

# Leonid Sigal

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## CONTACT INFORMATION

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## RESEARCH INTERESTS

**Computer Vision:** visual estimation and tracking of articulated human motion, analysis of biological motion, object detection and recognition.

**Machine Learning:** graphical models, hierarchical models, non-parametric models and inference methods, low-dimensional embeddings.

**Computer Graphics:** physics-based character animation.

## EDUCATION

**Brown University**, Providence, RI USA

Ph.D., Computer Science, September 2007 (awarded May 2008)

Sc.M., Computer Science, May 2003

- Dissertation Topic: "Continuous-state Graphical Models for Object Localization, Pose Estimation and Tracking"
- Advisor: Michael J. Black
- Committee: Michael J. Black, William Freeman, John F. Hughes, David Mumford

**Boston University**, Boston, MA USA

M.A., Computer Science, September 1999

- Dissertation Topic: "Skin Color Tracking Under Time-Varying Illumination"
- Advisor: Stan Sclaroff

B.A., Computer Science, May 1999

B.A., Mathematics, May 1999

## HONORS AND AWARDS

**Outstanding Reviewer Award**, European Conference on Computer Vision (ECCV) 2008

**Outstanding Reviewer Award**, Computer Vision and Pattern Recognition Conf. (CVPR) 2008

**Best Paper Award** 2006

IV Conference on Articulated Motion and Deformable Objects  
for "Predicting 3D People from 2D Pictures" (jointly with Michael J. Black)

Dissertation Fellowship, Brown University 2006

Deans Fellowship, Brown University 2001/2002

United States Achievement Award 1996

## TEACHING EXPERIENCE

**University of Toronto**, Scarborough, ON Canada

*Instructor*

**Fall, 2008**

*Instructor*

**Fall, 2007**

Department of Computer and Mathematical Sciences, CSCD18 - Computer Graphics

Senior undergraduate course with emphasis on object modeling, rendering and manipulation; efficient algorithms to perform these operations, and interfaces to transform and interact with objects. The course has significant theoretic and programming aspect and is taught in C++ and OpenGL. Duties included preparation and teaching of lectures, development of problem sets and exams, and supervision of a graduate TA.

**Brown University**, Brown, RI USA

*Teaching Assistant*

**Fall, 2005**

Computer Science, CS143 - Introduction to Computer Vision

Assisted in developing the curriculum and homework assignments. Duties included office hours, teaching, and grading of homeworks. Gave several in-class tutorials and lectures.

**Boston University**, Boston, MA USA

*Teaching Assistant*

**1997 - 1999**

Mathematics and Statistics, MA113 - Elementary Statistics I

Mathematics and Statistics, MA123 - Calculus I

Mathematics and Statistics, MA124 - Calculus II

Duties at various times have included office hours, teaching of discussion sections, and grading of homeworks.

ACADEMIC  
EXPERIENCE

**University of Toronto**, Toronto, ON Canada

*Postdoctoral Fellow*

**September, 2007 - present**

Research included physics-based models and priors for human motion tracking, semi-supervised low-dimensional embeddings for probabilistic regression, inference of gender and other perceptual attributes from human motion, analysis of time-series data. Helped to supervise one MA and one PhD student.

**Brown University**, Brown, RI USA

*Research Assistant*

**September, 2001 - September, 2007**

Worked on high-dimensional continuous-state models for computer vision applications, such as autonomous object motion, pose and shape estimation from images and video. Developed a number of techniques for 3-D articulated human pose estimation and tracking using graphical models and non-parametric inference methods. Developed dataset and testbed platform for quantitative evaluation of human pose and motion estimation.

**Boston University**, Boston, MA USA

*Research Assistant*

**December, 1998 - September, 1999**

Conducted research on the rigid object tracking in the real-time video sequences using statistical models and color-based segmentation.

ADVISING AND  
COLLABORATING  
STUDENTS

Marek Vondrak (Brown University, PhD student), *co-advised* with Prof. Chad Jenkins

Maja Omanovic (University of Toronto, PhD student), *co-advised* with Prof. David Fleet

Alexander Wong (University of Toronto, Masters student), *co-advised* with Prof. David Fleet

PROFESSIONAL  
SERVICE

**Editorial**

*Guest Editor* (with Michael J. Black), International Journal of Computer Vision, Special Issue on Evaluation of Human Motion and Pose Estimation, 2008.

