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### Employment History

Oct. 2003 – present	Professor, Department of Computer Science, University of Toronto
Jan. 1999 – Sept. 2003	Member of Research Staff and Area Manager (as of Feb, 2000), Perceptual Document Analysis and Digital Video Analysis Groups Palo Alto Research Center
July 1995 – Dec. 2002	Associate Professor Department of Computing and Information Science, Cross-appointed to Psychology and Electrical Engineering, Queen's University, Kingston
July 1996 – Aug. 1997	Visiting Research Scientist, Image Understanding Group, Xerox Palo Alto Research Center
July 1996 – Aug. 1997 Jan. 1994 – May 1994	Visiting Scholar, Department of Psychology, Stanford University
July 1990 – June 1995	Assistant Professor, Department of Computing and Information Science, Cross-appointed to Psychology, Queen's University, Kingston
Sept. 1987 – Apr. 1988	Research Associate and Lecturer, Cognitive Systems Group, Computer Science Department, University of Hamburg, Germany
Oct. 1984 – Apr. 1985	Research Associate, Artificial Intelligence Group, Department of Computer Science, University of Toronto

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## Academic Degrees

- Ph.D.**      **Department of Computer Science, University of Toronto, 1991**  
Supervision: Allan D. Jepson  
Thesis: *Measurement of Image Velocity*
- M.Sc.**      **Department of Computer Science, University of Toronto, 1984**  
Supervision: Allan D. Jepson and John K. Tsotsos  
Thesis: *Early Processing of Spatiotemporal Visual Information*
- B.Sc.**      **Queen's University, 1982**  
Mathematics and Computer Science

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## Awards / Honours

- 2010      Koenderink Prize, European Conference on Computer Vision '10  
2009      Best Paper Award, British Machine Vision Conference '09  
2005      Fellow, Canadian Institute for Advanced Research  
2003      Best Paper Award, UIST '03  
ACM Symposium on User Interface Software and Technology  
2003      Excellence in Science Award, Palo Alto Research Center  
2001      Best Paper Runner-Up Award,  
IEEE Conference on Computer Vision and Pattern Recognition '01  
1999      Marr Prize Honorary Mention (runner-up for best paper),  
IEEE International Conference on Computer Vision '99  
1996 – 99      Alfred P. Sloan Research Fellowship  
1985 – 87      NSERC Postgraduate Scholarship  
1982 – 84      NSERC Postgraduate Scholarship  
1982      NSERC Summer Research Grant  
1981 – 82      James H. Rattray Memorial Scholarship

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## Professional Activities

### Editorial Boards

- Advisory Board, *IEEE Trans. on Pattern Analysis and Machine Intelligence* (2009– )  
Associate Editor-In-Chief, *IEEE Trans. on Pattern Analysis and Machine Intelligence* (2005–2008)  
Associate Editor, *IEEE Trans. on Pattern Analysis and Machine Intelligence* (2000–2004)  
Guest Editor, *Computer Vision and Image Understanding*, Special Issue on Motion Analysis (2005)

### Conference Chairs (and Senior Program Committees)

- Program Co-Chair, European Conference on Computer Vision (2014)  
Program Co-Chair, IEEE Conference on Computer Vision and Pattern Recognition (2003)  
Area Chair, IEEE Conf. on Computer Vision and Pattern Recognition (2004, 2007, 2008, 2010)  
Area Chair, International Conference on Computer Vision (2009)  
Area Chair, International Conference on Machine Learning (2004)  
Area Chair, Neural Information Processing Systems, NIPS (2007, 2008)

### Program Committees

Asian Conference on Computer Vision, ACCV (2004)  
European Conference on Computer Vision, ECCV (2002, 2004)  
IAPR International Conference on Pattern Recognition, ICPR (2002, 2004)  
IEEE International Conference on Computer Vision, ICCV (1999, 2001, 2003, 2005)  
IEEE Conference on Computer Vision and Pattern Recognition, CVPR (1998, 2000, 2001, 2005)  
IEEE Workshop on Visual Motion (1991)  
IEEE Workshop on Motion and Video Computing (2002, 2007)  
IEEE Workshop on Statistical Methods for Video Processing (2003)  
IEEE Workshop on Event Mining: The Detection and Recognition of Events in Video (2003)  
IEEE Workshop on Spatial Coherence for Visual Motion Analysis (2004)  
Vision Interface, VI (1993, 1996, 1997, 2000)  
Conference on Articulated Motion and Deformable Objects (2006)  
Canadian Conference on Computer and Robot Vision, CRV (2004, 2005, 2006)  
Robotics Systems and Science, RSS (2006)  
NIPS Workshop on Evaluation of Articulated Human Motion and Pose Estimation (2006)  
CVPR Workshop on Evaluation of Human Motion and Pose Estimation (2007)

### Conference Reviewing

Most major vision conferences (CVPR, ECCV, and ICCV) since 1990, and certain machine learning conferences (NIPS) recently, along with miscellaneous vision workshops, and related conferences occasionally (SIGGRAPH, IJCAI and AAAI).

### Journal Reviewing

#### *Frequent reviewing:*

Computer Vision and Image Understanding;  
IEEE Transactions on Image Processing;  
IEEE Transactions on Pattern Analysis and Machine Intelligence;  
Image and Vision Computing;  
International Journal of Computer Vision;  
Journal of the Optical Society of America;  
Vision Research;  
Visual Neuroscience

#### *Occasional reviewing:*

Artificial Intelligence; Electronics Letters; Electronic Imaging; IEEE Transactions on Robotics and Automation; IEE Proceedings: Vision, Image and Signal Processing; Journal of Visual Communication and Image Representation; Optical Engineering; Pattern Recognition Letters; Psychological Research; Psychological Science;

### Other Technical Reviewing

ACM Distinguished Dissertation Awards;  
Kluwer Academic Press: Robotics Monograph Series;  
NSERC Research/Strategic Grant Proposals;  
FCAR Grant Proposals;  
NSF Grant Proposals

### Membership Activities

ARVO (Assoc. Research on Vision and Ophthalmology),  
IEEE (Inst. Electrical and Electronic Engineers),  
Chair, IEEE Computers & Communications Kingston Chapter (1994/95)

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## Research Programme

My research programme addresses fundamental problems in vision, spanning four related areas: machine vision; image processing; visual perception; and visual neuroscience. This includes the development of reliable algorithms for machine vision systems, and theoretical work on the neural basis of visual perception in biological systems. Most of my work to date has focused on *visual motion analysis binocular stereopsis, tracking, and human pose estimation*. Understanding these visual processes is central to the development of algorithms that would, for example, facilitate the determination of 3D scene layout, the detection and tracking of objects, the inference of the 3d motion of an observer (camera), and motion-based recognition of objects and their activities. Potential applications include novel human-computer interfaces, computer graphics and special effects, assisted automotive navigation, security, safety and surveillance, and markerless human motion capture.

### Computer Vision and Image Processing:

The general analysis and interpretation of visual motion requires that one model the relation between world properties and spatiotemporal variations in image intensity. This includes models of the scene dynamics, of object appearance, and of image formation. Early work in visual motion analysis focused on the task of 2D motion estimation, assuming simple models in which intensity is conserved and motion is unique and smooth in local image regions.

My research on visual motion, and early visual processing in general, is aimed at building richer mathematical models that allow us to estimate and interpret the motion of increasingly complex objects in natural image sequences. This research dates from my graduate work on the estimation of optical flow, to my most recent work on probabilistic methods for motion-based segmentation, image-based visual tracking, and the detection and tracking of 3D human pose.

