Bradley C. Davis

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References Available Upon Request

Education

University of North Carolina at Chapel Hill **2002–2008**
Department of Computer Science, Medical Image Display and Analysis Group
Ph.D.: May 2008, *Medical Image Analysis via Fréchet Means of Diffeomorphisms*
Adviser: Sarang Joshi; Committee: Stephen Pizer, Elizabeth Bullitt, J. S. Marron, Jack Snoeyink

Carleton College, Northfield, Minnesota **2001**
Bachelor of Arts, Magna Cum Laude
Computer Science with Distinction and Philosophy
Senior project: Computer vision

Teaching and Advising Experience

Full Course Responsibility
Introduction to Scientific Programming, University of North Carolina at Chapel Hill **Fall 2004**
Twice-weekly lectures and weekly hands-on lab; office hours
Designed lecture notes, assignments, quizzes, and exams
Approximately 30 students from a variety of levels and backgrounds

Other
Dissertation committee member, University of North Carolina and Kitware, Inc. **2008–Present**
Mentor and train junior students and interns, University of North Carolina and Kitware, Inc. **2002–Present**
Student departmental adviser, Department of Computer Science, Carleton College **2000–2001**
Lab assistant and paper grader, Carleton College **1998–2001**

Research and Technical Experience

Kitware, Inc., Clifton Park, New York; Carrboro, North Carolina **2006–Present**
Research and Development Engineer
Participate in multi-site academic and commercial R&D projects related to medical image analysis
Roles include proposal writing, project management, research, software development, and testing
Project lead on large (>1M) commercial R&D project for medical device manufacturer

University of North Carolina at Chapel Hill **2002–2008**
Research Assistant, Departments of Computer Science and Radiation Oncology
Research Topics Included:
Regression in nonlinear spaces
Large deformation image registration and atlas construction
Tracking organ motion for image-guided radiation therapy
Brain mapping and analysis of shapes in the brain
Statistics of shape
Image segmentation
Other Experience:
Over 20 peer-reviewed papers and abstracts
5 oral and 2 poster presentations at academic conferences
Regular research group meeting presentations
Extensive development of libraries and applications for image analysis, shape analysis, and visualization

St. Jude Children's Research Hospital, Memphis, Tennessee **2001–2002**
Research Assistant, Department of Radiation Oncology
Research Topics Included:
Methods and software tools for detecting treatment setup errors
Techniques to measure and account for portal image distortion

Awards and Activities

Winner, David Marr Prize for best paper, 11th International Conference on Computer Vision, 2007
Reviewer, *NeuroImage*, Medical Image Computing and Computer-Assisted Intervention (MICCAI), 2005–Present
Member, UNC Computer Science Undergraduate Planning Committee, 2004–2007
President, UNC Computer Science Graduate Student Association, 2003–2004
Coordinator, UNC Medical Image Display and Analysis Group meeting, 2002–2003
Elected to Sigma Xi (Scientific Research Society), Carleton College Chapter, 2001
Founding Chair, Carleton College student chapter of the Association for Computing Machinery (ACM), 2000–2001
Student Departmental Adviser, Carleton College Department of Computer Science, 2000–2001
ACM Programming Competition, 2000, 2001
IEEE member, 2003–Present

Abstract: *Medical Image Analysis via Fréchet Means of Diffeomorphisms*

The construction of average models of anatomy, as well as regression analysis of anatomical structures, are key issues in medical research, e.g., in the study of brain development and disease progression. When the underlying anatomical process can be modeled by parameters in a Euclidean space, classical statistical techniques are applicable. However, recent work suggests that attempts to describe anatomical differences using *flat Euclidean spaces* undermine our ability to represent natural biological variability. In response, this dissertation contributes to the development of a particular *nonlinear* shape analysis methodology.

This dissertation uses a nonlinear deformable model to measure anatomical change and define geometry-based averaging and regression for anatomical structures represented within medical images. Geometric differences are modeled by coordinate transformations, i.e., deformations, of underlying image coordinates. In order to represent local geometric changes and accommodate large deformations, these transformations are taken to be the group of diffeomorphisms with an associated metric.