*Member of Editorial Advisory Board*, The Open Artificial Intelligence Journal, Bentham Science Publishers Ltd.

**Tutorial**

*Co-Organizer*, Physics-Based Human Motion Modelling for People Tracking, in conjunction with IEEE International Conference on Computer Vision (ICCV), September 2009.

### **Program Chair or Organizer**

*Co-Organizer*, EHUM: Evaluation of Articulated Human Motion and Pose Estimation Workshop, in conjunction with Neural Information and Processing Systems (NIPS), December 2006.

*Co-Organizer*, EHUM<sub>2</sub>: 2nd Workshop on Evaluation of Articulated Human Motion and Pose Estimation, in conjunction with IEEE Conf. on Computer Vision and Pattern Recognition (CVPR), June 2007.

### **Program Committee**

Computer Vision and Pattern Recognition (2007, 2008, 2009)

European Conference on Computer Vision (2008)

IEEE International Conference on Computer Vision (2007, 2009)

International Joint Conferences on Artificial Intelligence (2009)

IEEE International Conference on Advanced Video and Signal Based Surveillance (2009)

### **Professional Societies**

Member of the ACM, the IEEE, the IEEE Computer Society.

### **Department Service**

Organized bi-weekly series of faculty /graduate student discussion lunches in 2006.

Helped to organize graduate student interviews during Brown CS faculty search in 2004.

### REVIEWING

Reviewed journal papers for:

Computer Vision and Image Understanding

**IEEE Transactions on Pattern Analysis and Machine Intelligence**

IEEE Transactions on Image Processing

IEEE Transactions on Systems, Man, and Cybernetics

IEEE Transactions on Circuits and Systems for Video Technology

IEEE Transactions on Multimedia

Image and Vision Computing Journal

**International Journal of Computer Vision**

International Journal of Pattern Recognition and Artificial Intelligence

Journal of Computer Science and Technology

Pattern Recognition

Reviewed conference and workshop papers for:

Asian Conference on Computer Vision (2009)

**Computer Vision and Pattern Recognition (2004-2009)**

**European Conference on Computer Vision (2004,2008)**

**IEEE International Conference on Computer Vision (2005,2007,2009)**

IEEE International Conference on Advanced Video and Signal Based Surveillance (2009)

IEEE International Workshop on Analysis and Modeling of Faces and Gestures (2003)

International Conference on Pattern Recognition (2008)

**Neural Information Processing Systems (2007-2009)**

**SIGGRAPH: International Conference and Exhibition of Computer Graphics and Interactive Techniques (2009)**

**SIGGRAPH Asia (2009)**

### IN PREPARATION

M. Vondrak, L. Sigal and O. C. Jenkins. Exploiting Physics in Motion Tracking. *International Journal of Computer Vision (IJCV)*.

### BOOK CHAPTERS

M. Vondrak, L. Sigal and O. C. Jenkins. Dynamics and Control of Multibody Systems. *Motion Control*, A. Lazinica (Eds), ISBN978-953-7619-X-X. To be published by IN-TECH, Vienna in September 2009. (*accepted*).

M. Brubaker, L. Sigal and D. Fleet. Video-Based People Tracking. *Handbook on Ambient Intelligence and Smart Environments*, H. Nakashima, H. Aghajan, and J.C. Augusto (Eds). To be published by Springer Verlag in 2009. (*accepted*).

JOURNAL  
PUBLICATIONS

L. Sigal, M. J. Black, M. Isard and H. Haussecker. Loose-limbed People: Estimating Human Pose and Motion using Non-parametric Belief Propagation. *International Journal of Computer Vision (IJCV)*, 2008. (*submitted*)

L. Sigal, A. Balan and M. J. Black. HumanEva: Synchronized Video and Motion Capture Dataset and Baseline Algorithm for Evaluation of Articulated Human Motion. *International Journal of Computer Vision (IJCV)*, EHuM special issue, 2008 (*submitted*).