#### *Phase-Based Visual Estimation:*

Among my most significant early contributions in machine vision are the development and analysis of phase-based techniques for measuring optical flow (i.e. 2D image velocity), image orientation, and binocular disparity. With Allan Jepson (University of Toronto) and Michael Jenkin (York University), my research on local phase information has involved both experimental and theoretical work. In addition to developing algorithms for phase-based matching, we have examined the stability of phase information, showing how unreliable measurements can be identified and rejected from subsequent analyses. Leif Haglund (Post-doc at Queen's Univ., 1994; now at Saab Research), Keith Langley (University College London) and I have since extended these techniques with the use recursive spatiotemporal filters toward real-time motion estimation, and to the measurement of orientation in small image regions for estimating surface orientation.

#### *Performance Analysis of Optical Flow Techniques:*

In collaboration with John Barron and Steven Beauchemin (University of Western Ontario), I conducted an extensive performance analysis of well-known optical flow algorithms. With independent implementations and a common set of synthetic and natural inputs, we showed how well-known techniques produce results which differed significantly in their accuracy and robustness. Phase-based and gradient-based techniques produced the most reliable results. This work was one of the first comprehensive benchmark tests in machine vision, and helped generate an interest in the theoretical and empirical comparison of visual algorithms. Our test suite and results, along with our implementations, have been available to others on the web. They have made a significant impact on the field of visual motion analysis and they remain the benchmark against which new methods are judged.

#### *Modeling Complex Motion and Appearance Changes in Image Sequences:*

Optical flow estimation methods work well with smooth, textured surfaces but not with complex deformations, occlusions, and significant changes in image appearance. To deal with more general classes of 2D motion,

Michael Black (Brown University), Yaser Yacoob (University of Maryland), Allan Jepson and I extended the use of parameterized motion models to handle discontinuous motion features (e.g., motion boundaries), as well as domain-specific classes of motion (e.g., the motion of human mouths and the motion of legs of a walking human). We learned linear parameterized models from robust optical flow estimates. The resulting models were then used to constrain the estimation of optical flow, and to detect occurrences of specific classes of motion in image sequences.

To deal with complex forms of appearance changes, Black, Yacoob and I proposed a formulation in which appearance changes were modeled by a linear mixture of causes. These included photometric causes such as lighting variations and specularities, as well as object-specific variations in appearance caused by complex local patterns of motion and occlusion. This research represents an encouraging first step toward the inference of the different physical causes of intensity variations in image sequences, but there exist many open problems in this area.

Horst Haussecker (PARC postdoc, then member of research staff 1999/2000; now at Intel Research) and I derived a linear formulation of a more restricted class of appearance changes based on physical models of image formation and photometry. Such physical models include changes in surface reflection caused by changes in surface orientation with respect to a direction light source, and thermal diffusion in infrared (IR) imaging. The latter formulation was used for tracking unmarked paper in a copier with laser-induced thermal emittance patterns on the paper surface.

#### *Motion Boundaries, Occlusions and Surface Depth:*

One of the most significant remaining problems in early motion estimation concerns occlusion boundaries, where the two key assumptions of current optical flow methods, brightness conservation and motion smoothness, are typically violated. Black and I recently formulated a probabilistic solution to this problem with a hybrid state-space model and a particle filter for approximate inference. The state space model included a discrete random variable to represent different motion classes (e.g., smooth motion, or discontinuous motion), and continuous variables to represent the parameters of each motion class. This work won Honorable Mention for the Marr Prize (runner-up for best paper) at the International Conference on Computer Vision in 1999.

Although these initial experiments produced encouraging results the method proved to be unreliable. Oscar Nestares (PARC post-doc 1999-2001; now at Intel Research) and I have since improved the method by introducing a random field of local neighborhoods to encourage spatiotemporal continuity of the inferred surface boundaries, and an empirical edge-based likelihood function to improve boundary localization.

#### *2.5D Visual Tracking and Layered Image Models:*

There exists a theoretical gap between model-based tracking of complex objects and early motion estimation, namely, the selection and initialization of models. It seems clear that some form of early analysis should help one select and initialize models, but this remains a largely unexplored topic. Allan Jepson, Michael Black and I have been working on methods for extracting effective representations of visual motion that provide an efficient characterization of the principal moving components of a scene and their relative depths. In future research we hope to use this representation to infer the occurrence of plausible models for subsequent model selection and refinement.

To provide stable image descriptions through time, Allan Jepson, Thomas El-Maraghi (University of Toronto) and I have developed an approach to learning 2D models of image appearance. The approach works with an on-line version of the EM algorithm to identify stable image structure during tracking. In this way the most stable regions can play the most significant role in the tracking, to facilitate tracking over long image sequences with precise image alignment. This work was awarded Best Paper Runner-Up at the IEEE Conference on Computer Vision and Pattern Recognition in 2001.

#### *Perceptual Organization for Rough Document Image Analysis:*

Most recently, my group at PARC has focused on the use of perceptual organization and graph-based recognition technologies for parsing the salient visual structure in a general class of document images. This class

includes both formatted documents as well as informal documents such as whiteboard images, annotated documents, sketches, and diagrams. We have produced software for rough document manipulation, especially targetted at whiteboard material, along with a parsing system for hand-drawn flow charts. This work was given the best paper award at UIST in 2003.

#### *3D People Tracking:*

The inference of human shape and motion in 3D has become a topic of great interest in the vision community. The problem is difficult because people move in complex ways, having with many degrees of freedom. Their appearance is similarly hard to model due to variations in lighting, to deformations of clothing, and to occlusions. To constrain people tracking, most existing methods assume one or more constraints, such as knowledge of a static background, the existence of multiple views of the person, or that color can be used to find skin regions. Hedvig Sidenbladh (KTH, Sweden), Michael Black and I proposed a Bayesian approach to tracking people in 3D from 2D video. With a motion-based likelihood function based on a robust form of intensity conservation, a particle filter to deal with nonlinear dynamics and observations, a learned parameterized model of human walking motion and manual initialization of the model, we were able to infer the time-varying 3D structure of a single person in unknown cluttered backgrounds in monocular, greyscale video.

More recently, in an attempt to provide more efficient stochastic sampling so that we could handle weaker models of human dynamics, Kiam Choo and I began to consider the use of particle filters with MCMC updates. Applied to the inference of 3D joint configuration from 2D motion capture point data, we found that a particle filter with hybrid Monte Carlo updates produced an estimator more than 2,000 times faster than a conventional particle filter, with similar estimator variance. In combination with richer likelihood functions, combining motion and edge information, I hope this will lead to more effective tracking in high-dimensional spaces with complex dynamics and observation equations.

#### *Learning Latent Variable Models for Human Motion:*

With Raquel Urtasun, Jack Wang, Pascal Fua, Aaron Hertzmann, and Neil Lawrence, I have recently worked on a new class of activity-specific latent variable model for representing priors over kinematic pose and motion. There are three variants on the original Gaussian Process Latent Variable Model of Lawrence (2004): the Gaussian Process Dynamical Model (GPDM) extends the GPLVM with a subspace dynamical model (Wang, Fleet, and Hertzmann 2005, 2008), the balanced-GPDM which has been applied successfully to monocular people tracking (Urtasun, Fleet and Fua, 2006), a topologically-constrained GPLVM with which one can influence the topology and coherence of the latent space to suit different classes of motion (such as periodic locomotion), to facilitate transitions between activities, and to generalize better; and the multifactor GPLVM (Wang, Fleet and Hertzman, 2007) which allows one to model known factors that combine to determine the pose (such as the subject's identity and the type of activity).

#### *Physics-Based Models for Human Pose Tracking:*

Despite the extensive use of kinematic models learned from mocap data, existing people trackers still produce unrealistic motions, with feet sliding on or above the ground, or implausible out-of-plane rotations of the body. We have begun to explore an entirely new approach in which physics-based models are used to ensure that the estimated poses and motions are physically realistic. With physics-based models we can enforce physical laws of motion and object interactions (e.g., people maintain balance and make contact with the ground during locomotion), Marcus Brubaker, Hertzmann and I developed a model based on the Anthropomorphic Walker of Kuo (2002) and used it to track people walking on level ground. Brubaker and I developed a more general model called *Kneed Walker* which can walk and run. It has been shown to track walking people with different speeds, on different slopes and with changing direction. It is also robust to occlusion.

