B. FACTUAL INFORMATION

I. BIOGRAPHICAL INFORMATION

1. Demographic Information

Name: Christian J. Darken
Title: Associate Professor
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Citizenship: U.S. citizen
Security Clearance: SECRET

2. Education

   a. 1993: *Ph.D. in Electrical Engineering, Yale University.* Dissertation title: Learning Rate Schedules for Stochastic Gradient Algorithms, Dissertation advisor: John Moody, Qualification exam in vision, control,pattern recognition, and neural networks. Full research fellowship.

   b. 1989: *M.S., M.Phil. Physics, Yale University*. Passed qualification exam and admitted to Ph.D. candidacy. University fellowship, Teaching Fellowship, and Research Assistantship.

   c. 1985: *B.A. Physics, Andrews University*. Minor in behavioral science with courses in learning theory and physiological psychology.

3. Chronology of Professional History

   a. 2001-present: Associate Professor of Computer Science, Naval Postgraduate School

   b. 1999-2001: Senior Member of Technical Staff and Project Manager, Siemens Corporate Research, Princeton, New Jersey.

   c. 1996-1999: Project Manager and Member of Technical Staff, Siemens Corporate Research, Princeton, New Jersey.

   d. 1994-1996: Member of Technical Staff, Siemens Corporate Research, Princeton, New Jersey.

   e. 1992-1994: Associate Member of Technical Staff, Siemens Corporate Research, Princeton, New Jersey.

   f. Summer 1989: Intern, IBM Thomas J. Watson Research Center

   g. 1986-1992: Graduate student, Teaching and Research Assistant, Yale University.

   h. Spring 1986: Student Research Program, Argonne National Laboratory.

i. 1985-1986: Program for Special Students, Yale University.

4. Academic Concentrations and Research Interests

My original academic field before my Ph.D. was physics. Like many physicists in the late 1980's, I became interested in neural networks, a subfield of machine learning. Ever since, I have been working in one or another subfield of computer science. My work for Siemens Corporate Research was originally focused solely on machine learning, but broadened to include many more artificial intelligence techniques as needed for the industrial projects I was working on at the time. Coming to the Naval Postgraduate School to work on modeling and simulation represented a substantial transition in and further broadening of my research.

1. Artificial Intelligence: machine learning, statistical algorithms, logic and reasoning, biologically-inspired models, neural networks, Bayesian models, signal processing, control

2. Modeling and Simulation: human behavior models, cognitive models, computer animation, physically based modeling, synthetic natural environments

5. Professional Certifications or Registrations

II. INTERNAL NPS ACTIVITIES

1. Internal Teaching Activities

a. Course and laboratory development

(i) MV4471 Computer Animation. Redesigned and redeveloped this course from scratch to focus on underlying concepts and algorithms.

(ii) CS3310 Artificial Intelligence. Developed own course materials to fit common list of learning objectives.

(iii) Eye tracking system. In 2007, I was awarded $40,000 in research recapitalization money to purchase a non-intrusive remote camera-based eye tracking system. This system will support the work of two current Ph.D. students and course projects and demos for the following courses: CS3204 Human Computer Interaction, MV4001 Human Factors in Virtual Environments, MV4002 Training Systems, OA3401 and OS3401 (both introductory Human Factors courses), OA3402 Research Methods, OA4401 Individual Performance as well as OA4408 Team Performance.

b. DoN/DoD applications: The following two courses cover behavioral and cognitive modeling as they pertain to defense simulations

(i) MV4025 Behavioral and Cognitive Modeling. Proposed, designed and developed

this course, dealing with the state of the art in implementing computer generated forces and characters. It has been offered three times so far (once under a provisional title as a special topics course), always with full enrollment.

(ii) MV4100 Cognitive Engineering. Proposed, designed and developed this course, which focuses on the design and implementation of cognitive models as predictive scientific models, and their testing against human performance data.

c. Teaching techniques developed

I have developed a technique for teaching artificial intelligence focused around the use of tasks set in virtual environments as an organizational and motivational tool. Students begin by performing the task themselves, then begin constructing intelligent software agents to accomplish part of the task, and conclude by constructing agents that perform the entire task. This approach is very demanding of student programming skills and time, but has proved to be highly motivating to the students. One of the best results was achieved by a student who was only enrolled as an auditor and thus was under no obligation to do any work at all on the lab.

d. Thesis supervision

(i) Theses advised

[T1] Trent Bottin, in progress

[T2] Sevdalin Stoykov, in progress

[T3] Patrick Jungkunz, in progress.

