BERNHARD BETTIG

West Virginia University Institute of Technology
Department of Mechanical Engineering

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EDUCATION

Ph.D. Mechanical Engineering – Arizona State University, Tempe, Arizona, 1999
- Design and Manufacturing
- Dissertation: "A Graph-Based Geometric Problem Solving System for Mechanical Design and Manufacturing"

M.S. Mechanical Engineering – University of Manitoba, Winnipeg, Canada, 1995
- Applied Mechanics
- Thesis: "Development of an Interactive Object-Oriented Program to Model Hydraulic Turbine-Generator Lateral Vibrations for Machine Health Monitoring"

B.S. Mechanical Engineering – University of Manitoba, Winnipeg, Canada, 1990
- Dean's Honor List 4 years out of 4

EMPLOYMENT

Associate Professor – West Virginia University Institute of Technology 2012-present

Assistant Professor – West Virginia University Institute of Technology 2006-2012
- Teaching kinematics, vibrations, CAD, FEA, and Measurements Lab.
- Directing Design Computations Lab. Performing research and proposal writing. Occasionally advising undergraduate students working on these projects.
- Advising SAE Baja team.

Assistant Professor – Michigan Technological University 2000-2006
- Directing Design and Manufacturing Computations Lab. Performing research and proposal writing. Advising 1 Ph.D. student and 4 M.S. students on average.
- Teaching CAD, FEA, and graduate Design Automation courses. Advising senior design projects.
- Advising SAE Clean Snowmobile Challenge Team.

Research Assistant – Arizona State University 1996-1999
- Performed National Science Foundation project to develop a geometric constraint-based high level reasoning capability for computer-aided design and computer aided manufacturing.
- Assist in proposal writing.
- Administer UNIX/PC/Mac workstations.

Research Assistant – University of Manitoba 1992-1995
- Wrote proposal and performed research for Manitoba Hydro project to develop a model for hydro-generator lateral vibrations including shaft deformation (finite element), bearing non-linear static and linearized dynamic forces (finite difference), generator magnetic forces, and turbine net lateral hydraulic forces.
- Developed software to visualize tethered spacecraft vibrations for Canadian Space Agency and Bristol Aerospace Ltd. (Oedipus-C project)

Design Engineer – Bristol Aerospace Ltd., F-5 Project Engineering Dept. 1990-1991 & summer 1989

- Projects included:
  - CF-5 Flight Procedures Trainer Mechanical Design
  - SF-5 Landing Gear Overhaul Statement of Work
  - Wing-Tip Tank Sump Pan Cracking Investigation
  - CF-5 Avionics Update Installation Mechanical Design
- Received NSERC work scholarship to work as student engineer for summer 1989

RESEARCH

INTERESTS

- Interactive Design Synthesis / Next-Generation CAD using Variational Constraint Solving
- Topology Optimization / Optimal Design of Smart Structures
- Internet Simulation Backbone / Automated Model Composition
- Feature Modeling and Exemplars in Design, Manufacturability Analysis and Structural Analysis
- Geometric Reasoning and Artificial Intelligence in Design and Manufacturing
- High Performance Computing and Hardware-Accelerated Computations

PUBLICATIONS - JOURNALS

1. Bettig, B., Kale, V., "Geometric Constraint Solving with Solution Selectors," *ASME Journal of Computing and Information Science in Engineering*, Vol. 12, 041002, 2012.
2. Bettig, B., Hoffmann, C.M., "Geometric Constraint Solving in Parametric Computer-Aided Design," *ASME Journal of Computing and Information Science in Engineering*, Vol. 11, 021001, 2011.
3. Bettig, B., Gershenson, J., "Representation of Module Interfaces," *Intl. Journal of Product Development*, Vol. 10, pp. 291-317, 2010.
4. Bettig, B., Bapat, V., "Integrating Multiple Data Representations in a Single CAD Environment," *Engineering with Computers*, Vol. 22, No. 1, pp. 11-23, 2006.
5. Miller, M.H., Perrault, J., Parker, G.G., Bettig, B., Bifano, T.G., "Simple Models for Piston Type Micromirror Behavior," *J. of Micromechanics and Microengineering*, Vol. 16, pp. 303-313, 2006.
6. Summers, J., Bettig, B., Shah, J., "The Design Exemplar: A New Data Structure for Embodiment Design Automation," *ASME Journal of Mechanical Design*, Vol. 126, No. 5, pp. 775-787, 2004.
7. Singh, P., Bettig, B., "Port-Compatibility and Connectability-Based Assembly Design," *ASME Journal of Computing and Information Science in Engineering*, Vol. 4, No. 3, pp. 197-205, 2004.
8. Buehler, M., Bettig, B., Parker, G., "Topology Optimization of Smart Structures using a Homogenization Approach," *J. of Intelligent Material Systems and Structures*, Vol. 15, No. 8, pp. 655-667, 2004.
9. Chen, W., Buehler, M., Parker, G., Bettig, B. "Optimal Sensor Design and Control of Piezoelectric Laminate Beams," *IEEE Transactions on Control Systems Technology*, Vol. 12, No. 1, pp. 148-155, 2004.
10. Buehler, M., Bettig, B., Parker, G. "Homogenization of Active Material Finite Element Cells," *Communications in Numerical Methods in Engineering*, Vol. 19, pp. 977-989, 2003.
11. Bettig, B., Shah, J., "Solution Selectors: A User-Oriented Answer to the Multiple Solution Problem in Constraint Solving," *ASME Journal of Mechanical Design*, Vol. 125, No. 3, pp. 443-451, 2003.
12. Bettig, B., Shah, J., "Derivation of a standard set of geometric constraints for parametric modeling and data exchange," *Computer-Aided Design*, Vol. 33, pp. 17-33, 2001.

