Sanjiv K. Bhatia

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Experience Summary

- Extensive experience in design and implementation of algorithms for image processing, target tracking, computer graphics, image databases, data clustering, and information retrieval.
- Over 16 years' experience in real-time software development projects.
- In-depth experience in Unix (Solaris and Linux) and C/C++ development (both Gnu and Visual Studio); some experience with Linux kernel programming
- Experienced in programming Linux cluster using MPI; familiar with grid computing and cloud computing
- Over 24 years' experience in teaching various Computer Science courses at both graduate and undergraduate levels, at universities as well as in corporate training environment.
- Extensive project management experience for research, academic, and industrial projects.
- Knowledge of Windows and network programming.

Employment Summary (Industry)

05/2015 – 05/2017 **Computer Vision Consultant**, Aerovironment Inc., Simi Valley, CA.

12/2013 – 09/2014 **Computer Vision Lead**, OIM Squared, San Diego, CA.

06/1998 – 04/2009
07/2010 – 04/2013
06/2009 – 07/2009
10/2009 – 05/2010
04/1997 – 09/1997 **R&D Consultant**, Visual Simulation Systems, FlightSafety International, St. Louis, MO.

Linux Consultant, Mobile Armor, St. Louis, MO.

Internet Consultant, US Army, Aviation and Troop Command, St. Louis, MO.

08/1983 – 08/1986 **Engineer (Real Time Applications)**, Engineers India Limited, New Delhi, India.

06/1982 – 10/1982 **Engineer Trainee**, Tata Institute of Fundamental Research, Bombay, India.

Employment Summary (Academic)

08/2015 – present **Professor (Computer Science)**, Univ. of Missouri – St. Louis, St. Louis, MO. Graduate Director since 08/2014.

03/98 – 07/15 **Associate Professor (Computer Science)**, Univ. of Missouri – St. Louis, St. Louis, MO.

08/02 – 08/03 **Associate Professor (Computer Science)**, Southern Illinois University, Edwardsville, IL. (On leave from UM–St. Louis)

08/91 – 03/98 **Assistant Professor (Computer Science)**, Univ. of Missouri – St. Louis, St. Louis, MO.

08/88 – 08/91 **Graduate Assistant**, University of Nebraska – Lincoln, Lincoln, NE.

08/87 – 08/88 **Graduate Assistant**, University of Southwestern Louisiana, Lafayette, LA.

08/86 – 08/87 **Graduate Assistant**, University of Arkansas, Fayetteville, AR.

Skills

Digital image processing, Information retrieval, and Algorithm design.
Unix (including some system administration), C/C++, Java, Perl, X windows, Prolog, and Lisp.
Good experience with Sun Solaris, SGI IRIX, and Linux, as well as Gnu tools under these environments.
Extensive experience with Matrox Genesis Native Library, Matrox Odyssey Native Library, Matrox Imaging Library, ImageMagick, OpenCV, Erdas Imagine, Erdas Objective.
Familiar with VSIPL and Datacube tools to program FPGAs, such as Visual Chip Studio and Video Layered Library.

Education

Ph.D. Computer Science.
University of Nebraska – Lincoln, Lincoln, NE. August 1991.
Thesis: *Knowledge Based Information Retrieval and Classification*

M.S. Computer Science.
University of Arkansas, Fayetteville, AR. August 1987.

B.E. (Honors) Computer Science Engineering.
Motilal Nehru Regional Engineering College, Allahabad, India. August 1983.

Employment

Computer Vision Consultant May 2015 – May 2017

Aerovironment Inc.,

Responsible to develop computer vision application for unmanned aerial vehicles.

- Developed a real-time computer vision application using Visual Studio and OpenCV. Responsible for all aspects of application, from algorithm design to implementation. Guided the porting of application to embedded processor on board the UAV.

Computer Vision Expert December 2013 – September 2014

OIM Squared

Responsible for the Computer Vision application to analyze videos and label the objects therein.

- Developed prototype Computer Vision application using OpenCV for demo to venture capitalists, and interfaced with the web architect.
- Assembled the team by hiring three CV engineers and developed the framework for the backend application. Developed the architecture for video analysis and guided the implementation.

