

Proceedings of The Fifth Conference on Computer Generated Forces and Behavioral Representation

**May 9-11, 1995
Orlando, Florida**

Sponsored by:

U.S. Army Simulation, Training, and Instrumentation Command
Defense Modeling and Simulation Office

Organized by:

Institute for Simulation and Training
3280 Progress Drive
Orlando, Florida 32826

University of Central Florida, Division of Sponsored Research

Contract N61339-92-C-0045 CDRL A00D
IST-TR-95-04

Reviewed By:



Daniel E. Mullally, Jr.

UB/TIB Hannover 89
119 246 457



Table of Contents

| | |
|--|-----------|
| Preface | i |
| Session 2a: Project Status Reports | |
| ModSAF Development Status..... | 3 |
| Anthony J. Courtemanche, Andy Ceranowicz <i>Loral ADS</i> <i>Cambridge, Massachusetts</i> | |
| The Distributed Interactive C3I Effectiveness (DICE) Simulation Project: An Overview | 15 |
| Mike Davies, Carsten Gabrisch <i>Information Technology Division, DSTO</i> <i>Salisbury, S. Australia</i> | |
| Integrated Eagle/BDS-D: A Status Report | 21 |
| Robert W. Franceschini <i>UCF/IST</i> <i>Orlando, Florida</i> | |
| Simulated Intelligent Forces for Air: The SOAR/IFOR Project 1995 | 27 |
| John E. Laird, Randolph M. Jones, Frank Koss, Paul E. Nielsen, Michael van Lent, Robert E. Wray, III <i>Artificial Intelligence Lab, University of Michigan</i> <i>Ann Arbor, Michigan</i> W. Lewis Johnson, Paul S. Rosenbloom, Karl Schwamb, Milind Tambe <i>Information Sciences Institute, USC</i> <i>Marina del Rey, California</i> Jill F. Lehman, Robert Rubinoff, Julie Van Dyke <i>Computer Science Department, Carnegie Mellon University</i> <i>Pittsburgh, Pennsylvania</i> | |
| Session 2b: Reasoning I | |
| Building Intelligent Pilots for Simulated Rotary Wing Aircraft | 39 |
| Milind Tambe, Karl Schwamb, Paul S. Rosenbloom <i>ISI, USC</i> <i>Marina del Rey, California</i> | |

| | |
|--|-----------|
| A Multiple Agent Hybrid Control Architecture for Automated Forces: Design & Software Implementation | 45 |
| <i>Xiaolin Ge, John James, Anil Nerode</i> | |
| <i>Mathematical Sciences Institute, Cornell University</i> | |
| <i>Ithaca, New York</i> | |
| | |
| Context-based Representation of Intelligent Behavior in Simulated Opponents | 53 |
| <i>Avelino J. Gonzalez</i> | |
| <i>Electrical & Computer Engineering Department, UCF</i> | |
| <i>Orlando, Florida</i> | |
| <i>Robert Ahlers</i> | |
| <i>Naval Air Warfare Center, Training Systems Division</i> | |
| <i>Orlando, Florida</i> | |
| | |
| Automated Agents That Learn and Explain Their Own Actions: A Progress Report | 63 |
| <i>Sakir Kocabas, Ercan Oztemal, Mahmut Uldudag, Nazim Koc</i> | |
| <i>Marmara Research Center</i> | |
| <i>Gebze, Turkey</i> | |
| | |
| Session 3a: Constructive + Virtual Simulation | |
| Integration of Constructive, Virtual, Live, and Engineering Simulations in the JPSD CLCGF | 71 |
| <i>Robert B. Calder, Jeffrey C. Peacock, Jr.</i> | |
| <i>SAIC</i> | |
| <i>Waltham, Massachusetts</i> | |
| <i>James Panagos</i> | |
| <i>TASC</i> | |
| <i>Reading, Massachusetts</i> | |
| <i>Thomas E. Johnson</i> | |
| <i>Raytheon Company</i> | |
| <i>Tewksbury, Massachusetts</i> | |
| | |
| Implementation of a Dynamic Aggregation/Deaggregation Process in the JPSD CLCGF | 83 |
| <i>Robert B. Calder, Jeffrey C. Peacock, Ben P. Wise</i> | |
| <i>SAIC</i> | |
| <i>Waltham, Massachusetts</i> | |
| <i>Thomas Stanzone, Forrest Chamberlain, James Panagos</i> | |
| <i>TASC</i> | |
| <i>Reading, Massachusetts</i> | |