L. Sigal, S. Sclaroff and V. Athitsos. Skin Segmentation under Time-Varying Illumination. *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, 26(7), pp. 862-877, July 2004. [75 citations, Google Scholar, ca 11/2008]

REFEREED  
CONFERENCE  
PUBLICATIONS

*Please note that CVPR and ICCV are highly competitive top rated computer vision conferences, typically with 20–25% acceptance rate. The number of citations is given only for papers with 50 citations or higher.*

M. Brubaker, L. Sigal and D. Fleet. Estimating Contact Dynamics. *International Conference on Computer Vision (ICCV)*, 2009. (*accepted*)

L. Sigal, R. Memisevic and D. Fleet. Shared Kernel Information Embedding for Discriminative Inference. *IEEE Conf. on Computer Vision and Pattern Recognition (CVPR)*, 2009. (*accepted*)

M. Vondrak, L. Sigal and O. C. Jenkins. Physical Simulation for Probabilistic Motion Tracking. *In Proc. of IEEE Conf. on Computer Vision and Pattern Recognition (CVPR)*, June 2008. (**oral acceptance rate 4%**)

L. Sigal, A. Balan and M. J. Black. Combined discriminative and generative articulated pose and non-rigid shape estimation. *In Proc. of Neural Information Processing Systems Conference (NIPS)*, December 2007.

A. Balan, M. J. Black, H. Haussecker and L. Sigal. Shining a Light on Human Pose: On Shadows, Shading and the Estimation of Pose and Shape. *In Proc. of International Conference on Computer Vision (ICCV)*, October 2007.

A. Balan, L. Sigal, M. J. Black, J. Davis and H. Haussecker. Detailed Human Shape and Pose from Images. *In Proc. of IEEE Conf. on Computer Vision and Pattern Recognition (CVPR)*, June 2007.

L. Sigal and M. J. Black. Predicting 3D People from 2D Pictures. *In Proc. of IV Conf. on Articulated Motion and Deformable Objects (AMDO)*, Springer-Verlag LNCS 4069, pp. 185-195, July 2006. (**Best Paper Award**)

L. Sigal and M. J. Black. Measure Locally, Reason Globally: Occlusion-sensitive Articulated Pose Estimation. *In Proc. of IEEE Conf. on Computer Vision and Pattern Recognition (CVPR)*, vol. 2, pp. 2041-2048, New York, NY, June 2006.

L. Sigal, S. Bhatia, S. Roth, M. J. Black and M. Isard. Tracking Loose-limbed People. *In Proc. of IEEE Conf. on Computer Vision and Pattern Recognition (CVPR)*, vol. 1, pp. 421-428, Washington, DC, June 2004. [153 citations, Google Scholar, ca 11/2008]

S. Roth, L. Sigal and M. J. Black. Gibbs Likelihoods for Bayesian Tracking, *In Proc. of IEEE Conf. on*

*Computer Vision and Pattern Recognition (CVPR)*, vol. 1, pp. 886-893, Washington, DC, June 2004.

L. Sigal, M. Isard, B. Sigelman and M. J. Black. Attractive people: Assembling loose-limbed models using non-parametric belief propagation. *In Proc. of Neural Information Processing Systems (NIPS)*, 2003. [52 citations, Google Scholar, ca 11/2008]

H. Sidenbladh, M. J. Black and L. Sigal. Implicit probabilistic models of human motion for synthesis and tracking. *In Proc. of European Conference on Computer Vision (ECCV)*, Springer-Verlag LNCS 2353, Vol. 1, pp. 784-800, 2002. [167 citations, Google Scholar, ca 11/2008]

R. Rosales, V. Athitsos, L. Sigal and S. Sclaroff. 3D Hand Pose Reconstruction Using Specialized Mappings. *In Proc. of International Conference on Computer Vision (ICCV)*, 2001. [81 citations, Google Scholar, ca 11/2008]

L. Sigal, S. Sclaroff and V. Athitsos. Estimation and Prediction of Evolving Color Distributions for Skin Segmentation Under Varying Illumination. *In Proc. of IEEE Conf. on Computer Vision and Pattern Recognition (CVPR)*, vol. 2, pp. 152-159, Hilton Head Island, SC, June 2000. [91 citations, Google Scholar, ca 11/2008]

REFEREED  
WORKSHOP  
PUBLICATIONS

A. Balan, L. Sigal and M. J. Black. A Quantitative Evaluation of Video-based 3D Person Tracking. *In Proc. of IEEE International Workshop on Visual Surveillance and Performance Evaluation of Tracking and Surveillance (VS-PETS)*, pp. 349-356, October 2005.