R&D Consultant June 1998 – April 2009; July 2010 – April 2013

FlightSafety International

Worked on a number of real-time development projects.

- *Target Tracking*. Developed algorithms to track multiple targets simultaneously in forward-looking infra-red and low-light TV video streams. Developed algorithms for centroid-based, normalized spatial correlation-based, and phase-correlation-based tracking modes and implemented them using Matrox Odyssey Xpro and Odyssey Native Library under Windows XP. Also developed an edge-based tracking algorithm using Matrox Imaging Library. Evaluated the new hardware/software platforms to implement the next generation tracking software. Developed the second-generation tracking software in software using OpenCV.
- *Infra-Red Post Processor*. Designed algorithms and successfully implemented an Infra-Red post processor system for the IR sensor in V-22 Osprey simulator, using COTS components (Matrox Genesis on Windows NT using Visual C++). Published an article in a conference.
- *Digital Terrain Modeling*. Designed algorithms to map generic texture patterns on digital maps for flight simulators; created algorithms to generate generic texture patterns automatically from aerial photography. Implemented on Silicon Graphics in C++, and later ported to Solaris and Linux, with hooks into ImageMagick library. Published two articles in conferences and gave a tutorial in IMAGE Conference. Also worked on terrestrial feature extraction from aerial imagery using Erdas Objective.

- *Adaptive Clustering*. Developed a clustering algorithm to improve search in multidimensional data (material map codes for infra-red properties of composite materials) and to generate perceptually uniform distribution of colors. Published an article in a conference.
- *Image Fusion*. Worked on image fusion from multiple sensors to improve the overall image quality. This was done in C++ on Linux and used Daubechies wavelet transform to perform multiresolution analysis.
- Developed code to translate ESRI shapefiles into GeoTIFF files.

Linux Consultant June 2009 – July 2009; October 2009 – May 2010

Mobile Armor

Worked on embedded Linux projects.

- *Data Armor OS*. Ported the Data Armor Pre-boot environment to work on different tablets using touchscreen.
- *Linux Kernel Pre-boot*. Worked on the Linux kernel pre-boot environment to clean up the code.
- Worked on porting the system to Mac under EFI (Extensible Firmware Interface). Developed a GUI in EFI for initial login using the mouse device driver.
- Worked on speeding up the bootstrapping using ideas from Ubuntu 10s boot project, specifically `bootchart` to profile kernel.

Internet Consultant April 1997 – September 1997

US Army; Aviation and Troop Command

Developed the Internet web site to post advisory messages for different aircraft.

- Developed CGI scripts to automatically format messages, attach table of contents to each message, and to perform search based on a specified criterion.
- Developed a set of administrative tools (PERL and Bourne shell) to modify the displays as new data is added to the system.
- Led a four person development team for the project.

Assistant Professor/Associate Professor/Professor & Graduate Director August 1991 – present

University of Missouri – St. Louis

Research and teaching in Computer Science; In addition to teaching various courses in Computer Science at undergraduate and graduate levels, I have been involved in several projects for my research and consulting. The projects described below were implemented by me, or by students under my supervision.

- Root analysis of plants. Guided a student to develop software to automatically segment plant roots in a lab setting for analysis. The project was done in collaboration with Danforth Plant Science Center.
- Shadow detection in aerial imagery. Developed techniques and guided a graduate student to implement the code to detect shadows in aerial imagery for urban planning. Published a paper in a journal.
- Led a project to compare the feasibility and performance of a transaction processing system using grid computing and cloud computing under a grant for a corporation.
- Image processing for ballistics in forensic investigation. Investigating the use of statistics to quantify the confidence in matching a spent bullet or cartridge case with others in a crime database. Published a paper in a journal.
- Image database research project. Developed a system to index a database of JPEG images for retrieval using query-by-example. Received a grant to implement the system as an Open Solaris package, using ImageMagick

and MySQL. Implementation in C. This system has been extended to analyze and retrieve satellite images that cannot be classified on the basis of color distribution. Currently working on a hierarchical image database data structure using wavelets, using C++.
- Web-based utilities for different projects. Developed utilities to create Unix-like `man` pages over the web. The utilities help create the man pages as well as to display them. Another utility was developed to be used as a bulletin board system by students.
- Software for human face recognition using wavelets. Developed programs for image degradation and analysis of psychophysical experiment data in C and Unix shellscripts. Currently working on face expression analysis.
- A package for knowledge acquisition and analysis – based on personal construct psychology – in C and X-windows toolkit.
- A list of classes taught by me is available on my web site.