[T4] Kris Poor, "An Analysis of Learning Algorithms in Complex Stochastic Environments", MOVES Masters 2007.

[T5] Drew Borovies, "Particle Filter Based Tracking in a Detection Sparse Discrete Event Simulation Environment", MOVES Masters 2007.

[T6] John Kelly, Masters, "Automated Run-Time Mission and Dialog Generation", MOVES Masters 2007.

[T7] Brian Jones, "A Computer Graphics-Based Target Detection Model", MOVES Masters 2006.

[T8] Dietmar Kunde, "Event Prediction for Modeling Mental Simulation in Naturalistic Decision Making", MOVES Ph.D., 2006.

[T9] Patricia Sweat, "The Importance of Artificial Intelligence for Naval Intelligence Training Simulations", MOVES Masters, 2006.

[T10] Erika Schaub, "Utilizing Biological Models to Determine the Popularity of the IRA by Modeling the Voting Behavior of Sinn Féin", National Security

Affairs Masters 2005.

[T11]Aaron Mueller, “Adding Artificial Intelligence to Delta3D: A Roadmap”, MOVES Masters 2005.

[T12] Joaquin Steve Correia, “Agent-Based Target Detection in 3-Dimensional Environments”, MOVES Masters 2005.

[T13] Louis Michael Gutierrez, “Agent-Based Simulation of Disease Spread Aboard Ship”, MOVES Masters 2005.

[T14] Eugene Ray Pursel, “Synthetic Vision: Visual Perception for Computer Generated Forces Using the Programmable Graphics Pipeline”, MOVES Masters 2004. (Phillips Award winning thesis).

[T15] Fahrettin Akbori, “Autonomous-Agent Based Simulation of Anti-Submarine Warfare Operations with the Goal of Protecting a High Value Unit”, MOVES Masters 2004.

[T16] Rene' Burgess, “Realistic Evaluation of Terrain by Intelligent Natural Agents (RETINA)”, MOVES Masters 2003. (SPAWAR research grant winner.)

[T17] David J. Morgan, “Algorithmic Approaches to Finding Cover in Three Dimensional Virtual Environments”, MOVES Masters 2003.

[T18] Supervised two German Diplom theses (Gregor Povh's, which won a best thesis prize at his school, and Andreas Mueller's) while at Siemens

(ii) Theses co-advised

[C1] Hyatt Moore, “Networked Humanoid Avatar Driven by Wireless Sensors for the MARG Project”, CS Masters, 2006.

[C2] Jon Ellis and Michael Martin, “Human Behavior Representation of Military Teamwork”, MOVES Masters 2006.

(iii) Thesis second-reader

[S1] Baris Ozkan, "Autonomous Agent-Based Simulation of a Model Simulating the Human Air-Threat Assessment Process", Naval Postgraduate School, MOVES Institute, Masters thesis, March 2004.

(iv) Doctoral committees

[D1] Curt Blais, MOVES PhD Committee, 2007.

[D2] Duane Davis CS PhD Committee, 2006

[D3] Waleed AlMannai MOVES PhD Committee, 2006

[D4] David Wells, MOVES PhD Committee, 2005

[D5] Simon Goerger, MOVES PhD Committee, 2005

e. Self-improvement efforts

i. Regularly attend the BRIMS and AIIDE conferences and incorporate new developments into my courses.

ii. Certification for Web-Based Course Development

f. Reading courses taught

i. MV4920-1 Game Engine Technologies and Development Processes. Taught on game and scenario-building with Epic's Unreal engine (a top-drawer commercial game engine) Spring 2005.

ii. MV4920 Virtual People: Software Agents that Simulate Humans. Course on recent virtual people research. Summer 2002.

iii. Periodically taught reading sections oriented towards needs of individual Ph.D. students.

g. Instructional materials

h. Mentoring

i. Course coordination

i. MV4921 Organized a popular weekly Agent Seminar attended by students and faculty from MOVES, CS, OR, and occasionally, the business school. 2003-present.