| | |
|--|------------|
| Survey of Constructive + Virtual Linkages | 93 |
| Matthew K. Kraus, David R. Stober, William F. Foss, Robert W. Franceschini, Mikel D. Petty | |
| <i>UCF/IST</i> | |
| <i>Orlando, Florida</i> | |
| | |
| Disaggregation Overload and Spreading Disaggregation in Constructive + Virtual Linkages | 103 |
| Mikel D. Petty, Robert W. Franceschini | |
| <i>UCF/IST</i> | |
| <i>Orlando, Florida</i> | |
| | |
| Session 3b: Reasoning II | |
| Natural Language Processing for IFORs: Comprehension and Generation in the Air Combat Domain | |
| | 115 |
| Jill Fain Lehman, Julie Van Dyke, Robert Rubinoff | |
| <i>Carnegie Mellon University</i> | |
| <i>Pittsburgh, Pennsylvania</i> | |
| | |
| Agent Tracking in Complex Multi-Agent Environments: New Results | 125 |
| Milind Tambe, Paul S. Rosenbloom | |
| <i>ISI, USC</i> | |
| <i>Marina del Rey, California</i> | |
| | |
| A Methodology and Tool for Constructing Adaptive Command Agents for Computer Generated Forces | 135 |
| Michael R. Hieb, Gheorge Tecuci, J. Mark Pullen | |
| <i>Department of Computer Science, George Mason University</i> | |
| <i>Fairfax, Virginia</i> | |
| Andrew Ceranowicz | |
| <i>Loral ADS</i> | |
| <i>Cambridge, Massachusetts</i> | |
| David Hille | |
| <i>ANSER</i> | |
| <i>Arlington, VA</i> | |
| | |
| Session 4a: Command & Control Modeling I | |
| An Automated CBS OPFOR | 149 |
| Ian Page | |
| <i>Defence Research Agency</i> | |
| <i>Kent, England</i> | |
| Gary Kendall | |
| <i>Logica UK Ltd.</i> | |
| <i>London, England</i> | |

| | |
|---|------------|
| Automated Mission Planning in ModSAF | 159 |
| Clark R. Karr, Sumeet Rajput, Jaime E. Cisneros, Hai-Lin Nee | |
| <i>UCF/IST</i> | |
| <i>Orlando, Florida</i> | |
| | |
| Multi-Application Command Agents | 169 |
| Helen Lankester | |
| <i>Software Engineering Centre, Defence Research Agency</i> | |
| <i>Kent, England</i> | |
| | |
| Session 4b: VV&A | |
| Measuring Entity and Group Behaviors of Semi-Automated Forces | 181 |
| Larry L. Meliza, Eric A. Vaden | |
| <i>U.S. Army Research Institute, Simulator Systems Research Unit</i> | |
| <i>Orlando, Florida</i> | |
| | |
| The Use of Automated Regression and VVA Testing in ModSAF | 193 |
| James Perneski, Paul Monday | |
| <i>Loral ADS</i> | |
| <i>Cambridge, Massachusetts</i> | |
| | |
| Verification and Validation of Modular Semi-Automated Forces (ModSAF) in Support of A2ATD Experiment 1 | 197 |
| John G. Thomas | |
| <i>U.S. Army Materiel Systems Analysis Activity</i> | |
| <i>Aberdeen Proving Ground, Maryland</i> | |
| | |
| Session 5a: Command & Control Modeling II | |
| Command Entity Cognitive Behaviors for SAF and CGF | 203 |
| Howard Mall, Kent Bimson, Jenifer McCormack, Dirk Ourston | |
| <i>SAIC</i> | |
| <i>Orlando, Florida</i> | |
| | |
| Intelligent Computer Generated Forces for Command and Control | 211 |
| Paul E. Nielsen | |
| <i>Department of Electrical Engineering and Computer Science, University of Michigan</i> | |
| <i>Ann Arbor, Michigan</i> | |
| | |
| Autonomous Agent Interactions in ModSAF | 219 |
| David R. Pratt, Gary McAndrews, Robert McGhee | |
| <i>Department of Computer Science - Naval Postgraduate School</i> | |
| <i>Monterey, California</i> | |