Real-time Applications Engineer August 1983 – August 1986

Engineers India Limited, New Delhi, India

Worked on a few real-time applications.

- Developed and implemented software for real-time process control in a large petroleum refinery (Madras Refineries Limited), including graphics and database development.
- Performed factory and site acceptance tests for various computers.

Engineer Trainee June 1982 – October 1982

Tata Institute of Fundamental Research, Bombay, India.

Worked as a summer intern in the Speech and Digital Systems Group.

- Designed and implemented a disk-based operating system using a Motorola 6800 development system. Designed and incorporated a line-based text editor in the system.
- Developed software for an electronic telephone exchange for the Indian Army using a Motorola 6809 microprocessor.

Publications	Over 50 publications in various journals and conferences, one conference tutorial, and four book articles.
Award	Chancellor's Award for Excellence in Teaching, September 2015.
Professional Affiliations	Association for Computing Machinery (Senior Member since January 2012) ACM SIGGRAPH American Association for Artificial Intelligence Information Systems Security Association St. Louis Unix Users' Group
Languages	Fluent in Hindi and Punjabi (read, write, converse). Can easily converse in Urdu.
Personal	U.S. citizen
References	Available upon request

Articles Published in Scholarly Journals

1. S. Bhaskaran, S. Devi, S. Bhatia, A. Samal, and L. Brown. Mapping Shadows in Very High-Resolution Satellite Data Using HSV and Edge Detection Techniques. *Applied Geomatics*, **5**:4. pp. 299-310. 2013.
2. S. Bhaskaran, K. Jimenez, E. R. Nez, and S. K. Bhatia. Rule-Based Classification of High Resolution Imagery over Urban Areas in New York City. *Geocarto International*. **28**:6. pp. 527-545. October 2013.
3. G. Gerules, S. K. Bhatia, and D. E. Jackson. A Survey of Image Processing Techniques and Statistics for Ballistic Specimens in Forensic Science. *Science and Justice*. **53**:2. pp. 236-250. June 2013.
4. N. Alugupally, A. Samal, D. Marx, and S. Bhatia. Analysis of Landmarks in Recognition of Face Expressions. *Pattern Recognition and Image Analysis*. **21**:4. pp. 681-693. 2011.
5. S. K. Bhatia, A. Samal, N. Rajan, and M. T. Kiviniemi. Effect of Font Size, Italics, and Color Count on Web Usability. *International Journal of Computational Vision and Robotics*. **2**:2. pp. 156-179. 2011.
6. S. K. Bhatia, A. Samal, V. Seri, and S. Gardner. Stitching Algorithms for Biological Specimen Images. *International Journal of Computational Vision and Robotics*. **2**:1. pp. 1-17. 2011.
7. A. Samal, S. Bhatia, P. Vadlamani, and D. Marx. Searching Satellite Imagery with Integrated Measures. *Pattern Recognition*. **42**:11. pp. 2502-2513. November 2009.
8. B. Beneš, V. Těšínský, J. Hornyš, and S. K. Bhatia. "Hydraulic Erosion." *Computer Animation and Virtual Worlds*. **17**:2. pp. 99-108. February 2006.
9. S. Climer and S. K. Bhatia. "LocalLines: A Linear Time Line Detector." *Pattern Recognition Letters*. **24**:14. pp. 2291-2300. October 2003.
10. S. Climer and S. K. Bhatia. "Image Database Indexing using JPEG Coefficients." *Pattern Recognition*. **35**:11. pp. 2479-2488. November 2002.
11. S. K. Bhatia and J. S. Deogun. "Conceptual Clustering in Information Retrieval." *IEEE Transactions on Systems, Man, and Cybernetics*. **28**:3. pp. 427-436. June 1998.
12. C. L. Sabharwal and S. K. Bhatia. "Image Databases and Near-Perfect Hash Table." *Pattern Recognition*. **30**:11. pp. 1867-1876. November 1997.
13. S. K. Bhatia, J. S. Deogun, and V. V. Raghavan. "Conceptual Query Formulation and Retrieval." *Journal of Intelligent Information Systems*. **5**:3. pp. 183-209. November 1995.
14. S. K. Bhatia, V. Lakshminarayanan, A. Samal, and G. V. Welland. "Human Face Perception in Degraded Images." *Journal of Visual Communication and Image Representation*. **6**:3. pp. 280-295. September 1995.
15. C. L. Sabharwal and S. K. Bhatia. "Perfect Hash Table Algorithm for Image Databases Using Negative Associated Values." *Pattern Recognition*. **28**:7. pp. 1091-1101. July 1995.
16. S. K. Bhatia and C. L. Sabharwal. "A Fast Implementation of A Perfect Hash Function for Picture Objects." *Pattern Recognition*. **27**:3. pp. 365-376. March 1994.
17. H. L. Berghel, R. Rankin, and S. K. Bhatia, "MS-DOS Prolog Implementations Revisited," *SIGPLAN Notices*, vol. 23, no. 1, January 1987, pp. 127-134.