j. Other instruction information

k. Other information on evaluation of instruction

2. Internal Research Activities

a. Summary of research projects

Below is a chronological list of all research projects including
(i) title
(ii) sponsor(s)
(iii) funding level
(iv) principal investigator
(v) brief description
(vi) level of effort

(vii) students participating
(viii) numbers of staff and faculty supported
(ix) my role
(x) resulting publications

[P1] October 1, 2007 - September 30, 2010
(i) Behavior Analysis and Synthesis for Intelligent Training: BASE-IT
(ii) Office of Naval Research
(iii) $794,000 (three years)
(iv) Christian J. Darken
(v) BASE-IT will use computer vision to capture live exercises with unprecedented levels of detail and data mining techniques to analyze the captured data. I am responsible for "behavior synthesis". The goal of my work is to make captured exercises come to life as simulations at the press of a button. This requires behavior models of unprecedented detail and quality, and a game-like user interface to drive them.
(vi) 30%
(vii) Kibel
(viii) Johnson, Guerrero, Dunhour, Hollister (anticipated)
(ix) Project management, student advising
(x) None yet

[P2] March 1, 2007 - September 30, 2007
(i) Future Force Warrior Human Systems Integration Experimentation and Analysis
(ii) U.S. Army TRADOC Analysis Center Monterey
(iii) $60,000
(iv) Christian J. Darken
(v) Extended the results of the Quick Reaction project [P2].
(vi) 3%
(vii) None
(viii) Johnson, Guerrero, Dunhour
(ix) Project management
(x) [B1]

[P3] December 1, 2006 - September 30, 2007
(i) Modeling Close Range Quick Reaction Engagements
(ii) U.S. Army TRADOC Analysis Center Monterey
(iii) $55,000
(iv) Christian J. Darken
(v) The goal of this study is to construct an accurate model of current Soldier behavior in close range quick reaction engagements. This model will take as inputs such factors as the range and exposure of the threat, lighting conditions, etc., and will produce as output a distribution over sequences of actions that the Soldier could execute in response. The actions include the primary split into seeking cover versus immediate firing, but will also include more fine-grained actions such as postural adjustment (i.e.. “taking a

knee").
(vi) 10%
(vii) None
(viii) Johnson, Guerrero, Dunhour, Grant
(ix) Project management, high-level design, data analysis
(x) [G1]

[P4] May 8, 2006 - September 30, 2007
(i) MPESS: Analysis of Alternative Concepts for Future Army M&S Strategy
(ii) U.S. Army TRADOC Analysis Center Monterey
(iii) $72,000
(iv) Christian J. Darken
(v) We supported the Army's MPESS project by providing expert consultation, development of alternative concepts for future Army modeling and simulation strategy, and requirements for conceptual and data exchange models.
(vi) 20%
(vii) None
(viii) None
(ix) Developed analysis for one of the three alternative concepts.
(x) None (all documents were internal to the project)

[P5] December 1, 2006 - December 30, 2007
(i) Realistic Infantry Operations in Delta3D
(ii) Naval Modeling and Simulation Office
(iii) $80,000
(iv) Christian J. Darken
(v) Adding capability for realistic and doctrinally-correct basic infantry operations to the Delta3D simulation/game engine.
(vi) 10%
(vii) Borovies, Kelly
(viii) Johnson, Guerrero, Dunhour
(ix) Project management, student advising
(x) [E1], [E2]

[P6] October 1, 2005 - September 30, 2006
(i) Trainable Software Agents for Rapid, Low Cost Simulation Development
(ii) Office of Naval Research / Naval Modeling and Simulation Office
(iii) $60,000
(iv) Christian J. Darken
(v) Added a learning capability to exploit the mental simulation models we had previously created.
(vi) 10%
(vii) None
(viii) None
(ix) Project management, student advising
(x) [G2]

