

# Sanford T. Freedman

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## Areas of Expertise

- mobile robotics
- human-robot interaction
- embedded systems
- device interfacing
- digital design
- system architecture
- system automation
- proposal writing
- requirements management
- situational awareness
- human factors
- GUI Design
- cognitive systems
- computer graphics
- distributed systems
- legacy system support
- probabilistic programming
- process automation
- software design
- system integration
- emulator design
- reverse engineering
- project management
- new technology integration
- computer maintenance
- build systems & installers

## Technical Competencies

**Primary Languages** - C, C++, Python, scripting, assembly

**Secondary Languages** – Java, MATLAB, Figaro, Scala

**Operating Systems** – Windows, Linux

**Computer** - embedded systems, Qt, networking, installers, Win32, JNI, VM, XML, SVN, GIT, CMAKE, SCONS, Wiki, JAXB, JAX-WS, SQL, Docker, AWS, UDP, ArcGIS, PostgreSQL, Linux device drivers

**Electrical** - digital systems, microcontrollers, circuit design, PCB design & assembly, soldering, USB

**Robot** - Player-Gazebo, YARP, USARSim, ROS, eCAL, remote interaction, proximate interaction, automation

## Education

**PhD in Computer Science**, 2006 – 2010

Vanderbilt University, Nashville, TN

GPA: 4.0

Dissertation title: Human-Inspired Forgetting for Robotic Systems

IBM Graduate Fellowship Award

**MS in Computer Science** (Specializing in Intelligent Robotics), 2004 – 2005

University of Southern California, Los Angeles, CA

GPA major: 3.96; GPA overall: 3.95

**BS in Computer Science & Electrical Engineering**, 1998 – 2003

Worcester Polytechnic Institute, Worcester, MA

Graduated with high distinction

## Experience

**Software**, 2019 – 2021

WaveSense Inc., Somerville, MA

Led the software design and implementation of a novel localizing ground penetrating radar sensor intended for autonomous vehicles. Captured and maintained functional and non-functional system and software requirements. Led software architecture development by cascading down requirements into functional modules. Designed and implemented data processing algorithms, Linux device drivers, network communication protocols, and database interfaces. Converted the legacy C codebase to C++, increased maintainability, and developed MATLAB bindings. Developed demo and testing GUIs using Qt, Python, and ArcGIS. Designed and implemented DevOps capabilities using AWS, Atlassian products, and LDAP. Mentored junior engineers and installed software development, testing, and release protocols, infrastructure, and best practices.

**Principal Software Engineer, 2017 – 2019**

iRobot, Bedford, MA

Identified opportunities for major software architecture restructuring and modularization. Developed new software classes, mechanisms, and processes to improve developer efficiency while increasing code defensiveness. Converted large robotics codebase from mostly C code to C++. Optimized existing build systems for improved build times and greater build quality. Redesigned Qt-based in-house development tools for improved thread safety and use of modern Qt coding paradigms. Co-led effort to implement coding standards and best practices. Mentored junior engineers. Developed scripts and automation tools to improve developer productivity. Developed Bitbucket plug-ins to improve pull request efficiency and effectiveness.

**Software Engineer III, 2013 – 2017**

Charles River Analytics, Cambridge, MA

Led the development of a multi-modal visualization tool for exploiting range data. Developed a probabilistic relational model for event characterization. Led the development of a task scheduler employing market-based optimization. Designed and assembled printed circuit boards for sensor interfacing. Created Android-based camera applications. Developed data visualizations in Gazebo. Led the redesign of a complex vision processing library. Led the development of Robot Operating System (ROS) based systems for algorithm testing. Led the effort to redesign an evolutionary-algorithm based scheduling tool. Developed web services based on JAX-WS and JAXB. Created complex build systems using QMake. Wrote SBIR, STTR, and BAA proposals and white papers. Developed a JNI wrapping library to support calling into Java from C++. Created and held division-wide training seminars. Mentored junior engineers. Reported to upper management with strategies and suggestions on how to improve company-wide engineering practices and infrastructure. Reviewed software requirements tracking software packages for potential company-wide adoption. Held clearances.