13. Bettig, B., Shah, J., Summers, J., "Geometric Exemplars: A Bridge between CAD and AI," From Knowledge Intensive CAD to Knowledge Intensive Engineering, Cugini and Wozny (eds.), Kluwer Academic Press, Netherlands, pp. 45-57, 2001.
14. Bettig, B., Shah, J., "An object-oriented program shell for integrating CAD software tools," *Advances in Engineering Software*, Vol. 30, No. 8, pp. 529-541, 1999.
15. Bettig, B., Han, R.P.S., "Modeling the lateral vibration of hydraulic turbine-generator rotors," *Journal of Vibration and Acoustics*, Transactions of the ASME Vol. 121, No. 3, pp. 322-327, 1999.
16. Bettig, B., Han, R.P.S., "Predictive maintenance using the rotordynamic model of a hydraulic turbine-generator rotor," *Journal of Vibration and Acoustics*, Transactions of the ASME, Vol. 120, No. 2, pp. 441-448, 1998.
17. Bettig, B., Han, R.P.S., "An Object-Oriented Framework for Interactive Numerical Analysis in a Graphical User Interface Environment," *Intl. Journal for Numerical Methods in Engineering*, Vol. 39, pp. 2945-2971, 1996.

PUBLICATIONS - CONFERENCES

1. Kale, V., Bapat, V., Bettig, B., "Geometric Constraint Solving with Solution Selectors," *ASME 2008 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, New York, NY, Aug. 3-6, 2008.
2. Bapat, V., Bettig, B., Summers., J., "Requirements-Driven Design Computations in Next-Generation CAD," *Int. Conf. on Engineering Design* (ICED'07), August 28-3, Paris, France, 2007.
3. Maier, J.R.A., Anandan, S., Bapat, V., Summers, J.D., Bettig, B., "A Computational Framework for Semantically Rich Design Problems Based on the Theory of Affordances and Exemplar Technology," *Int. Conf. on Engineering Design* (ICED'07), August 28-31, Paris, France, 2007.
4. Anandan, S., Maier, J., Bapat, V., Bettig, B., Summers, J., "Semantics in Engineering Design," *Int. Conf. on Engineering Design* (ICED'07), August 28-31, Paris, France, 2007.
5. Bettig, B., Gershenson, J.K., "Module Interface Representation," DETC2006/DAC99554 *ASME 2006 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, Philadelphia, Pennsylvania, Sept. 10-13, 2006.
6. Bettig, B., Hertel, J.E., LaCourt, M.A., Beard, J.E., Youn, B.-D., Vilmann, C.R., Vable, M.A., Peed, M.C., Predebon, W.W., "NX CAD/CAM/CAE through-out the Curriculum at Michigan Technological University," 2006 *PACE Annual Forum*, Provo, Utah, July 24-29, 2006.
7. Kumar, V., Bee, D.J., Shirodkar, P.S., Tumkor, S., Bettig, B., Sutherland, J.W., "Towards Sustainable Product and Material Flow Cycles: Identifying Barriers to Achieving Product Multi-Use and Zero Waste," IMECE2005-81347, *2005 ASME International Mechanical Engineering Congress and Exposition*, Orlando, Florida, Nov. 5-11, 2005.
8. Davis, G., Meyer, D., Messenger, M., Johnson, J., Dahlheimer, N., Bettig, B., "Incorporation of a High Performance, Four-Cylinder, Four-Stroke Motorcycle Engine into a Snowmobile Application," 2005-01-3678, *SAE International Powertrain & Fluid Systems Conference & Exhibition*, Oct. 24-27, 2005, San Antonio, Texas.
9. Bettig, B., Bapat, V., Bharadwaj, B., "Limitations of Parametric Operators to Support Systematic Design" DETC2005/DTM-85165 *ASME 2005 International Design Engineering Technical Conferences &Computers and Information in Engineering Conference*, Long Beach, California, Sept. 24-28, 2005.
10. Lokagariwar, D., Bettig, B., "Purely Declarative Feature-based Design with Feature Type Property Maintenance" DETC2004/DAC-57360 *ASME International Design Engineering Technical Conferences &Computers and Information in Engineering Conference*, Salt Lake City, Utah, Sept. 2-6, 2004.
11. Barr, B.D., McKinstry, D.J., Messenger, A.S., Seidenstucker, J.M., Kallio, D.H., Hoffman, D.P., Bettig, B., "Adaption of Four-Stroke Motorcycle Engine to Continuously Variable Transmission for Snowmobile Application." 2003-32-0083, *SAE Small Engine Technology Conference*, Sept. 15-18, 2003, Madison, WI.
12. Singh, P., Bettig, B., "Port-Compatibility and Connectability Based Assembly Design", DETC2003/DAC-48783 *ASME 2003 International Design Engineering Technical Conferences &Computers and Information in Engineering Conference*, Chicago, Illinois, Sept. 2-6, 2003.