### **Visual Perception and Visual Neuroscience:**

The study of biological visual systems faces many of the same problems as does research on machine vision. Most notably, the theoretical underpinings of how one might infer properties of the world from images

is common to both domains of enquiry. In biological vision my work has focused on mathematical formulations of visual processing, to elucidate the functional role of neural activity in the visual cortex.

*Second-Order Motion and Stereo Perception:*

With Keith Langley, I developed a formal description of so-called non-Fourier (or second-order) perceptual phenomena. Non-Fourier motion stimuli are signals whose perceived motion is not predicted by typical energy or gradient-based models. These stimuli include the motion of contrast envelopes (e.g., shadows), occlusion boundaries, and some illusory motions due to aliasing. We showed that many non-Fourier stimuli, when viewed as multiplicative combinations of elementary signals, have simple descriptions in the Fourier domain. Our formal description is derived, in part, from the definition of group velocity in wave mechanics.

This modeling effort has since led to several psychophysical studies. Langley, Paul Hibbard (University of St. Andrews), and I reported evidence supporting the hypothesis that contrast envelopes are processed by the visual system after orientation- and scale-specific filtering (in visual cortex). This showed that their perception is not an artifactual consequence of an early nonlinearity (e.g., in photo-transduction), which had been proposed to explain these percepts.

In binocular vision, Langley, Hibbard and I showed that non-Fourier stimuli sometimes produce a percept of transparency, distinct in its properties from transparent percepts that arise from a superposition of two signals. This supported the hypothesis of a non-Fourier channel in stereo depth perception. One consequence of this result, in conjunction with our earlier modeling efforts, was a hypothesis that non-Fourier stimuli are related to distinct physical properties of natural scenes (e.g., multiplicative transparency and occlusions), and therefore non-Fourier processing channels may not subserve all the same visual tasks (such as egomotion) as conventional first-order models. However, Rick Gurnsey, Cindy Potechin (Concordia University) and I found that non-Fourier motion can be used to induce a percept of self-motion (vection). In this study we found a dissociation between motion-aftereffects (non-existent with non-Fourier stimuli) and vection as the relative amounts of Fourier and non-Fourier motion energy were varied in the stimuli.

*Neural Model of Binocular Disparity:*

In visual neuroscience, with Hermann Wagner (Aachen University) and David Heeger (Stanford University), I developed a neural model for the processing of binocular disparity and 3d depth in visual cortex. The goal was to explain the binocular interaction of cells in the primary visual cortex from a functional perspective, in terms of the computation and representation of binocular disparity. The model involves linear neurons and energy neurons, interocular position-shifts and/or phase-shifts, monocular and binocular normalization, pooling in local spatial neighbourhoods, and pooling across orientation- and scale-specific channels. The basic computational framework was derived as a modified form of *phase-correlation*. This work produced a number of theoretical findings, including the fact that conventional energy models are not disparity detectors (as they regularly respond strongly to false matches). This work also makes specific predictions concerning how one might measure the source of disparity selectivity in V1 neurons, and how one might construct disparity detectors from their outputs. I have not continued this work since moving to Xerox PARC, except for my collaboration with Herman Wagner and his students.

*fMRI Studies of Human Binocular Depth Perception:*

More recently, Ben Backus (University of Pennsylvania), Geoff Boynton (Salk Institute), Andrew Parker (Oxford University), David Heeger and I began to use functional magnetic resonance imaging (fMRI) to study the neural basis of binocular vision and depth perception in humans. It is well known that disparity tuned neurons are widespread in several visual cortical areas, but it is not clear which of these neurons are involved in stereo depth perception, as opposed to binocular fusion or eye movement control for example. Using different 3d surface configurations, and varying amounts of binocularly uncorrelated noise, we identified several brain areas where the brain activity measured with fMRI correlates well with psychophysical tests of binocular acuity limits and disparity upper depth limits. Among these different visual areas, area V3A showed striking sensitivity to stereoscopic stimuli, suggesting that V3A may play a special role in the stereo pathway.

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## Research Contributions

### Books and Book Chapters

- Brubaker, M.A., Sigal, L. and Fleet, D.J. (2009) Video-based people tracking. **Handbook of Ambient Intelligence and Smart Environments**, H. Nakashima, H. Aghajan, J.C. Augusto (editors). Springer Verlag, pp. 57–88.
- Fleet, D.J. and Weiss, Y. (2005) Optical flow estimation. **Mathematical Models of Computer Vision: The Handbook**, N. Paragios, Y. Chen, and O. Faugeras (editors), Springer Verlag, Chapter 15, pp. 239-258
- Fleet, D.J., Black, M.J. and Nestares, O. (2002) Bayesian inference of visual motion boundaries. **Exploring Artificial Intelligence in the New Millennium**, G. Lakemeyer and B. Nebel (editors), Morgan Kaufmann Press (edited volume containing the invited Distinguished Papers from IJCAI 2001), pp. 139–173
- Weiss, Y. and Fleet, D.J. (2001) Velocity likelihoods in biological and machine vision. In **Probabilistic Models of the Brain: Perception and Neural Function**, R.P.N. Rao, B.A. Olshausen and M.S. Lewicki (editors), MIT Press, pp. 81–100.
- Fleet, D.J., Heeger, D.J. and Wagner, H. (1997) Neural encoding of binocular disparity. In **Computational and Biological Mechanisms of Visual Coding**, M. Jenkin and L. Harris (editors), Cambridge University Press, pp. 103-130
- Fleet, D.J. (1992) **Measurement of Image Velocity**. Kluwer Academic Publishers, Norwell MA
- Tsotsos, J.K., Fleet, D.J., Jepson, A.D. (1988) Towards a theory of motion understanding in man and machine. In **Motion Understanding: Robot and Human Vision**, W. Martin and J. Aggarwal (editors), Kluwer Academic Publishers, pp. 353-417

### Refereed Journal Publications

- Macrini, D., Dickinson, S., Fleet, D.J., and Siddiqi, K. (2010) Bone Graphs: Medial shape parsing and abstraction. *Computer Vision and Image Understanding*, (under major revision)
- de la Gorce, M., Fleet, D.J., Paragios, N. (2010) Hand tracking with occlusion, lighting and texture. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, (to appear)
- Wang, J., Fleet, D.J. and Hertzmann, A. (2010) Optimizing walking controllers with uncertain user inputs and environments. *ACM Transactions on Graphics (SIGGRAPH)*, 29(4), Article 73
- Brubaker, M.A., Fleet, D.J. and Hertzmann, A. (2010) Physics-based pose tracking with the Anthropomorphic Walker. *International Journal of Computer Vision*, 87(1):140–155
- Wang, J., Fleet, D.J. and Hertzmann, A. (2009) Optimizing walking controllers. *ACM Transactions on Graphics (SIGGRAPH Asia)*, 28(5), Article 168
- Levinshtein, A., Stere, A., Kutulakos, K., Fleet, D.J., Dickinson, S. and Siddiqi, K. (2009) TurboPixels: Fast superpixels using geometric flows. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 31(12):2290–2297
- Wang, J., Fleet, D.J. and Hertzmann, A. (2008) Gaussian process dynamical models. *IEEE Transactions on Pattern Analysis and Machine Intelligence* 30(2):283–298