L. Sigal, Y. Zhu, D. Comaniciu and M. J. Black. Tracking Complex Objects using Graphical Object Models. *In Proc. of 1st International Workshop on Complex Motion*, 2004.

S. Bhatia, L. Sigal, M. Isard and M. J. Black. 3D Human Limb Detection using Space Carving and Multi-view Eigen Models. *In Proc. of IEEE Workshop on Articulated and Nonrigid Motion*, 2004.

REFEREED  
ABSTRACTS

L. Sigal and M. J. Black. Hierarchical Approach for Articulated 3D Pose-Estimation and Tracking. *Learning, Representation and Context for Human Sensing in Video Workshop* (in conjunction with CVPR), 2006.

TECHNICAL  
REPORTS

L. Sigal and M. J. Black. HumanEva: Synchronized Video and Motion Capture Dataset for Evaluation of Articulated Human Motion. *Technical Report CS-06-08*, Brown University, September 2006.

CONFERENCE AND  
WORKSHOP  
PRESENTATIONS

"*Physical Simulation for Probabilistic Motion Tracking*",  
IEEE Conference on Computer Vision and Pattern Recognition, Ankorage, AK, June 2008.

"*HumanEva-I dataset and evaluation metrics*",  
EHuM: Evaluation of Articulated Human Motion and Pose Estimation Workshop, Whistler, BC, December 2006.

"*Hierarchical Inference Framework for Articulated Pose Estimation and Tracking*",  
Canadian Institute for Advanced Research (CIAR), 2nd Neural Computation and Adaptive Perception Summer School, Toronto, Canada, August 2006.

"*Predicting 3D People from 2D Pictures*",  
IV Conference on Articulated Motion and Deformable Objects, Mallorca, Spain, July 2006.

"*Graphical Object Models for Detection and Tracking*",  
NIPS Workshop on Graphical Models and Kernels, Vancouver, BC, 2004.

## INVITED TALKS

*"Human pose estimation, tracking, and physics-based models"*,

- University of British Columbia, Vancouver, BC, June 2009.
- Simon Fraser University, Burnaby, BC, June 2009.

*"Physics-based Models and Priors for Human Motion Tracking"*,

- Toyota Technological Institute at Chicago, Chicago, IL, March 2009.
- Carnegie Mellon University Robotics Institute, Vision and Autonomous Systems Center Seminar, Pittsburgh, PA, March 2009.
- AiLive, Mountain View, CA, April 2009.

*"Combined Discriminative and Generative Articulated Pose and Non-rigid Shape Estimation"*,

- Neural Computation and Adaptive Perception Workshop on Modeling Animate Motion, Vancouver, BC, December 2007.
- Queen's University, Kingston, ON, February 2008.
- Machine Learning Seminar, University of Toronto, ON, March 2008.

*"Continuous-state Graphical Models for Object Localization, Pose Estimation and Tracking"*,

- Smith-Kettlewell Eye Research Institute, San Francisco, CA, January 2007.
- Stanford University, BioMotion Research Group Meeting, Stanford, CA, January 2007.
- University of Toronto, Toronto, Canada, January 2007.
- Boston University, Boston, MA, February, 2007.
- University of Rochester, Rochester, NY, March 2007.
- Ecole Normale Supérieure, Paris, France, April 2007.
- Xerox Research Center Europe, Grenoble, France, April 2007.

*"Hierarchical Inference Framework for Articulated Pose Estimation and Tracking"*,

Honda Research Institute, Mountain View, CA, August 2006.

*"Loose-Limbed People Paradigm: Distributed Approach for Articulated Pose Estimation and Tracking"*,

MIT CSAIL Machine Vision Colloquium, Cambridge, MA, May 2006.