[P7] October 1, 2005 - September 30, 2006

(i) "An Artificial Intelligence Capability for the Delta3D Open Source Simulation Engine"
(ii) Office of Naval Research / Naval Modeling and Simulation Office
(iii) $50,000
(iv) Christian J. Darken
(v) The Delta3D simulation engine affords the Navy and its contractors an open source 3D engine that can be used in developing training simulations at all budget sizes. Delta3D is also used to support the teaching mission of NPS as course software for the MOVES graphics courses. Delta3D is still in its infancy, and it lacks some functionality that is essential to many applications, in particular artificial intelligence. Some artificial intelligence capability is necessary for many if not most training applications. It is also necessary to support MOVES teaching in the areas of computational autonomy (intelligent agent technology) and computer animation. We propose to develop an AI capability for Delta3D modeled on the best AI technologies that are available in commercial simulation/game engines. At a minimum, this technology will include navigation and perceptual capabilities. Time permitting, improved animation control and finite state infrastructure will also be investigated.
(vi) 10%
(vii) None
(viii) Anderegg
(ix) Project management, high level design, implementation
(x)

[P8] September 1, 2005 - December 1, 2005
(i) Gaming the Segway Centaur
(ii) U.S. Army Rapid Equipping Force
(iii) $60,000
(iv) Christian J. Darken
(v) The U.S. Army's Rapid Equipping Force was considering how the provision of Segway Centaurs (prototype electric all-terrain vehicles), possibly augmented with gun holster and blast shield, could affect the operational capabilities of an infantry squad in an Iraq-like environment. The goal of this project is to do modeling and simulation to support this investigation. The resulting software was demonstrated to all levels of U.S. Army personnel at the Association of the United States Army exhibition in October, 2005.
(vi) 15%
(vii) None
(viii) Dunhour, Clapham
(ix) Project management, design, implementation
(x) None

[P9] October 1, 2004 - September 30, 2005
(i) AI for Individual Combatant Simulation
(ii) U.S. Army TRADOC Analysis Center Monterey
(iii) $15,000
(iv) Christian J. Darken

(v) The entertainment industry has developed a wealth of technologies to be applied in simulating individual combatants in video games. Furthermore, it continues to develop and extend these technologies at a rapid pace. It seems likely that many of these technologies can be applied to training and analysis simulation, provided they are appropriately modified and extended. We will track the state of these technologies by studying notable exemplars of the technologies, tracking the published literature and attending technical conferences. We will analyze and prototype selected modifications and extensions necessary to apply the AI techniques developed by the entertainment industry to military modeling and simulation of individual combatants.
(vi) 5%
(vii) None
(viii) None
(ix) Project management and execution
(x) None

[P10] October 1, 2003 - September 30, 2004
(i) Agent-Based Modeling of Common Disease Spread on Naval Vessels
(ii) Office of Naval Research
(iii) $10,000
(iv) Christian J. Darken
(v) Extreme examples like the Spanish Flu pandemic of 1918 make clear the devastating impact that communicable diseases can have on military readiness. It is highly desirable to have models and tools that can be used to evaluate the medical requirements, both long and short term, associated with such occurrences. The primary difficulty with creating models and simulations for this purpose is that disease spread depends upon the details of human behavior. That is, the likelihood that a particular individual will catch a given disease depends upon such specifics as where he spends his day (i.e. what air he is breathing), who he talks to, what he touches, his habits of personal hygiene, etc. The agent-based approach is the state-of-the-art in modeling autonomous entities in software. While agent-based models are highly simplified as representations of human behavior, they are nonetheless much more complex and expressive as compared to traditional statistical and differential equation models. We investigated and partially confirmed the hypothesis that software agent models of human behavior can be made sufficiently accurate, detailed, and flexible to support an overall model of disease spread adequate for the purpose described.
(vi) 5%
(vii) Gutierrez
(viii) None
(ix) Project management and student advising
(x) None

[P11] October 1, 2002 - September 30, 2003
(i) Context-Driven Architecture for Natural Language Processing (extension of prior project)
(ii) N6M (predecessor of the Naval Modeling and Simulation Office)

(iii) $45,000
(iv) Christian J. Darken and Perry McDowell
(v) We developed an approach to learning context, modeled as the ability to predict future percepts. We have implemented a test-bed virtual environment and learning algorithm. This system has successfully learned the identification and consequences of up to 70,000 situations (contexts). It has achieved an average prediction ability of over 60% averaged over all percepts, including those that are irreducibly random and unpredictable.
(vi) 15%
(vii) None
(viii) None
(ix) Project management, algorithm design, implementation and testing
(x) None