- Urtasun, R., Fleet, D.J. and Fua, P. (2006) Motion models for 3D people tracking. *Computer Vision and Image Understanding* 104(2):157–177
- Nunes, P., Haines, N., Kuppuswamy, V., Fleet, D.J. and Stewart, B. (2006) Synaptic Vesicle Mobility and Presynaptic F-Actin Are Disrupted in an NSF Allele of *Drosophila*. *Molecular Biology of the Cell* 17:4709–4719
- Jepson, A.D., Fleet, D.J. and El-Maraghi, T. (2003) Robust on-line appearance models for vision tracking. *IEEE Transactions on Pattern Analysis and Machine Intelligence* 25(10):1296–1311
- Backus, B., Fleet, D.J., Parker, A.J. and Heeger, D.J. (2001) Human cortical activity correlates with stereoscopic depth perception. *Journal of Neurophysiology* 86:2054–2068
- Haussecker, H.W. and Fleet, D.J. (2001) Estimating optical flow with physical models of brightness variation. *IEEE Transactions on Pattern Analysis and Machine Intelligence* 23(6):661–673
- Gurnsey, R., and Fleet, D.J. (2001) Texture space. *Vision Research* 41(3):745–757
- Black, M.J. and Fleet, D.J. (2000) Probabilistic detection and tracking of motion boundaries. *International Journal of Computer Vision* 38(3):229–243
- Fleet, D.J., Black, M.J., Yacoob, Y., and Jepson, A.D. (2000) Design and use of linear models for image motion analysis. *International Journal of Computer Vision* 36(3):171–193
- Lippert, J., Fleet, D.J., and Wagner, H. (2000) Disparity tuning as simulated by a neural net. *Biological Cybernetics* 83(1):61–72
- Black, M.J., Fleet, D.J., and Yacoob, Y. (2000) Robustly estimating changes in image appearance. *Computer Vision and Image Understanding* 78(1):8–31
- Langley, K., Fleet, D.J., and Hibbard, P.B. (1999) Stereopsis from contrast envelopes. *Vision Research* 39(14):2313–2324.
- Langley, K., Fleet, D.J., and Hibbard, P.B. (1998) Linear and nonlinear transparencies in stereopsis. *Proceedings of the Royal Society London B*. 265:1837–1845.
- Gurnsey, R., Fleet, D.J. and Potechin, C. (1998) Second-order motions contribute to vection. *Vision Research* 38(18):2801–2816
- Fleet, D.J., Wagner, H., and Heeger, D.J. (1996) Neural encoding of binocular disparity: Energy models, position-shifts and phase-shifts. *Vision Research* 36(12):1839–1857
- Langley, K., Fleet, D.J., and Hibbard, P.B. (1996) Linear filtering precedes nonlinear processing in early vision. *Current Biology* 6(7):891–896
- Fleet, D.J. and Langley, K. (1995) Recursive filters for optical flow. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 17(1):61–67
- Fleet, D.J. and Langley, K. (1994) Computational analysis of non-Fourier motion. *Vision Research*, 34(22):3057–3079
- Barron, J.L., Fleet, D.J., and Beauchemin, S.S. (1994) Performance of optical flow techniques. *International Journal of Computer Vision*, 12(1):43–77
- Fleet, D.J. and Jepson, A.D. (1993) Stability of phase information. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 15(12):1253–1268

- Jepson, A.D. and Fleet, D.J. (1991) Phase singularities in scale-space. *Image and Vision Computing Journal*, 9(5):338–343
- Fleet, D.J., Jepson, A.D., and Jenkin, M. (1991) Phase-based disparity measurement. *Computer Vision, Graphics and Image Processing: Image Understanding*, 53(2):198–210
- Fleet, D.J. and Jepson, A.D. (1990) Computation of component image velocity from local phase information. *International Journal of Computer Vision*, 5(1):77–104
- Fleet, D.J. and Jepson, A.D. (1989) Hierarchical construction of orientation and velocity selective filters. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 11(3):315–325
- Fleet, D.J., and Jepson, A.D. (1985) Spatiotemporal inseparability in early vision: centre-surround models and velocity selectivity. *Computational Intelligence*, 1(3):89–102
- Fleet, D.J., Hallett, P.E., and Jepson, A.D. (1985) Spatiotemporal inseparability in early visual processing. *Biological Cybernetics*, 52(2):153–164

### Refereed Conferences/Workshops: Papers in Proceedings

- ICCV*: IEEE International Conference on Computer Vision, IEEE Press
- CVPR*: IEEE Conference on Computer Vision and Pattern Recognition, IEEE Press
- ICIP*: IEEE International Conference on Image Processing, IEEE Press
- ECCV*: European Conference on Computer Vision, Springer Verlag
- BMVC*: British Machine Vision Conference
- NIPS*: Advances in Neural Information Processing Systems, MIT Press
- ICML*: International Conference on Machine Learning, ACM Press
- Sigal, L., Fleet, D.J., Troje, N. and Livne, M.: Human attributes from 3D pose tracking. *ECCV*, Crete, September 2010
- Taylor, G., Sigal, L., Fleet, D.J. and Hinton, G.: Dynamical binary latent variable models for 3D pose tracking. *CVPR*, San Francisco, June 2010
- Manfredotti, C., Fleet, D.J., and Messina, E.: Relations to improve multi-target tracking in an activity recognition system. *International Conference on Imaging for Crime Detection and Prevention*, London, December 2009
- Brubaker, M., Sigal, L. and Fleet, D.J.: Estimating contact dynamics. *ICCV*, Kyoto, October 2009
- Estrada, F., Fleet, D.J. and Jepson, A.D.: Stochastic image denoising. *BMVC*, London, September 2009  
**[Best Paper Award]**
- Darby, J., Li, B., Costens, N., Fleet, D.J. and Lawrence, N.: Backing Off: Hierarchical decomposition of activity for 3D novel pose recovery. *BMVC*, London, September 2009
- Sigal, L., Memsevic, R., and Fleet, D.J.: Shared kernel information embedding for discriminative inference. *CVPR*, Miami, June 2009
- Urtasun, R., Fleet, D.J., Geiger, A., Popovic, J., Darrell, T. and Lawrence, N.: Topologically constrained latent variable models. *ICML*, Helsinki, June 2008, pp. 96-103
- De la Gorce, M., Paragios, N., and Fleet, D.J.: Model-based hand tracking with texture, shading and self-occlusions. *CVPR*, Anchorage, June 2008