A mean anatomical image is defined using this deformation-based metric via the Fréchet mean—the minimizer of the sum of squared distances. Similarly, a new method called *manifold kernel regression* is presented for estimating systematic changes—as a function of a predictor variable, such as age—from data in nonlinear spaces. It is defined by recasting kernel regression in terms of a kernel-weighted Fréchet mean. This method is applied to determine systematic geometric changes in the brain from a random design dataset of medical images. Finally, diffeomorphic image mapping is extended to accommodate *extraneous structures*—objects that are present in one image and absent in another and thus change image topology—by deflating them prior to the estimation of geometric change. The method is applied to quantify the motion of the prostate in the presence of transient bowel gas.

Graduate Coursework

Computer Science
Image Processing and Analysis, Graphics, and Computer Vision
Physically Based Modeling, Simulation, and Animation
Differential Geometry for Shape Analysis and Graphics (Visual Solid Shape)
Distributed Systems
Parallel Computing
Compilers
Digital Logic

Mathematics, Applied Mathematics, and Statistics
Functional Analysis; Advanced Calculus
Object-Oriented Data Analysis
Scientific Computation
Differentiable Manifolds
Methods of Theoretical and Applied Statistics
Probability

Other
Technical Writing
Seminar On Teaching

Full-Length Publications

[1] B. C. Davis, P. T. Fletcher, E. Bullitt, and S. C. Joshi. Population shape regression from random design data. *International Journal of Computer Vision*, Submitted 2008.

[2] B. C. Davis and S. Lazebnik. Analysis of human attractiveness using manifold kernel regression. In *Proceedings of the IEEE International Conference on Image Processing (ICIP 2008)*. IEEE, 2008.

[3] S. Aylward, J. Jomier, S. Barre, B. Davis, and L. Ibanez. Optimizing ITK's registration methods for multiprocessor, shared-memory systems. In *Proceedings of the Workshop on Open Source and Open Data for MICCAI*, October 2007.

[4] B. C. Davis, P. T. Fletcher, E. Bullitt, and S. C. Joshi. Population shape regression from random design data. In *Proceedings of the 10th International Conference on Computer Vision (ICCV 2007)*, 2007.

[5] G. Gerig, B. C. Davis, P. Lorenzen, S. Xu, M. Jomier, J. Piven, and S. C. Joshi. Computational anatomy to assess longitudinal trajectory of brain growth. In *Proceedings of the Third International Symposium on 3D Data Processing, Visualization and Transmission (3DPVT 2006)*, volume 3565, 2006.

[6] C. Goodlett, B. C. Davis, R. Jean, J. Gilmore, and G. Gerig. Improved correspondence for DTI population studies via unbiased atlas building. In A. F. Frangi and H. Delingette, editors, *Proceedings of the 9th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI 2006)*, volume 3216 of *Lecture Notes in Computer Science*. Springer, 2006.

[7] P. Lorenzen, M. Prastawa, B. Davis, G. Gerig, E. Bullitt, and S. Joshi. Multi-modal image set registration and atlas formation. *Medical Image Analysis*, 10(3):440–451, June 2006.

[8] S. Xu, M. Styner, B. C. Davis, S. C. Joshi, and G. Gerig. Group mean differences of voxel and surface objects via nonlinear averaging. In *Proceedings of the 2006 IEEE International Symposium of Biomedical Imaging (ISBI 06)*, 2006.

[9] B. C. Davis, M. Foskey, J. Rosenman, L. Goyal, S. Chang, and S. C. Joshi. Automatic segmentation of intra-treatment CT images for adaptive radiation therapy. In J. Duncan and G. Gerig, editors, *Proceedings of the 8th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI 2005)*, Lecture Notes in Computer Science. Springer, 2005.

[10] M. Foskey, B. C. Davis, L. Goyal, S. Chang, E. Chaney, N. Strehl, S. Tomei, J. Rosenman, and S. Joshi. Large deformation 3D image registration in image-guided radiation therapy. *Physics in Medicine and Biology*, 50:5869–5892, 2005.