13. Chen, W., Bühler, M., Parker, G., Bettig, B. "Robust Design and Control of Piezoelectric Laminate Beams using a Simultaneous Optimization Method, *SPIE Smart Structures and Materials Conference*, 2-6 March 2003, San Diego, CA.
14. Bettig, B., Sandu, C., Joshi, A., Birru, K. "Dynamic Solver Selection for an Internet Simulation Backbone", *ACM Symposium on Applied Computing SAC'03*, March 9-12, 2003, Melbourne, FL.
15. Wegleitner, J.A., Miers, S.A., Hayes, R.D., Heim, S.P., Hoffmann, D.P., Bettig, B., "Design and Testing of a Single Cylinder, Turbocharged, Four-Stroke Snowmobile with E.F.I. and Catalytic Exhaust Treatment." 2002-01-2761, *SAE Powertrain & Fluid Systems Conference & Exhibition*, Oct. 21-24, 2002, San Diego, CA.
16. Bühler, M., Bettig, B., Parker, G., "Topological optimization of smart structures using an homogenization approach" [4693-63], *SPIE Smart Structures and Materials Conference*, 17-21 March 2002, San Diego, CA.
17. Bettig, B., Shah, J., "Solution Selectors: A User-Oriented Answer to the Geometric Constraint Multiple Solution Problem", DETC01/DAC21029, *ASME 2001 Design Engineering Technical Conferences,* Sept. 10-13, 2001, Pittsburgh, PA.
18. Bettig, B., Shah, J., Summers, J., "Geometric Exemplars: A Bridge between CAD and AI", *Knowledge Intensive CAD*, IFIP 5.2, KIC-4, Parma, Italy, KIC-17, May 2000.
19. Bettig, B., Shah, J., Summers, J., "Domain Independent Characterization of Parametric and Geometric Problems in Embodiment Design" DETC00/DAC14259, *ASME 2000 Design Engineering Technical Conferences,* Sept. 10-13, 2000, Baltimore, MD.
20. Bettig, B., Shah, J., "Systematic Derivation of a Standard Set of Declarative Constraints for Shape Definition in CAD", DETC99/CAD-9923, *ASME 1999 Design Engineering Technical Conferences,* Sept. 12-15, 1999, Las Vegas, NV.
21. Bettig, B., Shah, J., "A Unified Representation of Geometric Constraint Problems to Support Design and Manufacturing Applications", DETC98/DAC-5627, *ASME 1998 Design Engineering Technical Conferences*, Sept. 13-16, 1998, Atlanta, GA.
22. Bettig, B., Han, R.P.S., "An Object-Oriented Machine Condition Monitoring Scheme for Rotating Machinery", DETC97/VIB-423, *ASME 1997 Design Engineering Technical Conferences*, Sept. 14-17, 1997, Sacramento, CA .

BOOK REVIEWS

Bettig, B. "Review of: Rhyder, R.F. *Manufacturing Process Design and Optimization*, Marcel Dekker, Inc. New York, 1997," *Materials and Manufacturing Processes*, Vol. 15, No. 4, pp. 624-626, 2000.