[P12] October 1, 2002 - September 30, 2005
(i) Artificial Eyes and Skin: A Computational Perception Test Bed
(ii) $25,000
(iii) N6M (predecessor of the Naval Modeling and Simulation Office)
(iv) Christian J. Darken
(v) While higher cognition is readily modeled by existing software tools, perception has by comparison been largely ignored or modeled in a coarse-grained, highly abstract manner (e.g. as in EPIC/ACT-RPM). For many applications, and most especially military ones, much of human ability may derive from or be simple extensions of perceptual and motor processing. We produced a aster-based approach to modeling visual perception and specifically target acquisition. In this approach, the agent is presented with information about the environment (a pixel raster) that is similar to what a human user receives through a graphical interface. This approach is the first to have the potential to realistically account for such factors as shadow, camouflage, silhouetting, and smoke in real time. We have designed a set of algorithms for this purpose and implemented one of them to run on the GPU of consumer graphics boards to allow real-time performance.
(vi) 10%
(vii) None
(viii) None
(ix) Project management, student advising, algorithm design
(x) None

[P13] October 1, 2002 - September 30, 2003
(i) A Context-Driven Architecture for Natural Language Processing
(ii) $50,000
(iii) N6M (predecessor of the Naval Modeling and Simulation Office)
(iv) Christian J. Darken
(v) Virtual people, software agents that simulate humans, can look identical to real ones when encountered inside a virtual environment. Because this is the case, human users of a simulation have the natural expectation that virtual people will be able to communicate. This expectation is particularly justified when the virtual person represents a teammate or a tutor. Measured by any human standard, the communication technologies available for application to

virtual people are sadly lacking. Our position is that, for understanding natural language, context is king. The context of an utterance must be taken into account from the beginning of processing, rather than being tacked on at the end as an afterthought, as is currently the case. We proposed to develop an improved natural language processing architecture.
Our work uncovered two key obstacles preventing adequate representation of context for software agents in military simulations: inadequate perceptual modeling (i.e. representing what parts of the environment are available for the agent to represent as context) and the lack of mental simulation algorithms that would allow agents to distinguish likely from unlikely interpretations. To address the most important aspect of the perceptual modeling deficit, we have developed a set of three methods exploiting computer graphics techniques for modeling the inter-visibility of battlefield entities in 3D simulations. To address the mental simulation issue, we have developed a methodology to exploit the class of mental simulations that are based on the metaphoric reapplication of models of the physical world to battlefield phenomena (e.g. modeling the movement of multi-entity forces as the movement of a fluid or gas).

(vi) 25%
(vii) Burgess, Morgan
(viii) None
(ix) Project management, student advising
(x) None

[P14] October 1, 2001 - September 30, 2003
(i) Advanced Technologies for Virtual People
(ii) Research Initiation Program, Naval Postgraduate School
(iii) $31,500 (two years)
(iv) Christian J. Darken
(v) This proposal concerns the development of advanced technologies for building virtual people (simulated human beings for virtual environments) that are more realistic, smarter, and better able to communicate with humans. Specifically, we will investigate:
- Incorporation of probabilistic modeling of world state for more intelligent situation assessment
- Incorporation of probabilistic modeling of world state evolution and behavior outcomes to support statistics-based on-line learning
- Investigation of possibilities for a unified method of building up context for general situation assessment as well as for specific use in dialoging
- Models of attention and curiosity (novelty detection) to support directed reflex responses
- Incorporation of planning technology into architectures for virtual people
- Integration of gestures and language for superior communication with humans

(vi) 20%
(vii) None
(viii) None
(ix) Project management and execution
(x) None

b. Thesis contributions

i. Supported David Wells' Ph.D. research by developing a machine learning approach to estimating missing terrain data based on known parameters of the terrain. Documented in publication [C5].

c. Contributions to interdisciplinary NPS research projects

i. Co-taught IS3900, supporting the TDSI student role in the SEAS research projects, 2007.

d. Visiting researchers attracted

3. Internal Administrative and Service Activities

a. Committee service

i. Computer Science Faculty Search Committee, 2003-present. Personally involved with evaluation, phone and personal interviews with every CS candidate since I have been on the committee with the exception of one.