Articles Published in Conference Proceedings, Books, etc.

1. S. K. Bhatia and J. S. Deogun. Data Mining Tools – Association Rules. *Encyclopedia of Business Analytics and Optimization*, J. Wang (ed.), IGI Global, Hershey, PA. 2014.
2. S. K. Bhatia and J. S. Deogun. Data Mining Tools – Formal Concept Analysis and Rough Sets. *Encyclopedia of Business Analytics and Optimization*, J. Wang (ed.), IGI Global, Hershey, PA. 2014.
3. M. W. Hauschild, S. Bhatia, and M. Pelikan. "Image Segmentation Using a Genetic Algorithm and Hierarchical Local Search." *GECCO '12: Proceedings of the Genetic and Evolutionary Computation Conference*, Philadelphia, PA. July 2012. pp. 633-639.
4. D. Goswami, S.K. Bhatia, and A. Samal. RISE: A Robust Image Search Engine. *Pattern Recognition Theory and Applications*. E. A. Zoeller (ed.). Nova Science Publishers, 2007. Invited paper.
5. S. K. Bhatia, A. Samal, and P. Vadlamani. "RISE-SIMR: A Robust Image Search Engine for Satellite Image Matching and Retrieval." *ISVC07: Proceedings of the 3rd International Symposium on Visual Computing*, Lake Tahoe, NV. November 2007. pp. 245-254.