Session 5b: Route Planning I

Route Planning in CCTT 233

Chuck Campbell, Richard Hull, Eric Root, Lance Jackson

SAIC

Orlando, Florida

Dynamic Obstacle Avoidance for Computer Generated Forces 245

Clark R. Karr, Michael A. Craft, Jaime E. Cisneros

UCF/IST

Orlando, Florida

Path Planning With Terrain Utilization in ModSAF 255

Bruce Hoff, Michael D. Howard, David Y. Tseng

Information Sciences Laboratory, Hughes Research Laboratories

Malibu, California

Session 6a: Implementation

Representation of Missiles in ModSAF 267

Anthony J. Courtemanche, Scott E. Hamilton, Paul Monday

Loral ADS

Cambridge, Massachusetts

From CIS to Software 275

Dirk Ourston, David Blanchard, Edward Chandler, Elsie Loh

SAIC

Orlando, Florida

Implementation of a Tactical Order Generator for Computer Generated Forces 287

David R. Pratt, Howard Mohn, Robert McGhee

Department of Computer Science - Naval Postgraduate School

Monterey, California

Session 6b: Route Planning I

Unit Route Planning 295

Clark R. Karr, Sumeet Rajput

UCF/IST

Orlando, Florida

Concealed Routes in ModSAF 305

Michael J. Longtin, Dalila Megherbi

Loral ADS

Cambridge, Massachusetts

| | |
|---|------------|
| Terrain Avoidance for CGF Helicopters | 315 |
| Stephen A. Schricker, Robert W. Franceschini, Mikel D. Petty, Tracy R. Tolley | |
| <i>UCF/IST</i> | |
| <i>Orlando, Florida</i> | |
| | |
| Session 7a: Non-Military Uses of CGF | |
| Bi-Directional Technology Transfer Between Government Applications of Computer Generated Agents and Commercial Entertainment | 329 |
| Rich Warren, Mike Crowe, Don Shillcutt | |
| <i>GreyStone Technology, Inc.</i> | |
| <i>San Diego, California</i> | |
| | |
| CGF Opportunities in Plowshares | 337 |
| Mikel Petty, Mary P. Slepov | |
| <i>UCF/IST</i> | |
| <i>Orlando, Florida</i> | |
| Paul D. West | |
| <i>United States Military Academy</i> | |
| <i>West Point, New York</i> | |
| | |
| Planning for Reactive Behaviors in Hide and Seek | 345 |
| Michael B. Moore, Christopher Geib, Barry D. Reich | |
| <i>Department of Computer and Information Science, University of Pennsylvania</i> | |
| <i>Philadelphia, Pennsylvania</i> | |
| | |
| Session 7b: Terrain Modeling I | |
| Abstracting Terrain Data Through Semantic Terrain Transformations | 355 |
| David Hille | |
| <i>ANSER</i> | |
| <i>Arlington, Virginia</i> | |
| Michael R. Hieb, Gheorge Tecuci, J. Mark Pullen | |
| <i>Department of Computer Science, George Mason University</i> | |
| <i>Fairfax, Virginia</i> | |
| | |
| Terrain Reasoning by Intelligent Player | 367 |
| Gregory A. Schaper, Ashok Pandari | |
| <i>Department of Computer Science, East Tennessee State University</i> | |
| <i>Johnson City, Tennessee</i> | |
| | |
| Recent Developments in ModSAF Terrain Representation | 375 |
| Joshua E. Smith | |
| <i>Loral ADS</i> | |
| <i>Barre, Massachusetts</i> | |

Session 8a: Applications of CGF

A Method to Quantify the Application Value of Intelligent Decision

Support Systems 385

Theodore Metzler, Joseph Kelly

LB&M Associates Inc.

Lawton, Oklahoma

**Supporting Materiel R&D Using Linked Engineering, Constructive, and
Virtual Modeling and Simulation Tools 391**

John A. O'Keefe, IV

U.S. Army, Natick RD&E Center

Natick, Massachusetts

Robert McIntyre

Simulation Technologies, Inc.