ii. High-Performance Computing Committee, 2003-2004.

iii. Wargaming Policy Advisory Committee, 2003.

b. Service as Academic Associate

III. EXTERNAL ACTIVITIES

1. External Teaching Activities

a. Courses

b. Course materials

c. Other significant products

d. Short course initiation, coordination, and participation

e. Distance Learning course initiation, coordination, and participation

2. External Research Activities

a. Products distributed outside NPS

i. Books

ii. Chapters in books

[B1] Darken, C. and Anderegg, B. “Particle Filters and Simulacra for More Realistic Opponent Tracking”, *Game AI Programming Wisdom 4*, Charles River, S. Rabin editor, To appear 2008.

[B2] Darken, C. and Kelly, J. “Individualized NPC Attitudes with Social Networks”, *Game AI Programming Wisdom 4*, Charles River, S. Rabin editor, To appear 2008.

[B3] Darken, C. and Paull, G. “Finding Cover in Dynamic Environments”, *Game AI Programming Wisdom 3*, Charles River, S. Rabin editor, 2006.

[B4] Darken, C. “Stochastic Approximation and Neural Network Learning", in *The Handbook of Brain Theory and Neural Networks*, Michael Arbib, editor, 1995.

iii. Refereed journal papers/cases

[C1] Greiner, R., Darken, C. and Santoso, N. I. “Efficient Reasoning", *ACM Computing Surveys*, 33:1, March 2001.

[C2] Donahue, M., Gurvits, L., Darken, C., and Sontag, E. “Rates of Convex Approximation in Non-Hilbert Spaces", *Constructive Approximation*, Vol. 13, pp. 187-220, 1997.

[C3] Gindi, G., Darken, C., O'Brien, K., Stetz, M., Deckelbaum, L. “Neural Network and Conventional Classiers for Fluorescence-Guided Laser Angioplasty", *IEEE Transactions on Biomedical Engineering*, Vol. 38, No. 3, March 1991.

[C4] Moody, J. and Darken, C. “Fast Learning in Networks of Locally-Tuned Processing Units", *Neural Computation* 1 p. 289, 1989.

iv. Non-refereed journal papers/cases

[D1] De Veaux, R. with Darken, C. and Ungar, L. Comment on “Neural Networks and Related Methods for Classication" *Journal of the Royal Statistical Society*, Series B, 56, 3, 446-447, 1994.

v. Refereed conference papers

[E1] Darken, C. “Level Annotation and Test by Autonomous Exploration”, *Proceedings of Artificial Intelligence and Interactive Digital Entertainment (AIIDE) 2007*.

[E2] Darken, C., Anderegg, B. and McDowell, P. “Game AI in Delta3D", *Proceedings of Computational Intelligence in Games (CIG) 2007*.

[E3] Darken, C. “Computer Graphics-Based Target Detection for Synthetic Soldiers", *Proceedings of Behavior Representation in Modeling and Simulation (BRIMS) 2007*.

[E4] Kunde, D. and Darken, C. “A Mental Simulation-Based Decision-Making Architecture Applied to Ground Combat”, *Proceedings of Behavior Representation in Simulation (BRIMS) 2006*. (*Outstanding paper award*).

[E5] Wells, D. and Darken, C. “Generating Enhanced Natural Environments and Terrain for Interactive Combat Simulations (GENETICS)”, *Proceedings of IMAGE 2005*.

[E6] Darken, C. "Heuristic Speed-Ups for Learning in Complex Stochastic Environments", *Proceedings of IJCAI 2005 Workshop on Planning and Learning in A Priori Unknown or Uncertain Domains*.

[E7] Darken, C. "Towards Learned Anticipation in Complex Stochastic Environments", *Proceedings of Artificial Intelligence and Interactive Digital Entertainment (AIIDE) 2005*.

[E8] Kunde, D., and Darken, C. "Event Prediction for Modeling Mental Simulation in Naturalistic Decision Making", *Proceedings of Behavior Representation in Modeling and Simulation (BRIMS) 2005.*

[E9] Paull, G., and Darken, C. "Integrated On- and Off-Line Cover Finding and Exploitation", *Proceedings of GAME-ON 2004*.

