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Employment History

March 2000 – present	Area Manager and Member of Research Staff, Perceptual Document Analysis and Digital Video Analysis Groups Palo Alto Research Center
Jan 2001 – present	Adjunct Associate Professor Department of Computing and Information Science, Cross-Appointed to Psychology and Electrical Engineering, Queen's University, Kingston
Jan 1999 – Feb 2000	Member of Research Staff, Digital Video Analysis Group Xerox Palo Alto Research Center
July 1995 – Dec 2000	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

Academic Degrees

Ph.D. **Department of Computer Science, University of Toronto, 1990**
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

Awards

2001 Best Paper Runner-Up Award,
IEEE Conference on Computer Vision and Pattern Recognition

1999 Marr Prize Honorary Mention (runner-up for best paper),
IEEE International Conference on Computer Vision

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

Professional Activities

Editorial Boards

Associate Editor, IEEE Transactions on Pattern Analysis and Machine Intelligence (2000–)

Conference Organization

Program Co-Chair, IEEE Conference on Computer Vision and Pattern Recognition (2003)

Programme Committees

European Conference on Computer Vision, ECCV (2002)
IEEE International Conference on Computer Vision, ICCV (1999, 2001)
IEEE Conference on Computer Vision and Pattern Recognition, CVPR (1998, 2000, 2001)
IEEE Workshop on Visual Motion (1991)
IAPR International Conference on Pattern Recognition, ICPR (2002)
Vision Interface, VI (1993, 1996, 1997, 2000)

Conference Reviewing

Most major vision conferences (CVPR, ECCV, and ICCV) since 1990,
along with miscellaneous vision workshops, and
related conferences occasionally (e.g., NIPS, 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;

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)

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* and *binocular stereopsis.* 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 and surveillance, and human motion capture.

Computer Vision and Image Processing:

The analysis and interpretation of visual motion requires models for how changes in image sequences are related to world properties. 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 for 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 at Xerox PARC on probabilistic methods for motion-based segmentation and visual tracking of complex 3D objects like people.

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 make 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 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 Instituto de Optica, Madrid) 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.

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.

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 online 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.

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 Surrey), 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 (nonexistent with non-Fourier stimuli) and vection as the relative amounts of Fourier and nonFourier 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 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 identifyed 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.

Research Contributions

Books

Fleet, D.J. (1992) **Measurement of Image Velocity**. Kluwer Academic Publishers, Norwell MA

Book Chapters

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)

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

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

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

Journal Submissions

Jepson, A.D., Fleet, D.J. and El-Maraghi, T.: Robust on-line appearance models for vision tracking. *IEEE Transactions on Pattern Analysis and Machine Intelligence* (submitted November 2001)

Bhotika, R., Fleet, D.J. and Kutulakos, K.: Probabilistic theory of occupancy and emptiness. *International Journal of Computer Vision* (submitted March 2002)

Refereed Conferences/Workshops: Papers in Proceedings

ICCV: *IEEE International Conference on Computer Vision*
CVPR: *IEEE Conference on Computer Vision and Pattern Recognition*
ICIP: *IEEE International Conference on Image Processing*
ECCV: *European Conference on Computer Vision*

Jepson, A.D., Fleet, D.J. and Black, M.J.: A layered motion representation with occlusion and compact spatial support. *European Conference on Computer Vision*, May 2002, Copenhagen (to appear)

Bhotika, R., Fleet, D.J., and Kutulakos, K.: A probabilistic theory of occupancy and emptiness. *European Conference on Computer Vision*, May 2002, Copenhagen (to appear)

Saund, E., Mahoney, J., Fleet, D.J., Larner, D. and Lank, E.: Perceptual organization as a foundation for intelligent sketch editing. *AAAI Spring Symp. on Sketch Understanding*, March 2002, Stanford University (to appear)

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 International Workshop on Graphics Recognition*, Kingston, Canada, Sept. 2001, pp. 175–179

Ormoneit, D., Lemieux, C., and Fleet, D.J.: Lattice particle filters. *Conference on Uncertainty in Artificial Intelligence*, 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

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 Verlag, 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

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 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. on Image Processing 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. *Isreali 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. *British Machine Vision Conf.*, Leeds, September 1992, Springer-Verlag, 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

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

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

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

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. Ophth. 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. Ophth. 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. Ophth. 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. Ophth. 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. Ophth. 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. Ophth. 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 *Opthal. 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 *Opthal. 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

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 US5949055: ”Automatic Geometric Image Transformations Using Embedded Signals”, David J. Fleet, David J. Heeger, Todd A. Cass, David L. Hecht (Filed: October 23, 1997; Awarded US Patent: September 1999)

Patent Filing: ”Method For Embedding Signals In a Color Image”, David J. Fleet, David J. Heeger, Todd A. Cass, David L. Hecht (Filed: October 23, 1997).

Patent Filing: ”Robust On-line appearance Models for Visual Tracking”, Allan D. Jepson, David J. Fleet, and Thomas F. El-Maraghi (Filed: December 7, 2001)

Invited Conference/Workshop Presentations

Fleet, D.J., Jepson, A.D. and El-Maraghi, T.F.: 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, September 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. *Workshop on Computational Neuroscience of Stereoscopic Depth Perception*, Max-Planck Institute 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

Fleet, D.J. and Jepson, A.D.: Velocity extraction without form interpretation, *Canadian Institute for Advanced Research Workshop on Vision*, Halifax, March 1986

Other Conference/Workshop Presentations and Panels

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)

Invited Talks/Seminars/Colloquia

Appearance Models for Visual Tracking
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 Tracking of 3D People from Video
Department 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 Pyschology, University College London, England, October 1993
Max-Planck Institute for Biological Cybernetics, Tubingen, 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 Linkoping, Sweden, June 1992
Department of Pyschology, 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
Siemans 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, Ithica, 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