PANELS

"EIM Panel: Streamlining EIM Implementations," *ASME 2003 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, Chicago, IL, Sept. 2-6, 2003 IDETC 2003/Session CIE-14.

"VIB Panel: System Health Monitoring," *ASME 1997 Design Engineering Technical Conferences*, Sacramento, CA, Sept. 14-17 DETC97/Session VIB-88.

INVITED WORKSHOPS

"Workshop on Mechanical Engineering Design Knowledge Modeling," *National Science Foundation,* Georgia Institute of Technology, Atlanta, GA, May 20-21, 2012.

"Workshop to EXchange Cyber-Infrastructure Themes in Engineering Design (EXCITED)," *National Science Foundation,* National Science Foundation, Arlington, VA, Feb. 28-Mar. 1, 2005.

"Engineering Design in 2030: A Strategic Planning Workshop," *National Science Foundation/Arizona State University,* Gold Canyon Resort, Gold Canyon, AZ, March 26-29, 2004.

INVITED PRESENTATIONS

"Next-Generation Computer-Aided Design," The Harold and Inge Marcus Department of Industrial Engineering Distinguished Lecture Series, The Pennsylvania State University, Sept. 11, 2008.

"Next-Generation Computer-Aided Design," Design Exemplar Workshop, Automation in Design Lab, Clemson University, Apr. 20, 2007.

"Overview of Simulation Backbone," *Northrop Grumman – Space Technology,* Redondo Beach, CA, Sept. 30, 2005.

"Limitations of Parametric Modeling," *GE Global Research*, Niskayuna, MA, June 13, 2005.

"Limitations of Parametric Modeling for Systematic Design," *UGS Corp.*, Milford, OH, May 31, 2005.

"A Unified Theory of Geometric and Topological Problems in Mechanical Design and Manufacturing," *Unigraphics Solutions*, Cypress, CA, Feb. 25, 2000.

FUNDING OBTAINED

Research projects

B. Bettig, "Development of Reliability Analysis for HMMWV Accounting for Variation in Operating Conditions," U.S. Army TARDEC, $40,000, 2007.

J. Summers, B. Bettig, "Collaborative SGER: Computational Support for Semantically Rich Design Problems – Addressing High Risk Elements," National Science Foundation, $112,000 (includes $12,000 REU), 2006.

M. Miller, B. Bettig, G. Parker, H. Sodano, P. Bergstrom, H. Liu, S. Green, "Optimizing Chemo-Mechanical Structure for MEMS Chemical Vapor Sensor Arrays," Michigan Economic Development Corporation, $1,324,046 (includes $515,210 cost share), 2006.

B. Bettig, "DOE ANOVA Evaluation of Results from Conceptual Design Experiments", Arizona State University/National Science Foundation, $14,037, 2005.

B. Bettig, "RadTherm/iSight Integration," ThermoAnalytics, Inc., $25,828, 2004-2005.

G. Parker, B. Bettig, "Optimal Design of Smart Structures," Air Force Office of Scientific Research, $207,388 (includes $56,401 cost share), 2001-2002.

Educational funding

B. Bettig, "Global Opportunities in Product Lifecycle Management (GO PLM™)," Siemens PLM Software, $13,939,125 in-kind software grant, 2008.

R.M. D'Souza, B. Bettig, "Knowledge Based Engineering (KBE) Curriculum Development for Knowledge Fusion", Partners for the Advancement of Collaborative Engineering Education (PACE) – GM Foundation, $11,000, 2006.

B. Bettig, M. LaCourt, "I-DEAS to UG NX Migration in the ME-EM Dept. at MTU," Partners for the Advancement of Collaborative Engineering Education (PACE) – GM Foundation, $20,000, 2005.

B. Bettig, "HP Computers for Design and Manufacturing Computations Lab," Partners for the Advancement of Collaborative Engineering Education (PACE) – Hewlett-Packard (HP), $5,691 in-kind computer grant, 2005.

B. Bettig, M. Rao, "HP Computers for ME-EM Faculty," Partners for the Advancement of Collaborative Engineering Education (PACE) – Hewlett-Packard (HP), $5,691 in-kind computer grant, 2005.

CONSULTING ACTIVITIES

CAD/PDM Consultant – The Ben Shima Group/Whirlpool Corporation 2006

- Provided recommendations for CAD/PDM implementation of interfaces in modular design.