[E10] Darken, C., Morgan, D., and Paull, G. "Efficient and Dynamic Response to Fire", *Proceedings of the AAAI Workshop on Challenges in Game AI 2004*.

[E11] Darken, C. "Visibility and Concealment Algorithms for 3D Simulations", *Proceedings of Behavior Representation in Modeling and Simulation (BRIMS) 2004*.

[E12] Burgess, R. and Darken, C. "Realistic Human Path Planning using Fluid Simulation", *Proceedings of Behavior Representation in Modeling and Simulation (BRIMS) 2004*.

[E13] Santoso, N. I., Darken, C., Povh, G. and Erdmann, J. “Nuclear Plant Fault Diagnosis Using Probabilistic Reasoning", *Proceedings of the 1999 IEEE Power Engineering Society Summer Meeting*.

[E14] Scheffer, T., Greiner, R., and Darken, C. “Why Experimentation can be better than 'Perfect Guidance'", *Proceedings of the Fourteenth International Conference on Machine Learning (IMLC-97)*, Nashville, July 1997.

[E15] Darken, C. and Darken, R. “Virtual Reality + Artificial Intelligence = Intelligent Environments: A Synergistic Approach to Engineering Design Support”, *Proceedings of SPIE Vol. 2653: Stereoscopic Displays and Virtual Reality Systems*, 1996.

[E16] Petsche, T., Marcantonio, A., Darken, C., Hanson, S., Kuhn, G., and Santoso, N. I. “A Neural Network Autoassociator for Induction Motor Failure Prediction", *Proceedings of Neural Information Processing Systems* (NIPS) 1995.

[E17] Darken, C., Donahue, M., Gurvits, L., and Sontag, E. “Rate of Approximation Results Motivated by Robust Neural Network Learning", *Proceedings of the Sixth Annual ACM Conference on Computational Learning Theory (COLT)*, ACM, New York, 1993.

[E18] Darken, C., Chang, J., and Moody, J. “Learning Rate Schedules for Faster Stochastic Gradient Search", *Neural Networks for Signal Processing II*, Kung, Fallside, Sorenson, and Kamm, eds., IEEE, Piscataway, New Jersey, 1992.

[E19] Darken, C. and Moody, J. “Towards Faster Stochastic Gradient Search", Christian Darken and John Moody, in *Advances in Neural Information Processing Systems (NIPS) 4*, Moody, Hanson, and Lippmann, eds., Morgan Kaufmann, Palo Alto, 1992.

[E20] Darken, C. and Moody, J. “Note on Learning Rate Schedules for Stochastic Optimization", in *Advances in Neural Information Processing Systems (NIPS) 3*, Lippmann, Moody, and Touretzky, eds., Morgan Kaufmann, Palo Alto, 1991.

[E21] Darken, C. and Moody, J. “Fast, Adaptive K-Means Clustering: Some Empirical Results", *Proceedings of the IEEE IJCNN Conference*, Vol. 2, pp. 233-238, San Diego, IEEE Press, Piscataway, NJ (1990).

vi. Invited conference papers

[F1] Loecher, M. and Darken, C. "Concurrent estimation of time-to-failure and effective wear", *Proceedings of the Maintenance and Reliability Conference (MARCON) 2003*.

[F2] Darken, C., Santoso, N. I., and Erdmann, J. “Accident Diagnosis with Probablistic Reasoning", *Proceedings of Nuclear Technology 1999*.

vii. Presentations

[G1] Alt, J., Tollefson, E., Darken, C., Zinser, R., and Schamburg, J. “A Methodology for Modeling Soldier Behaviors”, Briefing for MORS 75th Annual Symposium, Working Group 29,31. 16 June 2007.

[G2] Darken, C. "Learning Approaches for Trainable Agents", MOVES Open House, Naval Postgraduate School, August 9, 2006.

[G3] Darken, C. “Perception, Learning, Planning and Near-Future Game AI”, invited lecture, Seoul International Game Symposium, May 2006.

[G4] Darken, C. “New Directions for Military Gaming: Beyond *America's Army”, Designing Compelling Medical Games*, invited lecture, A SUMMIT-TATRC West Workshop, Stanford University, October 8, 2005.