- Brubaker, M. and Fleet, D.J.: The Kneed Walker for human pose tracking. *CVPR*, Anchorage, June 2008
- Urtasun, R., Fleet, D.J. and Lawrence, N.: Modeling human locomotion with topologically constrained latent variable models. *Workshop on Human Motion*, Rio de Janeiro, October 2007, pp. 104-118 (Lecture Notes in Computer Science, v. 4814)
- Hyndman, M., Jepson, A.D., Fleet, D.J.: Higher-order autoregressive models for dynamic textures. *BMVC*, Coventry, September 2007
- Wang, J.M., Fleet, D.J., and Hertzmann, A.: Multifactor Gaussian Process models for style-content separation. *ICML*, Corvallis, Oregon, June 2007, pp. 975-982
- Brubaker, M., Fleet, D.J., and Hertzmann, A.: Physics-based people tracking with simplified lower-body dynamics. *CVPR*, Minneapolis, June 2007
- Urtasun, R., Fleet, D.J., and Fua, P.: 3D people tracking with Gaussian process dynamical models. *CVPR*, New York, June 2006, Vol. 1, pp. 238-245
- Wang, J.M., Fleet, D.J., and Hertzmann, A.: Gaussian Process dynamical models. *NIPS 18*, (eds.) Weiss, Schokopf, and Platt, 2006, pp. 1441-1448
- Urtasun, R., Fleet, D.J., Hertzmann, A. and Fua, P.: Priors for people tracking from small training sets. *ICCV*, Beijing, October 2005, Vol. I, pp. 403-410
- Urtasun, R., Fleet, D.J. and Fua, P.: Monocular 3D tracking of the golf swing. *CVPR*, San Diego, June 2005, Vol. II, pp. 932-938
- Marinak, D., Dudek, G. and Fleet, D.J.: Learning sensor network topology through Monte Carlo expectation maximization. *Int. Conf. Robotics and Automation*, Barcelona, April 2005, pp. 4581-4587.
- Saund, E., Fleet, D.J., Larner, D. and Mahoney, J.V.: Perceptually-supported image editing of text and graphics. *ACM Symposium on User Interface Software and Technology (UIST '03)*, Vancouver, November 2003, *ACM CHI Letters* 5(2):183-192 **[Best Paper Award]**
- Nestares, O. and Fleet, D.J.: Error-in-variables likelihood functions for motion estimation. *IEEE International Conference on Image Processing*, Barcelona, September 2003, vol. III, pp. 77-80
- Poon, E. and Fleet, D.J.: Hybrid Monte Carlo filtering: Edge-based people tracking. *IEEE Workshop on Motion and Video Computing*, Orlando, December 2002, pp. 151-158
- Jepson, A.D., Fleet, D.J. and Black, M.J.: A layered motion representation with occlusion and compact spatial support. *ECCV*, Copenhagen, May 2002, Vol. I, pp. 692-706
- Bhotika, R., Fleet, D.J., and Kutulakos, K.: A probabilistic theory of occupancy and emptiness. *ECCV*, Copenhagen, May 2002, Vol. III, pp. 112-130
- Jepson, A.D., Fleet, D.J. and El-Maraghi, T.: Robust on-line appearance models for vision tracking. *CVPR*, Kauai, December 2001, Vol. I, pp. 415-422 **[Best Paper Runner-Up Award]**
- Nestares, O. and Fleet, D.J.: Probabilistic tracking of motion boundaries with spatiotemporal predictions. *CVPR*, Kauai, December 2001, Vol. II, pp. 358-365
- Saund, E., Mahoney, J., Larner, D., and Fleet, D.J.: Perceptual organization as a foundation for graphics recognition. *IAPR Int. Workshop on Graphics Recognition*, Kingston, Canada, Sept. 2001, pp. 175-179

- Ormonet, D., Lemieux, C., and Fleet, D.J.: Lattice particle filters. *Conference on Uncertainty in Artificial Intelligence (UAI)*, Seattle, August 2001, Morgan Kaufmann Press, pp. 395–402
- Choo, K. and Fleet, D.J.: Tracking people using hybrid Monte Carlo. *ICCV*, Vancouver, July 2001, Vol II, pp. 321-328
- Sidenbladh, H., Black, M.J., and Fleet, D.J.: Stochastic tracking of 3D human figures using 2d image motion. *ECCV*, Dublin, June 2000, Vol. II, pp. 702–718 [**Koenderink Prize**]
- Haussecker, H. and Fleet, D.J.: Computing optical flow with physical models of brightness variation. *CVPR*, Hilton Head, South Carolina, June 2000, Vol. II, pp. 760-767
- Nestares, O., Fleet, D.J., and Heeger, D.J.: Likelihood functions and confidence bounds for total-least-squares problems. *CVPR*, Hilton Head, South Carolina, June 2000, Vol. I, pp. 523–530
- Ma, B., Ellis, R.E. and Fleet, D.J.: Spotlights: A robust method for surface-based registration in orthopedic surgery. *Int. Conf. Medical Image Comp. and Computer-Assisted Intervention*, Cambridge, UK, Springer, September 1999, pp. 936-944
- Black, M.J. and Fleet, D.J.: Probabilistic detection and tracking of motion discontinuities. *ICCV*, Corfu, Greece, September 1999, pp. 551–558 [**Marr Prize Honorable Mention**]
- Fleet, D.J., Black, M.J. and Jepson, A.D.: Motion feature detection using steerable flow fields. *CVPR*, Santa Barbara, June 1998, pp. 274-281
- Black, M.J., Fleet, D.J., and Yacoob, Y.: A framework for modeling appearance change in image sequences. *ICCV*, Mumbai, India, January 1998, pp. 660-667
- Fleet, D.J. and Heeger, D.J.: Embedding invisible information in color images. *ICIP*, Santa Barbara, October 1997, Vol. I, pp. 532-535
- Black, M.J., Yacoob, Y., Jepson, A.D., and Fleet, D.J.: Learning parameterized models of image motion. *CVPR*, Puerto Rico, June 1997, pp. 561-567
- Black, M.J., Yacoob, Y., and Fleet, D.J.: Modeling appearance change in image sequences. *Third Int. Workshop on Visual Form*, Capri, Italy, May 1997, C. Arcelli, L.P. Cordella, and G.S. di Baja, Eds., World Scientific Pub., pp. 11–20.
- Ellis, R., Fleet, D.J., Bryant, T., Rudan, J., and Fenton, P.: A method for evaluating CT-based surgical registration. *Proc. Int. Conf. Medical Robotics and Computer Assisted Surgery*, Grenoble, March 1997 pp. 141-150
- Clifford, C., Langley, K. and Fleet, D.J.: Centre-frequency adaptive IIR temporal filters for phase-based image velocity estimation. *IEE Int. Conf. Image Proc. and Applic.*, Edinburgh, July 1995, pp. 173-178
- Haglund, L. and Fleet, D.J.: Stable estimation of image orientation. *ICIP*, Austin, November 1994, Vol. III, pp. 68-72
- Fleet, D.J.: Disparity from local weighted phase-correlation. *IEEE International Conf. Systems, Man, & Cybernetics*, San Antonio, October 1994, pp. 48-56
- Barron, J.L., Beauchemin, S.S., and Fleet, D.J.: On optical flow. *6th Int. Conf. AI and Inform.-Control Systems of Robots*, Bratislava, Slovakia, Sept. 1994, World Scientific Publ., pp. 3-14
- Fleet, D.J. and Langley, K.: Toward real-time optical flow. *Vision Interface*, Toronto, May 1993, pp. 116-124

- Langley, K. and Fleet, D.J.: Recursive filters for phase-based optical flow. *Israeli Conf. on Vision and AI*, Ramat Gan, Isreal, December 1992, pp. 255-264
- Langley, K. and Fleet, D.J.: Multiple binaural time delay estimation. *ESCA Workshop on Speech Processing in Adverse Conditions*, Cannes, November 1992, pp. 159-162 (ISSN 1018-4554)
- Langley, K., Fleet, D.J., and Atherton, T.J.: On transparent motion computation. *BMVC*, Leeds, September 1992, pp. 245-255
- Barron, J.L., Fleet, D.J., Beauchemin, S.S., and Burkitt, T.: Performance of optical flow techniques. *CVPR*, Champaign, June 1992, pp. 236-242
- Langley, K., Fleet, D.J., and Atherton, T.J.: Multiple motions from instantaneous frequency. *CVPR*, Champaign, June 1992, pp. 846-849
- Fleet, D.J. and Jepson, A.D.: Stability of phase information. *IEEE Workshop on Visual Motion*, Princeton, October 1991, pp. 52-60
- Jepson, A.D., and Fleet, D.J.: Scale-space singularities. *ECCV*, Antibes, April 1990, Springer-Verlag, pp. 50-55
- Fleet, D.J. and Jepson, A.D.: Computation of normal velocity from local phase information, *CVPR*, San Diego, June 1989, pp. 379-386
- Fleet, D.J. and Jepson, A.D.: Computation of normal velocity from local phase information, *OSA Image Understanding and Machine Vision Meeting*, Cape Cod, June 1989, pp. 58-61
- Mohnhaupt, M. and Fleet, D.J.: Raum-zeitliche Filter fur eine top-down Steuerung der Bewegungs-analyse, *German AI Workshop*, August 1988, Springer-Verlag, pp. 296-305
- Fleet, D.J. and Jepson, A.D.: Velocity extraction without form interpretation, *IEEE Workshop on Computer Vision*, Bellaire, October 1985, pp. 179-185
- Tsotsos, J.K., Jepson, A.D., and Fleet, D.J.: Motion understanding meets early vision: an introduction, *IEEE Applications of AI*, Denver, December 1984, pp. 239-244