**Senior Software Engineer, 2012 – 2013**

Spectra Analysis Instruments, Inc., Marlborough, MA

Led development and maintenance of molecular analysis instrumentation software. Developed and redesigned GUI interfaces, reverse engineered communications protocols, created modules to control third-party instrumentation, and refactored the existing C++, Visual Basic, and Array Basic code base to increase maintainability, reduce code redundancy, and incorporate unit testing. Developed a Windows Basic MSI installer for the instrumentation software and setup corporate SVN, wiki, bug tracker, and web servers.

**Robotic Systems Software Engineer, 2011 – 2012**

Digilab, Inc., Holliston, MA

Led development efforts to modernize automation equipment for the life sciences research, health care, manufacturing, and safety & security markets. Updated electro-mechanical components, designed electrical subsystems, documented system architecture, redesigned graphical interfaces, reverse engineered undocumented communication protocols and circuits, added USB and Ethernet capabilities, and supported legacy products. Devices included automation equipment for liquid test sample production, microscopy, DNA shearing, and laser spectroscopy. Designed and configured corporate SVN, wiki, and web servers.

**Research Assistant, 2006 – 2010**

Human-Machine Teaming Laboratory, Vanderbilt University, Nashville, TN

Working under the direction of Dr. Julie A. Adams, researched robotic systems capable of improving both mobile robot and human operator situational awareness. Led the development of graphical user interfaces providing control of robot teams within CBRNE environments. Conducted user testing experiments and mentored junior researchers. Maintained the laboratory's computers, servers, networks, codebase, and development platforms.

*Human-Inspired Forgetting for Robotic Systems*

Explored the benefits of incorporating human-inspired forgetting mechanisms into robotic systems. ActSimple, a novel model of forgetting, was developed to increase the ability for robots to negotiate the waves of data generated by robotic sensors. Unlike some existing models of human forgetting and robotic systems, the

forgetting approach does not select items from memory, but filters data available to existing algorithms. The data screening may allow traditional robotic algorithms to realize improved performance while increasing accuracy. Results suggest ActSimple may not only provide the benefits of forgetting to robotics, but also realize increased performance over a number of existing algorithms. ActSimple is a non-domain specific algorithm with a number of adjustable parameters and subcomponents that can be tuned for individual domains and tasks.

*Cognitively Compatible and Collaboratively Balanced Human-Robot Teaming in Urban Military Domains*

Designed a hierarchical system of Qt-based graphical interfaces for the manipulation and control of robot teams in large CBRNE and disaster rescue environments. Led interface development and created multiple backend servers allowing the system to communicate with both simulators and real hardware. Introduced advanced scripting capabilities to support user and reliability testing.

*Effective Control of Multiple Unmanned Robotic Vehicles*

Designed and developed a multi-modal Qt-based GUI interface for the control of robot teams. High-level task assignment and direct teleoperation capabilities are present, along with a novel overlay mechanism aiding in the generation of situational awareness. Comprehensive system information is presented in the form of side panels. Design decisions from this project heavily inspired future laboratory interface projects.

*Usability Study of The Courseware Authoring and Packaging Environment (CAPE)*

Developed and administered a usability study for the software package The Courseware Authoring and Packaging Environment (CAPE). The study explored the software's ease of use and potential for current educators to use CAPE to develop courseware for their students. Custom online surveys were administered and participant performance was analyzed with the Morae usability testing application.

**Teaching Assistant, 2006 – 2007**

Vanderbilt University, Nashville, TN

Lectured class, held office hours, and graded assignments and exams. Courses included Introduction to Computer Graphics and Theory of Automata, Formal Languages, and Computation.

**Co-op, 2006**

The MITRE Corporation, Bedford, MA

Maintained and updated a legacy, research-based client server application. Developed in-house GUI development tools operating on custom file formats. *Secret Clearance*

**Research Assistant, 2004 – 2006**

The Interaction Laboratory, University of Southern California, Los Angeles, CA

Researched social and assistive human-robot interaction under the direction of Dr. Maja J Mataric. Constructed real-time mobile robotic systems employing voice recognition, vision processing, video presentation, and alternative forms of communication.