Dayton, Ohio

Session 8b: Terrain Modeling II

Integrated Computer Generated Forces Terrain Database 399

Thomas Stanzione, Forrest Chamberlain

TASC

Reading, Massachusetts

Dr. Alan Evans, Cedric Buettner

SAIC

Waltham, Massachusetts

Terrain Capabilities in CCTT 411

Jon Watkins

SAIC

Orlando, Florida

Evening Plenary Session

ARPA CFOR Briefing

Implementation of Command Forces (CFOR) Simulation 423

Marnie R. Salisbury, Lashon B. Booker, David W. Seidel, Judith S. Dahmann

The MITRE Corporation

McLean, Virginia

Session 9a: Experimental Results

Experimental Conversion of the IST Computer Generated Forces

Simulator from C to Ada 433

Michael A. Craft, Mikel D. Petty

UCF/IST

Orlando, Florida

| | |
|---|------------|
| Comparison of A* and Iterative Deepening A* in Graph Search | 443 |
| Clark R. Karr, Sumeet Rajput, Larry J. Breneman | |
| <i>UCF/IST</i> | |
| <i>Orlando, Florida</i> | |
| | |
| Intervisibility Heuristics for Computer Generated Forces | 451 |
| Sumeet Rajput, Clark R. Karr, Mikel D. Petty, Michael A. Craft | |
| <i>UCF/IST</i> | |
| <i>Orlando, Florida</i> | |
| | |
| Benchmarking and Optimization of the IST CGF Testbed | 465 |
| Stephen A. Schricker, Tracy R. Tolley, Robert W. Franceschini | |
| <i>UCF/IST</i> | |
| <i>Orlando, Florida</i> | |
| | |
| Session 9b: Dismounted Infantry | |
| Individual Combatant Development in ModSAF | 479 |
| Michael D. Howard, B. Hoff, D.Y. Tseng | |
| <i>Hughes Research Laboratories</i> | |
| <i>Malibu, California</i> | |
| | |
| Mobility Behavior in Dismounted Forces | 487 |
| George R. Mastroianni | |
| <i>U.S. Army Natick RDEC</i> | |
| <i>Natick, Massachusetts</i> | |
| Reed W. Hoyt | |
| <i>USARIEM</i> | |
| <i>Natick, Massachusetts</i> | |
| Mark J. Buller | |
| <i>GEO-CENTERS, Inc.</i> | |
| <i>Natick, Massachusetts</i> | |
| | |
| A Behavioral Approach to Fidelity Requirements for Simulation of Dismounted Combatants | 495 |
| Robert T. McIntyre, III | |
| <i>Simulation Technology Inc.</i> | |
| <i>Raleigh, North Carolina</i> | |
| Victor E. Middleton | |
| <i>Simulation Technologies, Inc.</i> | |
| <i>Dayton, Ohio</i> | |

| | |
|---|------------|
| Simulation of Suppression for the Dismounted Combatant | 501 |
| Victor E. Middleton | |
| <i>Simulation Technologies Inc.</i> | |
| <i>Dayton, Ohio</i> | |
| W. M. Christenson | |
| <i>Institute for Defense Analyses</i> | |
| <i>Alexandria, Virginia</i> | |
| John D'Errico | |
| <i>Dismounted Battlespace Battle Lab</i> | |
| <i>Ft. Benning, Georgia</i> | |
| | |
| Session 10a: Architecture | |
| Representing Role-Based Agents Using Coloured Petri Nets | 513 |
| Mike Davies, Fred D. J. Bowden, John M. Dunn | |
| <i>Information Technology Division, DSTO</i> | |
| <i>Salisbury, S. Australia</i> | |
| | |
| Realistic Doctrinal Behaviors in CGF Through Plurality | 521 |
| Denis Gagné | |
| <i>IntelAgent R&D</i> | |
| <i>Victoriaville, Quebec, Canada</i> | |
| | |
| A Comparison Study of Behavioral Representation Alternatives | 529 |
| Se-hung Kwak | |
| <i>Loral ADS</i> | |
| <i>Cambridge, Massachusetts</i> | |
| | |
| Session 10b: General Interest | |
| The OPFOR Model in CCTT and Beyond: Applications in DIS | 543 |
| Penny L. Mellies | |
| <i>TRADOC DCSINT, Threat Support Division</i> | |
| <i>Ft. Leavenworth, Kansas</i> | |
| | |
| Report on the State of Computer Generated Forces 1994 | 549 |
| H. Kent Pickett | |
| <i>TRADOC Analysis Center</i> | |
| <i>Ft. Leavenworth, Kansas</i> | |
| Mikel D. Petty | |
| <i>IST/UCF</i> | |
| <i>Orlando, Florida</i> | |
| | |
| Asynchronous Rule-Based Systems in CGF..... | 559 |
| Craig Williams, Paul F. Reynolds, Jr. | |
| <i>Department of Computer Science, University of Virginia</i> | |
| <i>Charlottesville, Virginia</i> | |
| | |
| Author's List | 567 |