### **Conference Video Proceedings**

- Urtasun, R., Fleet, D.J., and Fua, P.: 3D people tracking with Gaussian Process dynamical models. *CVPR*, New York, June 2006
- Urtasun, R., Fleet, D.J., Hertzmann, A. and Fua, P.: Priors for people tracking from small training sets. *ICCV*, Beijing, October 2005, Vol. I, pp. 403-410
- Urtasun, R., Fleet, D.J. and Fua, P.: Monocular 3D tracking of the golf swing. *CVPR*, San Diego, June 2005, Vol. II, pp. 932-938

### **Lightly Refereed Conferences/Workshops: Papers in Proceedings**

- Manfredotti, C., Messina, E. and Fleet, DJ.: Relations as context to improve multi-target tracking and activity recognition. Proc. of 1st Workshop Log-IC09, Potsdam, September 2009. (CEUR Workshop Proceedings, ISSN 1613-0073)
- Urtasun, R., Fleet, D.J., Darrell, T. and Lawrence, N.: Modeling human locomotion with topologically constrained latent variable models. *NIPS Workshop on Topology Learning*, Vancouver, December 2007

- Brubaker, M.A., Fleet, D.J. and Hertzmann A.: Physics-based human pose tracking. *NIPS Workhop: Evaluation of Articulated Human Motion and Pose Estimation*, Vancouver, December 2006
- Saund, E., Fleet, D., Mahoney, J., and Lerner, D.: Rough and degraded document interpretation by perceptual organization. *Symposium on Document Image Understanding Technology*, Maryland, April 2003
- Saund, E., Mahoney, J., Fleet, D.J., Lerner, D. and Lank, E.: Perceptual organization as a foundation for intelligent sketch editing. *AAAI Spring Symp. on Sketch Understanding*, March 2002, Stanford University, pp. 118–125
- Ormoneit, D., Sidenbladh, H., Black, M., Hastie, T., and Fleet, D.: Learning and tracking human motion using functional analysis. *Proc. IEEE Workshop on Human Modeling, Analysis and Synthesis*, Hilton Head, SC, June 2000.
- van der Willigen, R.F., Lippert, J., Fleet, D.J., Wagner, H.: Binocular information processing in the owl. In: *GISI'97*, M. Jarke and K. Pasedach (editors), Springer Verlag, Berlin, Sept, 1997
- Fleet, D.J. and Jepson, A.D.: The extraction of orientation and 2-d velocity through hierarchical processing, *SPIE Conf. on Image Coding (vol. 594)*, Cannes, December 1985, pp. 10-20

#### Conferences with Published Abstracts

- ARVO: Association for Research in Vision and Ophthalmology Annual Meeting*  
*ECVP: European Conference on Visual Perception*  
*OSA: Optical Society of America Annual Meeting*
- Saund, E., Fleet, D., Lerner, D. and Mahoney, J.: Perceptually Supported Image Editing of Text and Graphics. *ACM Transactions on Graphics: Proceedings of ACM SIGGRAPH 2004*, V. 23, No. 3, August, 2004.
- Backus, B., Fleet, D.J., Parker, A.J., Heeger, D.J.: Cortical activity correlates with stereoscopic depth perception. *Conf. on Functional Brain Imaging in Vision*, Fort Lauderdale, Florida, May 2000
- Weiss, Y. and Fleet, D.J.: Velocity likelihoods from generative models. *ARVO*. Fort Lauderdale, May 2000 (see *Invest. Ophth. and Vis. Res.*, vol. 41)
- Backus, B.T., Fleet, D.J., Tyler, C.W., and Heeger, D.J.: fMRI correlates of stereo depth discrimination. *Society for Neuroscience Annual Meeting*, October 1999
- Backus, B.T., Fleet, D.J. and Heeger, D.J.: Differential fMRI response to absolute and relative disparity in area V3/V4. *ARVO*, Fort Lauderdale, May 1999 (see *Invest. Ophth. and Vis. Res.*, vol. 40)
- Langley, K., Fleet, D.J., and Hibbard, P.: A comparison of first-order and second-order transparency thresholds in stereopsis. *ECVP*, Oxford, August 1998 (see *Perception*, vol. 27 suppl., p. 102)
- Fleet, D.J.: Binocular energy models and the encoding of binocular disparity. *OSA*, Long Beach, October 1997 (see *Optics and Photonics News*, vol. 8 supplement, p. 92)
- Potechin, C., Gurnsey, R. and Fleet, D.J.: Vection and motion after-effects with nonFourier stimuli. *ARVO*, Fort Lauderdale, May 1997 (see *Invest. Ophth. and Vis. Res.*, vol. 38)
- Khan, R., Boynton, G., Fleet, D.J., Heeger, D.J.: Neural basis of stereo depth perception measured with fMRI. *ARVO*, Fort Lauderdale, May 1997 (see *Invest. Ophth. and Vis. Res.*, vol. 38)
- Gurnsey, R. and Fleet, D.J.: A multidimensional scaling study of texture perception. *ARVO*, Fort Lauderdale, May 1996 (see *Invest. Ophth. and Vis. Res.*, vol. 37)

- Langley, K. and Fleet, D.J.: Combined multiplicative/additive model of plaid transparency. *ARVO*, Fort Lauderdale, May 1996 (see *Invest. Ophthalm. and Vis. Res.*, vol. 37)
- Potechin, C., Gurnsey, R. and Fleet, D.J.: Vection, motion aftereffects and first and second-order motion signals. *ARVO*, Fort Lauderdale, May 1996 (see *Invest. Ophthalm. and Vis. Res.*, vol. 37)
- Langley, K., Fleet, D.J. and Hibbard, P.: Linearity of early visual analysis. *Proc. Ann. Meeting of Applied Vision Assoc.* Reading, April 1996
- Hibbard, P., Langley, K., and Fleet, D.J.: Transparent asymmetry in stereopsis. *ECVP*, Tuebingen, August 1995
- Langley, K., Fleet, D.J., and Hibbard, P.: Scale dependence of transparency in RDS. *ECVP*, Tuebingen, August 1995
- Fleet, D.J., Heeger, D.J. and Wagner, H.: Computational model of binocular vision. *ARVO*, Fort Lauderdale, May 1995 (see *Invest. Ophthalm. and Vis. Res.*, vol. 36)
- Langley, K. and Fleet, D.J.: A model for coherent and multiplicatively transparent plaids. *ARVO*, Fort Lauderdale, May 1995 (see *Invest. Ophthalm. and Vis. Res.*, vol. 36)
- Fleet, D.J. and Langley, K.: Non-Fourier channels in stereopsis and motion. *ECVP*, Eindhoven, September 1994 (see *Perception*, vol. 23 supplement, p. 83)
- Hibbard, P., Langley, K., and Fleet, D.J.: Computational model for stereoscopic slant using orientational differences from Fourier and non-Fourier mechanisms. *ECVP*, Eindhoven, September 1994 (see *Perception*, vol. 23 supplement, p. 35)
- Fleet, D.J. and Langley, K.: Computational analysis of non-Fourier motion. *ARVO*, Sarasota, May 1994 (see *Invest. Ophthalm. and Vis. Res.*, vol. 35, no. 4, p. 1267)
- Langley, K. and Fleet, D.J.: Analysis of subsampled image motion. *ARVO*, Sarasota, May 1994 (see *Invest. Ophthalm. and Vis. Res.*, vol. 35, no. 4, p. 1406)
- Langley, K. and Fleet, D.J.: A post-filtering logarithmic transformation applied to multiplicative transparency and motion discontinuities. *Proc. Applied Vision Assoc.* Bristol, April, 1994 (see *Ophthalm. Physiol. Optics* 14, p. 441, 1994)
- Langley, K. and Fleet, D.J.: Phase and energy velocity: An alternative to Fourier/non-Fourier motion mechanisms. *ECVP*, Edinburgh, August 1993 (see *Perception*, vol. 22 supplement, p. 83-84)
- Langley, K. and Fleet, D.J.: On  $D_{max}$  in Optic Flow. *ECVP*, Pisa, September 1992 (see *Perception*, vol. 21 supplement, p. 41)
- Langley, K. and Fleet, D.J.: Using group and phase velocity to explain coherent and transparent motion. *Proc. Ann. Meeting of Applied Vision Assoc.* Manchester, 1992, pp. 1-2 (see *Ophthalm. Physiol. Optics*)
- Fleet, D.J. and Langley, K.: Computing orientational disparities from phase gradients. *U.K. SERC III Workshop*, Glasgow, September 1991
- Langley, K. and Fleet, D.J.: Causal velocity mechanisms applied to transparent surfaces. *ECVP*, Moscow, August 1991 (see *Perception*, vol. 20 supplement, p. 79)
- Fleet, D.J. and Jepson, A.D.: Measurement of orientation and image velocity through hierarchical processing. *OSA*, Washington DC, October 1985 (see *J. Optical Society of America A*, vol. 2, No. 13, p. 19)