[G5] Darken, C., Pursel, E., and Correia, J. "AI on the GPU", Extended abstract for poster presentation at the ACM Workshop on General Purpose Computing on Graphics Processors and SIGGRAPH, 2004

[G6] Darken, C. “'Serious Games' and Academic AI Research”, invited panel, with Will Wright (Maxis/Electronic Arts), Damian Isla (Bungie/Microsoft), and David Fotland (Smart Games), *SDForum: Artificial Intelligence From Research to Reality - Computer Games*, Xerox PARC, December 8, 2004.

viii. Refereed technical reports

[H1] Moody, J. and Darken, C. “Learning with Localized Receptive Fields", *Proceedings of the 1988 Connectionist Models Summer School*, Hinton, Sejnowski, and Touretzsky, eds. Morgan Kaufmann, 1988.

ix. Non-refereed technical reports

[I1] Darken, C. and Karnin, E. “Pixel Classication By Networks of Locally-Tuned Processing Units", IBM Technical Report, August (1989).

x. Published computer programs

[J1] Darken, C. Statistical modeling and implementation of Close Range Quick Reaction Engagement behavior models (probability of hit, engagement time, initial action on contact). Delivered to IWARS (US Army analytic simulation) team, 2007.

[J2] Darken, C. High level design for AI support of the Delta3D open source game/simulation engine (thousands of downloads, described and published multiple times), 2006.

[J3] Darken, C. Ubuntu binary distribution of the entire Delta3D engine (about one thousand downloads), 2006.

[J4] Darken, C., and many others. *Meridian 59*, First 3D massively multiplayer game, 3DO, 1996.

xi. Book reviews

xii. Other

Patents

[L1] Darken, C. and Loecher, M. “Method and apparatus for providing a virtual age estimation for remaining lifetime prediction of a system using neural networks, US Patent 7,031,950.

[L2] Darken, C., Santoso, I. and Erdmann, J. “ Fault diagnosis in a complex system, such as a nuclear plant, using probabilistic reasoning”, US Patent 6,785,636 (also filed internationally).

Patent applications

[M1] Darken, C. and Loecher, M. "Method and apparatus for providing a virtual age estimation for remaining lifetime prediction of a system using neural networks", US Patent Application 20040059694.

[M2] Darken, C., Hasling, W., Loecher, M., and Mueller, A. "System and method for estimation of asset lifetime", US Patent Application 20030158803 .

[M3] Loecher, M. and Darken, C. "Method and apparatus for providing a polynomial based virtual age estimation for remaining lifetime prediction of a system", US Patent Application 20030014226.

b. Reviews (indicators of quality or significance)

i. Over 1,000 references (according to INSPEC database) [C4]

ii. Outstanding paper award for [E3]

iii. Outstanding paper award for [E4]

iv. More than 20,000 downloads for Delta3D engine including [J2]

v. More than 1,000 downloads for [J3]

vi. Arguably the first 3D massively multiplayer game [J4]

3. External Professional and Service Activities

a. Navy/DoD activity

i. External reviewer for computer science proposals to SPAWAR's independent research program together with a faculty member from U. of C. San Diego

Computer Science. Attended proposal presentations and provided advice. 2002, and again in 2003.

b. External professional activities

i. Special events committee AIIDE 2007

ii. Program review committee AIIDE 2005, 2006, 2007

iii. Program review committee Game-On 2005, 2006, 2007

iv. Program review committee Game-On NA 2006, 2007

v. Program review committee DIGRA 2005

vi. Reviewed many papers for the journals *Presence*, *Neural Computation*, *IEEE Transactions on Neural Networks*, and the NIPS and AAAI conferences. Except for *Presence*, this work was done before joining NPS in 2001.

vii. Member, ACM

viii. Member AAAI

ix. Member Cognitive Science Society

x. NATO Advanced Study Institute “From Statistics to Neural Networks" participant 1995.

xi. Fellowship to DIMACS Workshop on Theoretical Neural Networks 1991.

xii. Scholarship to CMU Connectionist Models Summer School 1989.

xiii. Review of proposal and two drafts of Parent's *Computer Animation* 2nd Edition. Parent is the textbook I use in teaching MV4471 Computer Animation.

c. Other external service activities