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SYST 683 - MODELS, GAMING, AND SIMULATION
Course Syllabus

COURSE OVERVIEW: This course will focus on the use and characteristics of combat simulations as aids to decision-making. Principles of good analysis using combat models will provide the overall theme of the course. It will include discussion of techniques to model attrition, acquisition, movement, battlefield environment, command and control, communications, intelligence, air-to-air combat, and decision-making. The future of combat simulations will be discussed, including Advanced Distributed Simulation (Distributed Interactive Simulation and High-Level Architecture).

COURSE GOAL: The overall goal of the course is to prepare students to be good "consumers" of military simulation products, for example, as military decision-makers, advisors to decision-makers, or as critical observers of the acquisition, research, or operational planning processes within the U.S. or other military organizations.

COURSE OBJECTIVES:

1. Students will be familiar with the terminology and definitions associated with models, simulations, and wargames.

2. Students will understand the purposes of combat models as aids to decision-making, including principles of proper use, formulation of measures of effectiveness, analysis of results, and common pitfalls and abuses in the construction and application of combat models.

3. Students will understand the basic framework of general-purpose simulations, with application to a simple queueing model.

4. Students will understand strategies for representing combat such as stochastic versus deterministic modeling, event-based versus time-stepped simulation, aggregation, distributed versus standalone simulation, and closed versus human-in-the-loop simulation.

5. Students will understand techniques for representing acquisition, attrition, movement, battlefield environment, command and control, communications, intelligence, air-to-air combat, and decision-making.

6. Students will be familiar with the functions of major components of air-land combat simulations, using as examples algorithms employed by Eagle, a US Army corps-level combat simulation, and THUNDER, a USAF theater-level air combat simulation. These components will include command and control, direct fire, indirect fire, acquisition, sensors and intelligence fusion, terrain, mobility/countermobility, air and air defense, logistics support, and possibly others based on student interest.

7. Students will demonstrate an understanding of the use of combat models by conducting an analysis of the impact on force effectiveness of a modernized (notional) tank.

8. Students will be familiar with the concept of Advanced Distributed Simulation, including Distributed Interactive Simulation and High-Level Architecture.

9. Students will be familiar with Agent-Based Models, simulation toolkits, and non-standard uses for military simulations in arenas such as the Global War on Terror and Stability and Support Operations.

SCHEDULE:

Day 1 (Session 1): Introduction; purposes of combat models; the scientific basis of combat models; definitions, taxonomies, and examples; aggregation; stochastic versus deterministic modeling; discrete-event simulation, event-based versus time-stepped control; closed versus man-in-the-loop simulation. Examples: (1) queueing model in NetLogo, (2) overview of Eagle corps-level combat simulation.
Day 2 (Session 2): Principles of good analysis using combat models; common pitfalls and abuses in practice; measures of effectiveness; example analytical studies using combat models; simulation control concepts. Introduce project. Review statistical techniques for hypothesis testing*. (Project Part I assigned.)
Day 3 (Session 3): Attrition algorithms for High-Resolution models: Physical models of attrition.
Day 4 (Session 4): Attrition algorithms for Aggregated models: Lanchester attrition model.
Day 5 (Session 5): Attrition algorithms for Aggregated models: Stochastic models of Lanchester attrition; Attrition as a Markov chain; attrition coefficient generation.
Day 6 (Session 6): Attrition algorithms for Aggregated models: Non-Lanchester attrition algorithms; Fire-power scores/correlation-of-forces method; potential/anti-potential method; ATCAL method.
Day 7 (Session 7): Target detection algorithms: glimpse, continuous-observation, DYNTACS, and ACQUIRE models; Line-of-sight models (explicit and implicit). Review for Midterm.
Day 8 Midterm Exam. (Project Part I due at start of class.)
Day 9 (Session 8): Battlefield environment representations: Terrain mobility models (hex, sector, patch, homogeneous, network); Mobility algorithms: route planning and movement. Weather-and-obscuration models. Combat Engineers, Countermobility - barriers and other terrain features. Review Midterm Exam. (Project Part II assigned).
Day 10 (Session 9 & 10): Command-and-control: definition; decision tables versus rule-based reasoning; a comprehensive C2 example. Modeling intelligence fusion. Communications. Modeling Other Battlefield Functions: Force representation, Fire Support, Air Defense, Air Combat models, Logistics.
Day 11 (Session 11): The future of combat models: Object-oriented design, parallelism, and distributed combat simulations. Distributed Interactive Simulation and High-Level Architecture. Current issues in military simulation. Student Presentations
Day 12 (Session 12): High-Level Architecture overview. Student Presentations
Day 13 (Session 13): High-Level Architecture case studies. Student Presentations
Day 14: Review. Student Presentations (Project Part II due at start of class.)
Day 15: Final Exam.

***For use in Project Part I

PROJECT:

Concept: Each student will use combat models to analyze a notional modernized tank to determine its impact on force effectiveness.

Given:

1. A high-resolution tank-on-tank combat simulation. This model will be provided by the instructor. It is written in Pascal, and will run on an IBM-compatible PC.

2. Attrition and acquisition data to describe the modernized tank and the tank it would replace, and data for a set of other friendly and threat weapon systems.

3. A simple Lanchester-based low-resolution model. This model will be implemented by each student in a spreadsheet or other format as desired.

4. Statistical tools as available in Excel or other spreadsheets.

Requirement: Students will develop attrition rates for Blue (friendly) and Red (threat) weapons using a high-resolution simulation and statistical techniques (Part I). They will then build a Lanchester-based spreadsheet model of aggregated combat and use the attrition rates developed in Part I to assess the overall contribution of the modernized tank to force effectiveness (Part II).

Optional Alternative to Part II: Student will present a topic based on his/her own experience or research relevant to Military Modeling and Simulation, but not covered in the course.

GRADING:

Project: 40% (Part I: 20%; Part II: 20%)
Midterm Exam: 20%
Final: 40%

TEXT:

(1) High Resolution Combat Models and Aggregated Combat Models, Hartman, Parry, and Caldwell, US Naval Postgraduate School, Monterey CA, 1992, unpublished; available on SYST683 website.

RECOMMENDED SUPPLEMENTAL READING:

(1) Warfare Modeling, Ed. Bracken, Kress, and Rosenthal, Military Operations Research Society, John Wiley & Sons, 1995.
(2) Simulation Modeling and Analysis, Averill M. Law, 4th Edition, McGraw-Hill, 2007.
(3) Virtual Combat, David L. Neyland, Stackpole Books, 1997.
(4) "Introduction to Military Training Simulation: A Guide for Discrete Event Simulationists," Ernest H. Page and Roger Smith, Proceedings of the 1998 Winter Simulation Conference. (http://www.wintersim.org/prog98.htm)