6. D. Goswami and S. K. Bhatia. "RISE: A Robust Image Search Engine." *Proceedings of 2006 IEEE International Conference on Electro Information Technology*, E. Lansing, MI. May 2006.
7. S. K. Bhatia. "Hierarchical Clustering for Image Databases." *Proceedings of 2005 IEEE International Conference on Electro Information Technology*, Lincoln, NE. May 2005.
8. S. K. Bhatia. "Adaptive K-Means Clustering." *Proceedings of the FLAIRS 2004 Conference*, Miami Beach, FL. May 2004.
9. S. K. Bhatia. "Creating Large Isotropic Textures Using Image Quilting." *WSCG '2004: Proceedings of the 12th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision*, Plzen, Czech Republic. February 2004. pp. 23-30.
10. S. K. Bhatia. "Creating Isotropic Toroidal Texture Patterns." *Proceedings of the IMAGE 2003 Conference*. Scottsdale, AZ. July 2003.
11. S. K. Bhatia and G. M. Lacy. "Infra-Red Sensor Simulation." *Proceedings of the Interservice/Industry Training, Simulation and Education Conference*, Orlando, FL. November 1999.
12. V. Lakshminarayanan, S.K. Bhatia, A. Samal, and G.V. Welland. "Reaction Times for Recognition of Degraded Facial Images." In V. Lakshminarayanan (ed.), *Basic and Clinical Applications of Vision Science*, Kluwer Academic Publishers, Dordrecht, The Netherlands. p. 287–293. 1997.
13. G. Bebis, M. Georgiopoulos, and S. K. Bhatia. "Learning Orthographic Transformations for Object Recognition." *Proceedings of the IEEE SMC-97*, Orlando, FL. October 1997. pp. 3576-3581.
14. S. K. Bhatia. "Image Database Indexing Using JPEG Coefficients." In D.D. Dankel (ed.), *FLAIRS-97: Proceedings of the Tenth International Florida Artificial Intelligence Research Symposium*, Daytona Beach, FL. May 1997. pp. 166-170.
15. S. K. Bhatia and C. L. Sabharwal. "Near Perfect Hash Table for Image Databases." In K.M. George, *et. al.*, (eds.), *SAC-96: Symposium on Applied Computing*, Philadelphia, PA. February 1996. pp. 442-446.
16. V. Lakshminarayanan, S. Bhatia, G. Welland, and A. Samal. "Human Face Recognition using Wavelets." In *Vision Science and its Applications: Technical Digest (vol. 1)*, Santa Fe, NM. February 1995. pp. 167-170.
17. S. K. Bhatia and Q. Yao. "Analyzing Interval-Valued Repertory Grids." In J.W. Brahan and G.E. Lasker (eds.), *Advances in Artificial Intelligence – Theory and Applications*, (vol. 2). International Institute for Advanced Studies in Systems Research and Cybernetics, Baden-Baden, Germany. August 1994. pp. 13-18.
18. S. K. Bhatia and C. L. Sabharwal. "A Fast Perfect Hash Function for Image Databases." In F. D. Anger, *et al.* (eds.), *Proceedings of the Seventh International Conference on Industrial and Engineering Applications of Artificial Intelligence and Expert Systems*, Austin, TX. June 1994. pp. 337-346.
19. C. L. Sabharwal and S. K. Bhatia. "A Perfect Hash Function for Image Database Indexing." In E. Deaton, *et al.* (eds.), *Proceedings of the 1994 ACM Symposium on Applied Computing*, Phoenix, AZ. March 1994. ACM Press, pp. 534-538.
20. S. K. Bhatia and Q. Yao. "A New Approach to Knowledge Acquisition by Repertory Grids." In B. Bhargava, et. al. (eds.), *CIKM 93: Proceedings of the Second International Conference on Information and Knowledge Management, Washington, D.C.*, November 1993. ACM Press, pp. 738-740.
21. S. K. Bhatia and J. S. Deogun. "Cluster Characterization in Information Retrieval." In E. Deaton, et. al. (eds.), *Applied Computing: States of the Art and Practice – 1993 (Proceedings of the 1993 ACM/SIGAPP Symposium on Applied Computing, Indianapolis, IN*, February 1993. ACM Press, pp. 721- 728.
22. S. K. Bhatia. "Selection of Search Terms Based on User Profile." In H. Berghel, et. al. (eds.), *Applied Computing: Technological Challenges of the 1990s (Proceedings of the 1992 ACM/SIGAPP Symposium on Applied Computing – vol. 1), Kansas City, MO*, March 1992. ACM Press, pp. 224-233.
23. S. K. Bhatia, J. S. Deogun, and V. V. Raghavan. "User Profiles for Information Retrieval." In Z. W. Ras and M. Zemankova (eds.), *Methodologies for Intelligent Systems: 6th International Symposium, ISMIS '91, Charlotte, NC*, October 1991. Lecture Notes in Artificial Intelligence # 542. Springer-Verlag, pp. 102-111.
24. S. K. Bhatia, J. S. Deogun, and V. V. Raghavan, "Query Formulation through Knowledge Acquisition," in L. A. Birnbaum and G. C. Collins (eds.) *Machine Learning: Proceedings of the Eighth International Workshop, Evanston, IL, June 1991*, Morgan Kaufmann, pp. 250-254.
25. J. S. Deogun, S. K. Bhatia, and V. V. Raghavan, "Automatic Identification of Message Destinations," FLAIRS-91*: Proceedings of the Florida AI Research Symposium*, Cocoa Beach, FL, April 91, pp. 140-144.
26. S. K. Bhatia, J. S. Deogun, and V. V. Raghavan, "Document Classification Using ID3," *Proceedings of the Artificial Intelligence and Simulation Conference*, New Orleans, LA, April 1991, pp. 133-138.

