value Directed Learning of Facial Displays. In Proc of IEEE *Conference on Computer Vision and Pattern Recognition* (CVPR), Washington, DC, June 2004
- **Jesse Hoey** and James J. Little. Decision Theoretic Modeling of Human Facial Displays. In Proc. of $8^{th}$ *European Conference on Computer Vision* (ECCV), Prague, CZ, May 2004
- Pantelis Elinas, Enrique Sucar, Alberto Reyes and **Jesse Hoey**. A Decision Theoretic Approach for Task Coordination in Social Robots. In *Proc. of Intl. Workshop on Robot and Human Interactive Communication*. Kurashiki, Okayama Japan, September 2004.
- **Jesse Hoey** and James J. Little. Bayesian Clustering of Optical Flow Fields. In Proc. of *Intl. Conference on Computer Vision* (ICCV), Nice, France, October 2003.
- **Jesse Hoey**. Clustering Contextual Facial Display Sequences. In Proc. of *Intl. Conference on Automatic Face and Gesture Recognition* (FG), Washington, DC, May 2002.
- Pantelis Elinas, **Jesse Hoey**, Darrell Lahey, Jeff Montgomery, Don Murray, Stephen Se and James J. Little Waiting with Jose, a vision based mobile robot. In Proc. *Intl. Conference on Robotics and Automation* (ICRA) Washington, DC, May 2002.
- **Jesse Hoey**. Hierarchical unsupervised learning of facial expression categories In Proc. *Workshop on detection and recognition of events in video*, Vancouver, BC, July, 2001.
- **Jesse Hoey** and James J. Little. Representation and recognition of complex human motion. In Proc. of *Intl. Conference on Computer Vision and Pattern Recognition* (CVPR), Hilton Head, SC, June 2000.
- Robert St-Aubin, **Jesse Hoey**, and Craig Boutilier. APRICODD: Approximate policy construction using decision diagrams. In Proc. *Neural Information Processing Systems* (NIPS) 14, 2000.
- **Jesse Hoey**, Robert St-Aubin, Alan Hu, and Craig Boutilier. SPUDD: Stochastic planning using decision diagrams. In Proc. of *Uncertainty in Artificial Intelligence* (UAI), Stockholm, 1999.

**Unrefereed Workshops and Posters**

- **Jesse Hoey**, Daniel Gunn, Alex Mihailidis and Pantelis Elinas. Obstacle Avoidance Wheelchair System. In *Proc. International Conference on Robotics and Automation* (ICRA) Poster Session, May 2006.

- **Jesse Hoey**, Pascal Poupart, Craig Boutilier and Alex Mihailidis. POMDP models for Assistive Technology. In *Proc. AAAI Fall Symposium on Caring Machines: AI in Eldercare*, Washington, DC, November 2005
- **Jesse Hoey**. Decision Theoretic Learning of Facial Displays. In NIPS *Workshop on Challenges in Cognitive Vision*, Whistler, BC, December 2003.
- Pantelis Elinas, **Jesse Hoey**, and James J. Little. HOMER: Human Oriented MEssenger Robot In Proc. of AAAI *Spring Symposium on Human Interaction with Autonomous Systems in Complex Environments*, Stanford CA, March 2003.

**Theses**

- **Jesse Hoey**. *Decision Theoretic Learning of Facial Displays* Ph.D. Thesis. University of British Columbia, May 2004
- **Jesse Hoey**. *On the use of an acoustic Doppler current profiler to study zooplankton biomass distributions on the Vancouver Island continental margin.* M.Sc. Thesis. University of British Columbia, May 1995.

## Invited Talks and Demonstrations

POMDPs for Human Interactive Tasks **January** $9^{th}$**, 2006**
Invited talk, Palo Alto Research Center (PARC), Palo Alto, California

Ubiquitous Algorithms for Assistive Technologies **November** $17^{th}$**, 2005**
Invited talk, Computing Department, University of Dundee, Dundee, Scotland

Assistive Technology and POMDPs **March** $18^{th}$**, 2005**
Invited presentation to AI group, University of Waterloo, Waterloo, Ontario

Learning Models of Human Behavior using a Value Directed Approach **June** $9^{th}$ **2004**
Invited talk, IRIS Machine Learning Workshop 2004, Ottawa, Ontario

University of British Columbia downtown campus opening gala **July** $10^{th}$ **2002**
Demonstrated José, the robotic waiter, to senior UBC officials.

Vicky Gabereau Show. Canadian Broadcasting Corporation (CBC). **September** $20^{th}$ **2002**
Live television robotic waiter demonstration.

UBC awards night gala reception **June** $3^{rd}$ **2002**
Robotic waiter demonstration.

Advanced Systems Institute of British Columbia Technology Exchange. **March** $23^{rd}$ **2002**
Robotic waiter demonstration.

UBC Department of Computer Science Open House **January** $17^{th}$ **2002**
Robotic waiter demonstration.