Geometric Computing Education Consultant – C-K Shene, Computer Science Dept., Michigan Tech. 2002
- Review and recommendations on geometric computing educational materials for computer science and mechanical engineering students.

Hydro-generator Rotordynamics Modeling Consultant – Power Engineering Inc., Irvine, CA 2002
- Provided short course, software, and assistance with modeling hydro-generator rotordynamics.

SIGNIFICANT SOFTWARE DEVELOPED

Design_shell 1995-present
- A framework for CAD and interactive numerical analysis
- Various versions used at WVU Tech, MTU, Clemson U., and Arizona State U.

Op_rel 2007-present
- Operational reliability computation software employing distributed computing on Army Linux cluster.
- Developed for the U.S. Army.

Hom_xx & opt_xx 2001
- A library of Matlab programs for Finite Element homogenization and subsequent topological optimization of smart structures.

GPSS (Geometric Problem Solving System) 1999
- A C++ library for integrated variational algebraic and geometric constraint solving.
- Used previously at Michigan Tech., Clemson, and Arizona State.

MHYFECS – RotorSim 1995
- Rotordynamic simulation of hydraulic turbine-generator lateral vibrations. Employs finite element and finite difference computation techniques with analytical models.
- Developed for Manitoba Hydro, Winnipeg, Canada.
- Also used at U. of New Brunswick, Fredericton, Canada and Power Engineering Inc., Costa Mesa, CA

tether_c++ 1995
- Visualization of tethered spacecraft vibration.
- Developed for the Canadian Space Agency/Bristol Aerospace Ltd.

TEACHING

INTERESTS

Computer-Aided Design
Finite Element Analysis
Mechanical Vibrations
Dynamics of Machines
Engineering Design/Senior Design Capstone Project
Design Automation (graduate level)
Design Theory and Methodology (graduate level)

NOTABLE ACCOMPLISHMENTS

Course development

- Created new Computer-Aided Design course syllabus that includes modern topics (e.g., top-down design methodology using Control Model approach; geometric constraints).

- Developed new graduate level Design Automation course – several students have credited it with finding work positions and helping in their existing work.
- Most courses have significant development of lecture note handouts, interesting practice questions, some group problems and a web page.
- Teaching evaluation scores are typically around 4.5 out of 5.

Graduated students at Michigan Tech

- Graduated one Ph.D. student and ten M.S. students – the students have found professionally significant jobs at CAD/CAE software companies and engineering/manufacturing companies such as Siemens PLM Software, Parametric Technology Corp., IC.IDO, B/E Aerospace Inc., Sabare USA Inc. and Baysys Tech.
- Graduated Markus Buehler – he is now a very successful Associate Professor at the Massachusetts Institute of Technology. His thesis was nominated by Michigan Tech for best M.S. thesis 2000-2001 for the Midwest Area Graduate Schools competition.

Student Design Team Advising

- The Clean Snowmobile Challenge team at Michigan Tech took second place overall at 2003 and 2004 SAE inter-collegiate competitions and received five awards over five years. An article was written in SAE Off-Highway Magazine about the 2002 competition snowmobile.
- The SAE Baja team at WVU Tech took 6th place out of 16 at the 2008 Louisville Midnight Mayhem.

SERVICE

PROFESSIONAL MEMBERSHIP

American Society of Mechanical Engineers (ASME)
Society of Automotive Engineers (SAE)

PROFESSIONAL SERVICE

ASME Design Automation Conference
- Regular paper review coordinator
- Occasional session co-chair

Regular paper reviewer for:
- ASME Journal of Computing and Information Science in Engineering
- ASME International Design Engineering Technical Conferences (Design Automation Conference, Computers and Information in Engineering conference)

Reviewed papers for: Advanced Engineering Informatics, Journal of Intelligent Material Systems and Structures, Information and Software Technology, Software Practice and Experience, ASME Journal of Vibrations and Acoustics, ASME Journal of Mechanical Design, Research in Engineering Design, Computer Aided Geometric Design, IEEE Transactions on Automation Science & Engineering, International Journal of Numerical Methods in Engineering, ACM Solid Modeling Conference, Materials and Manufacturing Processes, Symposium on Tools and Methods of Competitive Engineering, ASME International Mechanical Engineering Congress and Exposition.

NSF Proposal Review Committee (2 times)

SAE eTool Automotive Working Group – co-chair of working group to establish standards for vendor digital product data.

DEPARTMENTAL AND UNIVERSITY SERVICE

- Chair of faculty search committee
- Faculty Evaluation Committee
- Faculty Status Committee
- Advisor to the student chapter of the Society of Automotive Engineers