[11] P. J. Lorenzen, B. C. Davis, and S. C. Joshi. Unbiased atlas formation via large deformations metric mapping. In J. Duncan and G. Gerig, editors, *Proceedings of the 8th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI 2005)*, Lecture Notes in Computer Science. Springer, 2005.

[12] B. C. Davis, P. Lorenzen, and S. C. Joshi. Large deformation minimum mean squared error template estimation for computational anatomy. In *Proceedings of the 2004 IEEE International Symposium of Biomedical Imaging (ISBI 04)*, 2004.

[13] S. C. Joshi, B. C. Davis, M. Jomier, and G. Gerig. Unbiased diffeomorphic atlas construction for computational anatomy. *NeuroImage (Supplemental issue on Mathematics in Brain Imaging)*, 23:S151–S160, 2004.

[14] P. J. Lorenzen, B. C. Davis, and S. C. Joshi. Model based symmetric information theoretic large deformation multi-modal image registration. In *Proceedings of the 2004 IEEE International Symposium of Biomedical Imaging (ISBI 04)*, 2004.

[15] P. J. Lorenzen, B. C. Davis, and S. C. Joshi. Multi-class posterior atlas formation via unbiased kullback-leibler template estimation. In C. Barillot, D. R. Haynor, and P. Hellier, editors, *Proceedings of the 7th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI 2004)*, volume 3216 of *Lecture Notes in Computer Science*. Springer, 2004.

[16] G. Mageras, S. C. Joshi, B. C. Davis, A. Pevsner, A. Hertanto, E. Yorke, K. Rosenzweig, and C. C. Ling. Evaluation of an automated deformable matching method for quantifying lung tumor motion in respiration-correlated CT images. In *Proceedings of the International Conference on the Use of Computers in Radiation Therapy (ICCR 2004)*, volume 3216, 2004.

Abstracts

[1] B. C. Davis, D. Prigent, J. Bechtel, J. Rosenman, D. M. Lovelock, and S. C. Joshi. Accommodating bowel gas in large deformation image registration for adaptive radiation therapy of the prostate. In *Proceedings of the 46th Annual Meeting of the American Association of Physicists in Medicine (AAPM 2004)*, volume 3216, 2004.

[2] S. C. Joshi, T. Cullip, B. C. Davis, S. Chang, P. Keall, Y. Erdi, S. Nehmeh, G. Mageras, and J. Rosenman. 4D IMRT optimization accommodating respiratory motion using image mapping. In *Proceedings of the 46th Annual Meeting of the American Association of Physicists in Medicine (AAPM 2004)*, volume 3216, 2004.

[3] A. Pevsner, G. Mageras, S. C. Joshi, B. C. Davis, A. Hertanto, E. Yorke, K. Rosenzweig, Y. Erdi, S. Nehmeh, J. Humm, S. Larson, and C. C. Ling. Evaluation of a deformable matching algorithm for automatic segmentation of lung tumors from respiratory correlated CT data. In *Proceedings of the 46th Annual Meeting of the American Association of Physicists in Medicine (AAPM 2004)*, volume 3216, 2004.

[4] S. Samant, N. Parra, B. C. Davis, M. Sontag, and N. Narasimhan. A new multi-modality image registration algorithm. In *Proceedings of the 44th Annual Meeting of the American Association of Physicists in Medicine (AAPM 2002)*, volume 3216, 2002.

[5] S. Samant, J. Wu, B. Davis, A. Crouch, D. Kahler, and M. Sontag. Supervised gradient edge detection for inline MLC verification using EPID imaging. In *Proceedings of the 44th Annual Meeting of the American Association of Physicists in Medicine (AAPM 2002)*, volume 3216, 2002.

[6] P. Wang, D. Lovelock, S. Joshi, B. C. Davis, G. Mageras, and C. C. Ling. Evaluation of an automated deformable registration algorithm for localizing the prostate in serial CT image sets. In *Proceedings of the 46th Annual Meeting of the American Association of Physicists in Medicine (AAPM 2004)*, volume 3216, 2004.