AAAI *Hors D'œuvres Anyone?* Mobile Robot Competition **August** $4^{th} - 9^{th}$ **2001**
Winning entry in the robotic waiter competition. Three demonstrations.

## Software / Hardware

Programming Experience: Designed and wrote several large projects in C/C++ in both Unix and Microsoft Windows environments. Included writing code to communicate with hardware devices, and computer graphics user interfaces with OpenGL. OpenGL work further involved using graphics hardware for fast image computation, such as image re-scaling and optical flow computation. Expert in Matlab programming for computation and data visualization. Extensive experience programming in Java, FORTRAN, Visual Basic, and Scheme. Working knowledge of Prolog. Internet design work includes HTML, Javascript, CGI and Perl.

Hardware Experience: Worked extensively with single-lens and stereo cameras. Worked on IEEE 1394 (Firewire) and s-video interfaces. Experienced working with a RWI B14 mobile robot.

## Citizenship

Canadian

## Languages

Completely fluent in written and spoken English and French. Basic spoken Spanish.

## Interests

Childhood development, skiing, playing hockey, playing guitar, traveling, reading, brewing.

## References

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# Research Statement

## View of Future Research Opportunities

As computer vision and video processing algorithms become increasingly sophisticated, their placement into the real world is becoming more and more prevalent. Examples include video-based assistive technologies, entertainment and educational games, security, and service robotics. However, the deployment of computer vision systems requires coupling them with algorithms for action and planning. While both computer vision and planning are significant areas of research independently, there is much to be gained from a close examination of how they can be unified in a principled manner. Such an integration leads to insights into both fields, as the high-level information from a planning system can be used for recognition at the video level, and compact representations of video observations lead to more tractable planning algorithms.

Work towards this integration of computer vision and planning into a unified and principled framework will contribute to computer science research in three important ways. First, it will lead to new video processing algorithms that are geared towards their eventual goals by researching how video can be analysed in the context of a well defined decision-theoretic task. Second, it will contribute to research into approximate planning algorithms by uncovering methods for learning compact representations of video inputs. Third, much of this type of research leverages machine learning algorithms and techniques, to which it symbiotically contributes by defining new optimality measures based on task performance. Establishing a research group based on these notions of integration will lead to cross-fertilisation between the respective sub-fields in computer science: artificial intelligence, computer vision, and machine learning.

There are many application areas in which the models and algorithms resulting from such research can be deployed. Perhaps the most significant are in the health services domain, but other examples include for robotics, software interfaces, game playing, and entertainment. Within health services, the use of automated systems for assistive technology and rehabilitation is a fast growing phenomenon which requires the use of computer vision and planning algorithms, making it an ideal application area for the type of research I wish to pursue. I believe that committed research into this area will lead to enormous opportunities for improvement of home-administered or tele-operated health care and to significant progress in computer science research.

## Statement of Research Goals

My primary research goal is to study principled methods for learning models of action and visual observation in real world environments. My secondary goal is to implement systems based on these methods, and to deploy them in real-world situations in which they can positively contribute to the human condition. I have pursued these goals by studying how to learn models for visual interactions between artificial systems and humans. The approach I have developed for this problem combines computer vision, probabilistic modeling and decision theory. The three are closely related, and together are a powerful solution concept for vision-based human computer interaction.

The computer vision task is to detect human motions from video streams, and to compress the motions into spatially and temporally abstract representations suitable for higher level processing. The uncertainties inherent in such a sensing task call for probabilistic modeling techniques. Dynamic Bayesian networks (DBNs) in particular are a consistent structured representation of uncertain beliefs for sequential data.

A rational system must not only sense and represent non-verbal human behaviors, but must also use the information obtained through such modeling to help it choose actions which optimize utility over outcomes. Expected utility maximization is the standard approach for rational decision making, and forms the basis for my work on partially observable Markov decision processes (POMDPs). My research has shown how POMDPs can be used to combine computer vision, probabilistic modeling and decision theory. The model allows a system to incorporate actions and utilities into the sensing and representation of visual observations, and provides top-down value-based evidence for the learned probabilistic models: the system can learn models most conducive for achieving value in a particular task.

I wish to pursue my research goals by continuing to study interactions between artificial systems and humans in real world tasks along three main lines of research. First, research into the modeling of human behaviors from video inputs. My strong background in video analysis of human behaviors at the University of British Columbia (UBC) gives me the skills necessary to make contributions in this area. Second, research into the optimal and approximate solution of POMDPs. I have consistently made significant contributions in this area throughout my work at UBC and at the University of Toronto, and plan to continue doing so in the future. Third, and most important, research into the learning and solving large-scale POMDPs with computer vision observations in a unified framework. I am particularly interested in applying such models to assisted living tasks, resulting in systems that help elderly or disabled people function more effectively and independently. My current research at the University of Toronto has given me a strong scientific foundation and a solid collaborative connection in occupational therapy and rehabilitation science. I plan to continue to forge these collaborative links through a commitment to applying my theoretical work to the many and varied real-world tasks presented by the medical field.

March, 2006