*A 'Hands Off' Physical Therapy Assistance Robot*

Developed an autonomous system to empirically study the effects of different types of interaction between robotic assistants and cardiac surgery patients. The system assisted patients in reaching physical therapy goals by providing engaging feedback and encouragement during the completion of painful but necessary breathing exercises. A 'Hands-Off' approach was employed, allowing for lower cost designs and decreased liability. A proof of concept experiment was conducted at the USC University Hospital and experiments were conducted to evaluate the relative effectiveness of purely verbal communication and interaction that incorporated the use of a small PDA type device. Robot capabilities included voice recognition, vision processing, video presentation, and navigation. The system provided a popular demonstration for the Interaction Laboratory.

*The Humanoid Robot - Bandit*

Created a new servomotor controller for a small humanoid robot. Angular position and velocity control is available for up to 6 servomotors with host control provided through RS-232. The redesigned system provided a popular demonstration during tours and university celebrations.

*Enhanced Inertial Motion Capture System*

Re-engineered the transmitter portion of a custom inertial motion capture system. The transmission range was amplified, interference reduced, durability enhanced, and reliability increased.

**Electrical Engineer, 2003 – 2006**

IISI Corporation, North Billerica, MA

Researched software and hardware designs in proof of principal applications for the US government. Areas of research included unconventional communications and remote sensing. *Top Secret Clearance*

**Co-op, 2002**

Analog Devices, Inc., Wilmington, MA

Designed an automation suite to test semiconductor properties with Agilent VEE. Analyzed the effects of a new fabrication process on existing semiconductor designs, verified PCB designs, and developed Windows device drivers.

**Intern, 2001**

Bose Corporation, Framingham, MA

Designed, constructed, and tested a 12-channel audio amplifier durability box and inspected car audio amplifiers for EMI interference.

**Design Engineer Co-op, 2000**

Texas Instruments, Merrimack, NH

Constructed evaluation boards for semiconductor testing, performed semiconductor testing, correlation, simulation, and probing.

**Co-op, 1999**

Siemens Business Services, Burlington, MA

Provided internet software quality assurance, performed computer backup and restoration, and inspected software for ease of use and aesthetic issues.

**Undergraduate Projects, 1998 – 2003**

Worcester Polytechnic Institute, Worcester, MA

Developed a behavior representation, embedded system, and an information packet for a non-profit organization.

*Evolving NPC*

Produced a behavioral representation, called Behavioral Curve Summation, capable of reproduction highly intelligent behavior and reducing artificial intelligence design time. Developed an evolution algorithm for system training.

*Synchronized Audio Sample Looper*

Developed a device alleviating playback tempo problems occurring when digital samples are used during live musical performances. The system adjusts playback of digital samples to match the tempo of a monitored drummer.

### *Efficiency and Effectiveness of ThaiWheel Wheelchairs*

Developed a resource packet facilitating improvements in the ThaiWheel organization. Contents included consumer input, information for future opportunities, and a program to calculate total wheelchair costs. Methods included focus groups, obtaining government and manufacturing contacts, and writing a make-buy and total cost program.

## Publications

### Dissertation

**Freedman, Sanford T.** *Human-Inspired Forgetting for Robotic Systems*. Ph.D. thesis, Vanderbilt University, December 2010.

### Journal articles

**Freedman, Sanford T.** and Adams, Julie A. Filtering data based on human-inspired forgetting. *IEEE Transactions on Systems, Man, and Cybernetics - Part B*, 41(6):1544-1555, December 2010.

### Conference papers

**Freedman, Sanford T.** and Adams, Julie A. Human-inspired robotic forgetting: Filtering to improve estimation accuracy. In *Proceedings of the 14th IASTED International Conference on Robotics and Applications*, pages 434–441, 2009.

Adams, Julie A. and **Freedman, Sanford T.** Unmanned system autonomy, situation awareness, and system safety. In *Proceedings of the 25th International System Safety Conference*, pages 800–810, 2007.