*"Loosely Connected Body Model for Pose Estimation and Tracking"*,

10-th Anniversary of Image and Video Computing at Boston University, Boston, MA, May 2005.

## OTHER TALKS

*"Combining Tracking and Physics-based Simulation"*,

Intel Applications Research Lab (ARL), Santa Clara, CA, September 2006.

Guest lectures in Computer Science 143 at Brown University (*Introduction to Computer Vision*), fall term 2006.

*"Finding and Tracking Loose-Limbed People: Distributed Approach"*,

Intel Applications Research Lab (ARL), Santa Clara, CA, August 2005.

*"Attractive People: Assembling and Tracking Loose-Limbed Models using Non-Parametric BP"*,

Siemens Corporate Research, Princeton, NJ, December 2004.

## PATENTS

L. Sigal and I. Bachelder. Method for Determining a Pose of a Portion of an Object Using Fixtures. US Patent Application 10/039,388, filed September 27, 2001.

L. Sigal, Y. Zhu and D. Comaniciu. Graphical Object Models for Detection and Tracking. US Patent 2005/0286738, December 29, 2005.

L. Sigal, Y. Zhu and D. Comaniciu. Graphical Object Models for Detection and Tracking. Interna-

tional Patent WO 2005/119596, *December 15, 2005*.

I. Bachelder, L. Jacobson, J. Negro and L. Sigal. Method and System for Aligning Geometric Object Models with Images. US Patent 6,804,416, *October 12, 2004*.

PROFESSIONAL  
EXPERIENCE

**Intel Applications Research Lab**, Santa Clara, CA USA

*Research Intern*

**June, 2006 - Sep, 2006**

Designed and implemented new models and algorithms for tracking high speed athletic motions. Explored and developed algorithms for handling of motion blur and complex kinematics. Developed new class of physics-based priors for human motion.

**Intel Applications Research Lab**, Santa Clara, CA USA

*Research Intern*

**June, 2005 - Sep, 2005**

Developed probabilistic computer vision algorithms for tracking of 3D human bodies in video sequences. Advanced the state of the art techniques by developing algorithms for efficient inference in graphical models. Incorporated developed algorithms into existing probabilistic human tracking system.

**Siemens Corporate Research**, Princeton, NJ USA

*Research Intern*

**December, 2004 - May, 2004**

Developed novel statistical approaches to object detection and recognition for automated vehicle driver assistance. Formulated and developed a graphical model based approach for part-based object detection and tracking using AdaBoost likelihoods.

**Cognex Corporation**, Natick, MA USA

*Senior Software Engineer*

**1999 - 2001**

Developed recognition software for industrial vision applications. Headed an effort in developing a new tool for pattern matching and alignment, capable of identification and verification of highly non-linearly distorted patterns. Worked on development of Optical Character Verification (OCV) and Optical Character Recognition (OCR) software.

**P & E Microcomputer Systems Inc.**, Boston, MA USA

*Sophomore Software Engineer*

**1995 - 1998**

Worked in a team of three on the development of an Integrated Assembler/Debugger Windows Package for the Motorola 68HC05, 68HC08, and 68HC3xx families of microcontrollers for professional commercial use.

BIOGRAPHIC

*Date of Birth:* May 23, 1977

*Citizenship:* USA

*Languages:* English (native), Russian (native), Ukrainian (basic knowledge)

REFERENCES

Prof. Michael J. Black  
Brown University  
black@cs.brown.edu  
Tel: 1-401-863-7637

Prof. Stan Sclaroff  
Boston University  
sclaroff@cs.bu.edu  
Tel: 1-617-353-8928

Prof. David Mumford  
Brown University  
David.Mumford@brown.edu  
Tel: 1-401-863-3441

Prof. David Fleet  
University of Toronto  
fleet@cs.toronto.edu  
Tel: 1-416-946-8485

Prof. Chad Jenkins  
Brown University  
cjenkins@cs.brown.edu  
Tel: 1-401-863-7600

Prof. Horst Haussecker  
Intel Research  
horst.haussecker@intel.com  
Tel: 1-408-765-1560

**Additional references are available upon request.**