27. J. S. Deogun, S. K. Bhatia, and V. V. Raghavan, "Automatic Cluster Assignments for Documents," *Proceedings of the Seventh IEEE Conference on Artificial Intelligence Applications*, Miami Beach, FL, February 1991, pp. 25-28.
28. S. K. Bhatia, J. S. Deogun, and V. V. Raghavan, "Automatic Rule-Base Generation for User-Oriented Information Retrieval," *Proceedings of the Fifth International Symposium on Methodologies for Intelligent Systems*, Knoxville, TN, October 1990, pp. 118-125.
29. S. K. Bhatia, J. S. Deogun, and V. V. Raghavan, "Assignment of Term Descriptors to Clusters," *Proceedings of the 1990 Symposium on Applied Computing*, Fayetteville, AR, April 1990, pp. 181-185.
30. S. K. Bhatia, J. S. Deogun, and V. V. Raghavan, "Formation of Categories in Document Classification Systems," in N. A. Sherwani, E. de Doncker, and J. A. Kapenga (eds.) *Computing in the 90's: The First Great Lakes Computer Science Conference, Kalamazoo, MI, October 1989*, Lecture Notes in Computer Science # 507, Springer-Verlag, pp. 91-97.
31. J. S. Deogun, V. V. Raghavan, and S. K. Bhatia, "A Theoretical Basis for the Automatic Extraction of Relationships from Expert-Provided Data," *Proceedings of the Fourth International Symposium on Methodologies for Intelligent Systems: Poster Session*, Charlotte, NC, October 1989, pp. 123-131.
32. S. K. Bhatia and A. G. Starling, "Multilayered ILLIAC Network Scheme," *Computer Architecture News*, vol. 15, no. 4, September 1987, pp. 23-31.
33. S. K. Bhatia and A. N. Rocha, "The Traveling Salesman Problem," *Communications of the Computer Society of India*, August 1987, pp. 3-10.

Reviewed Abstracts.

1. V. Lakshminarayanan, S. Bhatia, G. Welland, and A. Samal. "The Use of Haar Wavelets in Human Face Recognition Experiments." In *Optical Society of America Annual Meeting/ILS-X*, Dallas, TX. October 1994.

Edited Volumes

1. S. K. Bhatia, K. K. Mishra, S. Tiwari, and V. K. Singh. *Advances in Computer and Computational Science Volume I*. Springer. 2017.
2. S. K. Bhatia, K. K. Mishra, S. Tiwari, and V. K. Singh. *Advances in Computer and Computational Science Volume II*. Springer. 2017.

Guest Editorial.

1. K. K. Mishra, A. K. Misra, P. Mueller, G. M. Perez, S. K. Bhatia and Y. Wang. Guest Editorial. Special Issue of Recent Advancements in Computer and Software Technology. *The Scientific World Journal*. 2014.

Conference Tutorial

1. S. K. Bhatia. *Creating Large Textures: Building Large Models of Terrain for Simulation and Games*. IMAGE 2004. Phoenix, AZ. July 2004.

Magazine Articles

1. S. K. Bhatia. Regular Expressions. *Computer Apex*. Summer 2005.

Current Work.

1. R. K. Venkatarama, A. K. Samal, and S. Bhatia. A Two-Step Approach Towards Eye Recognition. under review.

Creative Software Development

- RISE: A Robust Image Search Engine. An image database system to organize, index, and retrieve images over the internet.
- Code to perform wavelet analysis on an image, using Daubechies wavelet.
- A web based application to generate isotropic toroidal tile from an arbitrary image.
- A web based image processing application.
- A package to mathematically determine contrast sensitivity in an image.
- A package for image database indexing using JPEG transform. This package has been improved by rewriting in Java and adding a relational database back end, resulting in RISE.
- A package for knowledge acquisition and analysis based on personal construct psychology
- Image processing package for image degradation for a project
- A utility to create documentation for projects (like man pages in Unix) using WWW interface
- A bulletin board system in world-wide web for students