**Freedman, Sanford T.** and Adams, Julie A. The inherent components of unmanned vehicle situation awareness. In *Proceedings of the 2007 IEEE International Conference on Systems, Man and Cybernetics*, pages 973–977, 2007.

Kang, Kyong Il, **Freedman, Sanford**, Mataric, Maja J., Cunningham, Mark J., and Lopez, Becky. Hands-off physical therapy assistance robot for cardiac patients. In *Proceedings of the International Conference on Rehabilitation Robotics*, pages 337–340, Chicago, IL, June 28 - July 1 2005.

### Symposium papers

**Freedman, Sanford T.** and Adams, Julie A. Synthetic cognitive agent situational awareness components. In *AAAI Fall Symposium on Biologically Inspired Cognitive Architectures, AAAI Technical Report FS-08-04*, page 62, 2008.

### Posters

Stouch, Daniel, **Freedman, Sanford T.**, and Ramser, Nick. An Intelligent Scheduling Framework for Market-based Optimization of Sensor Resources to Improve SSA. *The Space Situational Awareness (SSA) Conference*, 2015.

### Technical reports

**Freedman, Sanford T.** Human inspired forgetting for robotics systems: Ph.D. Proposal. Technical Report HMT-09-02, Human-Machine Laboratory Technical Report, 2009.

**Freedman, Sanford T.** and Adams, Julie A. Improving robot situational awareness through commonsense: side-stepping incompleteness and unsoundness. Technical Report HMT-09-03, Human-Machine Laboratory Technical Report, 2009.

**Freedman, Sanford T.** Robots that forget: Improving robot situational awareness by purging information - preliminary examination paper. Technical Report HMT-08-03, Human-Machine Laboratory Technical Report, 2008.

**Freedman, Sanford T.** and Adams, Julie A. Synthetic cognitive agent situational awareness components. Technical Report HMT-08-04, Human-Machine Laboratory Technical Report, 2008.

Wu, Roger, Humphrey, Curtis M., **Freedman, Sanford T.**, and Adams, Julie A. Multi-robot disaster recon: Building software foundations with real and simulated robots to work with a common interface. Technical Report HMT-07-01, Human-Machine Teaming Laboratory Technical Report, 2007.

Kang, Kyong Il, **Freedman, Sanford**, Mataric, Maja J., Cunningham, Mark J., and Lopez, Becky. Hands-off physical therapy assistance robot for cardiac patients. Technical Report CRES Technical Report CRES-05-001, University of Southern California, Los Angeles, CA, 2005.

### Media

Gray, Jesse, Berlin, Matt, Breazeal, Cynthia, Aguilera, Paula, Williams, Kenton, Adams, Julie A., Robbel, Philipp, **Freedman, Sanford T.**, How, Jonathan P., Undurti, Aditya, Tellex, Stefanie, Roy, Nicholas, Kollar, Thomas, Adalgeirsson, Sigurdur Orn, Alonso, Jason B., Faridi, Fardad, Lee, Jun Ki, Siegel, Mikey, Wang, Sophie, and Williams, Jonathan. Robots to the rescue: Mixed initiative human-robot teaming for disaster response. *The 2009 International Joint Conference on Artificial Intelligence*, July 2009. (Nominated: Best Video and Best Sound Track).

### Certifications

Project Management Professional (PMP)

Deep Learning, a 5-course specialization by deeplearning.ai on Coursera

### Professional Memberships

Eta Kappa Nu - Electrical and Computer Engineering Honor Society

Tau Beta Pi - Engineering Honor Society

Association for Unmanned Vehicle Systems International (AUVSI)

Association for Computing Machinery (ACM)

Institute of Electrical and Electronics Engineers (IEEE)

Project Management Institute (PMI)

### Media Coverage

- Grifantini, Kristina. Absent-minded robots remember what matters. *Technology Review*, MIT, November, 6th 2009.
- Vieru, Tudor. Making robots absent-minded boosts their memory. *Softpedia*, November, 7<sup>th</sup> 2009.
- Vivian, Tan Sze Sze. A hands-off physical therapy assistance robot for cardiac patients. *Robot News*, April 2007.