## Technical Reports

RPL: Robotics and Perception Laboratory, Queen's University

RBCV: Research in Biological and Computational Vision, University of Toronto

FBI-HH: Department of Computer Science, University of Hamburg

Bhotika, R., Fleet, D.J. and Kutulakos, K.: Probabilistic theory of occupancy and emptiness. University of Rochester, TR 753, December 2001.

Fleet, D.J., Wagner, H. and Heeger, D.J.: Neural encoding of binocular disparity: Energy models, position shifts and phase shifts. RPL-TR-9510

Darrell, T. and Fleet, D.J.: Second-order method for occlusion relationships in motion layers. MIT Media Lab TR: 314, 1995

Fleet, D.J. and Langley, K.: Computational analysis of non-Fourier motion. RPL-TR-9309

Barron, J.L., Fleet, D.J., and Beauchemin, S.S.: Performance of optical flow techniques. RPL-TR-9207 – Revised, July 1993

Fleet, D.J. and Langley, K.: Recursive filters for optical flow. RPL-TR-9308

Barron, J.L., Fleet, D.J., and Beauchemin, S.S.: Performance of optical flow techniques. RPL-TR-9207

Fleet, D.J. and Jepson, A.D.: Stability of Phase Information. RPL-TR-9105

Fleet, D.J., Jepson, A.D. and Jenkin, M.: Phase-based disparity measurement. RBCV-TR-89-29

Fleet, D.J. and Jepson, A.D.: Computation of normal velocity from local phase information. RBCV-TR-89-27

Fleet, D.J.: Implementation of velocity-tuned filters and image encoding. FBI-HH-M-159/88

Fleet, D.J. and Jepson, A.D.: On the hierarchical construction of orientation and velocity selective filters. RBCV-TR-85-8

Fleet, D.J.: The early processing of spatio-temporal visual information. RBCV-TR-84-7

Fleet, D.J. and Jepson, A.D.: A cascaded filter approach to the construction of velocity selective mechanisms. RBCV-TR-84-6

Fleet, D.J., Jepson, A.D., and Hallett, P.E.: A spatio-temporal model for early visual processing. RBCV-TR-84-1

## Patents

Patent US7,093,202: "Method and system for interpreting imprecise object selection paths", Eric Saund, James Mahoney, David Fleet, Dan Larner (Filed: Mar. 22, 2002, Awarded US Patent: Aug. 15, 2006).

Patent US7,058,205: "Robust on-line appearance models for visual tracking", Allan D. Jepson, David J. Fleet, and Thomas F. El-Maraghi (Filed: December 7, 2001, Awarded US Patent: June 6, 2006)

Patent US6,903,751: "System and method for editing electronic images", Eric Saund, James Mahoney, David J. Fleet, Dan Larner (Filed: March 22, 2002, US Patent Awarded: June 7, 2005).

Patent US6,954,544: "Visual motion analysis method for detecting arbitrary numbers of moving objects in image sequences", Allan D. Jepson, David J. Fleet, and Michael J. Black (Filed: May 22, 2002, Awarded US Patent: Oct. 11, 2005).

Patent US5,949,055: "Automatic Geometric Image Transformations Using Embedded Signals", David J. Fleet, David J. Heeger, Todd A. Cass, David L. Hecht (Filed: Oct. 23, 1997; Awarded US Patent: Sept. 7, 1999)

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## Invited Conference/Workshop Presentations

- Fleet, D.J.: Physics-Based models for human motion analysis. *British Machine Vision Conference*, [Keynote Presentation], August, 2011
- Fleet, D.J.: Physics-Based models for human motion analysis. *IEEE ECCV Workshop on Human Motion: Understanding, Modeling, Capture and Animation*, [Keynote Presentation], September, 2010
- Fleet, D.J.: Tracking human pose and motion. *IEEE CVPR Workshop on Evaluation of Human Motion and Pose Estimation*, [Keynote Presentation], June, 2007
- Fleet, D.J.: Motion models for 3D human tracking. *BIRS Workshop on Mathematical Methods in Computer Vision*, Banff, October, 2006
- Fleet, D.J.: Vision as Bayesian Inference: Looking at people. *APICS Conference on Mathematics and Computer Science* [Keynote Presentation], University of Cape Breton, October, 2006
- Fleet, D.J.: Gaussian process dynamical models for modeling and tracking human motion. *IEEE Workshop on Learning, Representation and Context for Human Sensing in Video*, New York, June 2006
- Fleet, D.J.: Inference of visual motion boundaries. *Early Cognitive Vision Workshop* [Keynote presentation], Isle of Skye, Scotland, May 2004
- Fleet, D.J.: Bayesian inference of visual motion boundaries on random fields. *Vision Interface 2003* [Keynote presentation], Halifax, June, 2003
- Fleet, D.J.: Appearance models for visual tracking. *Workshop on Recent Advances and Future Trends in Computer Vision*, Stanford University, March, 2002
- Fleet, D.J. and Black, M.J.: Bayesian inference of visual motion boundaries. *IJCAI: International Joint Conference on Artificial Intelligence* [Distinguished Paper Track], Seattle, August, 2001
- Fleet, D.J.: Bayesian image sequence analysis. *Workshop on Image Sequence Processing for Studying Dynamic Systems*, University of Heidelberg, Germany, Sept. 2000
- Fleet, D.J.: Bayesian detection and tracking of motion boundaries. *BASICS: Banff Annual Seminar in Cognitive Science*, May 2000
- Fleet, D.J.: Binocular energy models and the encoding of binocular disparity. *Annual Meeting of the Optical Society of America*, Long Beach, October 1997
- Fleet, D.J., Black, M.J., and Jepson, A.D.: Learning parameterized models for optical flow. *Workshop on Image Sequence Processing for Studying Dynamic Systems*, University of Heidelberg, Germany, June 1997
- Fleet, D.J.: Extraction and representation of binocular disparity. *International Conference on Visual Coding*, Toronto, June 1995
- Fleet, D.J.: Models of binocular interaction and disparity estimation. *Computational Neuroscience of Stereoscopic Depth Perception*, Max-Planck Inst. for Biological Cybernetics, Tubingen, Germany, July 1994
- Fleet, D.J. and Jepson, A.D.: Hierarchical construction of velocity-tuned filters, *University of Toronto Symposium on Vision*, Toronto, May 1986

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## Other Invited Conference/Workshop/Symposium Presentations and Panels

- Fleet, D.J.: Gaussian Process models for human motion. *International Workshop on Recent Trends in Computer Vision*, Kyoto, June 2009
- Fleet, D.J.: Gaussian Process models for human motion. *CIAR Workshop on Neural Computation and Adaptive Perception*, Vancouver, December 2007
- Fleet, D.J.: People Tracking with Simplified Lower-Body Dynamics. *Workshop on Computer Vision*, CMU, Pittsburgh, April 2007
- Fleet, D.J.: Motion models for 3D people tracking. *CIAR Workshop on Neural Computation and Adaptive Perception*, Vancouver, December 2005
- Fleet, D.J.: Priors for people tracking from small datasets. *CIAR Workshop on People Tracking*, Toronto, July 2005
- Fleet, D.J.: Bayesian inference of visual motion boundaries. *CIAR Workshop: Learning to See*, Vancouver, December 2003
- Fleet, D.J.: Appearance model for visual tracking. *Computational Neuroscientists of Upper Canada (CNUC) Meeting*, Fields Institute, Toronto, October 2003
- Fleet, D.J.: Structure in motion. *IEEE Workshop on Motion and Video Computing, Panel on Visual Motion Analysis*, Orlando, December 2002
- Fleet, D.J., Black, M.J., and Nestares, O.: Probabilistic detection and tracking of motion boundaries. *Annual Interdisciplinary Conference*, Jackson Hole, WY, January 2001
- Haussecker, H. and Fleet, D.J.: Computing optical flow with physical models of brightness variation. *Bay Area Vision Meeting*, IBM Almaden, May, 2000
- Sidenbladh, H., Black, M.J., and Fleet, D.J.: Stochastic tracking of 3D human figures using 2d image motion. *Bay Area Vision Meeting*, IBM Almaden, May, 2000
- Barron, J.L., Fleet, D.J., Beauchemin, S.S., and Burkitt, S.: Performance of optical flow techniques. *IEEE Visual Motion Workshop: Experimental Session*, Princeton, October 1991
- Fleet, D.J.: Phase-based optical flow. *IEEE Visual Motion Workshop: Experimental Session*, Princeton, October 1991
- Fleet, D.J. and Jepson, A.D.: Computation of normal velocity from local phase information, *Univ. Buffalo Graduate Conf. in Computer Science*, March 1989 (Proceedings in SUNY Buffalo TR)
- Fleet, D.J. and Jepson, A.D.: Velocity extraction without form interpretation, *Canadian Institute for Advanced Research Workshop on Vision*, Halifax, March 1986

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## **Invited Talks/Seminars/Colloquia**

### **Estimating Contact Dynamics**

Department of Applied Mathematics, University of Bonn, December 2009  
Department of Applied Mathematics, Ecole Centrale de Paris, December 2009

### **Physics-Based 3D People Tracking**

Department of Computer Science Colloquium, McGill University, February 2010  
Department of Computer Science, University of Aachen, December 2009  
Department of Computer Science, University of Darmstadt, December 2009  
Department of Applied Mathematics, Ecole Centrale de Paris, May 2008  
Honda Research Institute, Mountain View, CA, March 2008  
Computer Vision Colloquium, CSAIL, MIT, October 2007  
Department of Computer Science, Boston University, October 2007

### **Motion Models for 3D People Tracking**

Department of Computer Science Colloquium, Dartmouth College, April 2009  
Computer Vision Distinguished Seminar Series, EECS, University of Central Florida, February 2008  
Department of Computer Science, Swiss Federal Inst. of Technology Zurich (ETH), May 2006  
Department of Computing and Information Science, University of Pennsylvania, November 2005.  
Department of Computer Science, York University, November 2005

### **Appearance Models for Visual Tracking**

Computer and Communication Science, Swiss Federal Inst. of Technology Lausanne (EPFL), June 2004  
Department of Psychology, Queen's University, February 2004  
IBM Almaden Research Center, San Jose, October 2002  
Department of EECS, University of California at Berkeley, February 2002  
Fuji-Xerox Research Labs, Palo Alto, February 2002  
Department of Computer Science, Vision Seminar, Stanford University, February 2002

### **Bayesian People Tracking from Image Sequences**

Department of Computer Science, University of British Columbia, June 2002  
Department of Computer Science, University of Toronto, May 2002  
School of Computing, Queen's University, April 2002  
School of Computer Science, University of Waterloo, March 2002  
School of Engineering, University of California at Santa Cruz, November 2001

### **Bayesian Detection and Tracking of Motion Boundaries**

Los Alamos National Laboratory, Sante Fe, New Mexico, December 2000  
Department of Biology, Universitat Aachen, September 2000  
Department of Computer Science, York University, August 2000  
Xerox Research Center Europe, Cambridge, U.K., June 2000  
Department of Computer Science, University of Waterloo, March 2000  
Xerox Wilson Research Center, Rochester, NY, March 2000  
Department of Computer Science, University of Rochester, March 2000  
Department of Computing and Information Science, Queen's University, March 2000  
Department of EECS, University of California at Berkeley, February 2000  
Broad-Area Colloquium, Department of Computer Science, Stanford University, December 1999

### **Parameterized Motion Models for Image Sequence Analysis**

Department of Computer Science, McGill University, Montreal, October 1998

Department of Computing and Information Science, Queen's University, September 1998  
Xerox Palo Alto Research Center, August 1998

**Neural Basis of Stereo Depth Perception With fMRI**

Institute for Zoology, Aachen University, June 1997

**Embedding Invisible Information in Color Images**

Department of Computing and Information Science, Queen's University, March 1998  
Image Understanding Seminar, Xerox PARC, February 1997

**Neural Encoding of Binocular Disparity**

Department of Psychology, York University, September 1998  
Department of Psychology, Stanford University, November 1996  
Neuroscience Seminar Series, Queen's University, November 1995  
Smith-Kettlewell Research Institute, San Francisco, July 1995

**Computational Analysis of Non-Fourier Motion**

Interval Research Corp., Palo Alto, CA, January 1997  
Department of EECS, University of California at Berkeley, April 1994  
Department of Psychology, Stanford University, Stanford, March 1994  
Machine Perception Seminar, Xerox PARC, Palo Alto, February 1994  
Centre for Intelligent Machines, McGill University, Montreal, December 1993  
Department of Psychology, University College London, England, October 1993  
Max-Planck Institute for Biological Cybernetics, Tübingen, Germany, October 1993  
Department of Computer Science, University of Hamburg, Germany, October 1993

**Stability of Phase for Signal Matching**

Department of Electrical Engineering, University of Linköping, Sweden, June 1992  
Department of Psychology, University College London, England, May 1992  
Department of Computer Science, York University, Downsview, January 1992  
Department of Electrical Engineering, Yale University, New Haven, December 1991  
Department of Electrical Engineering, Brown University, Providence, December 1991  
Siemens Research Centre, Princeton, November 1991  
Department of Computer Science, University of British Columbia, Vancouver, June 1991  
Centre for Intelligent Machines, McGill University, Montreal, April 1991

**Phase-Based Measurement of Binocular Disparity**

Computer Science Department, University of Rochester, Rochester, November 1989

**Phase-Based Measurement of Image Velocity**

Center for Scientific Computation, University of Heidelberg, December 1990  
Department of Computer Science, Brown University, Providence, April 1990  
Department of Computing and Information Science, Queen's University, February 1990  
Centre for Intelligent Machines, McGill University, Montreal, December 1989  
Department of Computer Science, University of Western Ontario, London, November 1989  
Fraunhofer Research Institute, Karlsruhe, West Germany, May 1989  
Department of Computer Science, University of Hamburg, West Germany, April 1989

**Measurement of Image Properties**

Department of Psychology, Cornell University, Ithaca, April 1992  
Department of Psychology, Queen's University, Kingston, March 1990

**Spatiotemporal Inseparability in Early Visual Processing**

Department of Psychology, New York University, New York, June 1985  
Sarnoff Research Labs, Princeton, June 1985

**Velocity Extraction Using Velocity-Tuned Filters**

Computer Science Department, Carnegie-Mellon University, Pittsburg, June 1985