

Modeling & Simulation (CS-503)

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Outline

- Objective of the Course
- Scope of the Course
- Course Outline
- Course Requirements
- Assessment Method

Course Objective

- In this course, modeling and simulation (M&S) methodologies considering both practical and theoretical aspects
 - Primarily in the context of defense industry and game programming will be studied in details.
- By taking the lecture, you will be supported with sufficient knowledge about
 - A wide range of M&S concepts that will lead you to develop your own M&S applications.

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What is M&S ?

- Discipline of **understanding** and **evaluating** the **interaction** of parts of a **real** or **theoretical system** by;
 - Designing its representation (**model**) and
 - Executing (running) the model including the time and space dimension (**simulation**).

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What is a System ?

- An entity (unit, process, event...), which **exists** and **operates in time and space** through the **interaction** of its parts.

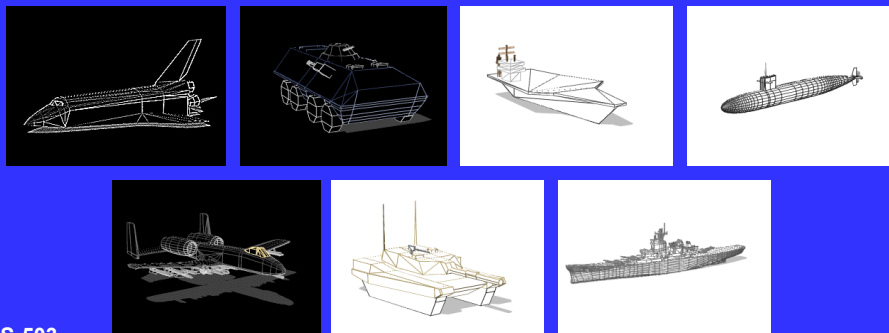


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What is a Model ?

- A **simplified representation** of a real or theoretical system **at some particular point in time or space** intended to **provide understanding** of the system.



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What is a Simulation ?

- The **manipulation of a model** in such a way that it **operates in time or space** to summarize it.



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A Popular R&D Area

- In recent decades,
 - M&S has become a very popular research and development area, which can be applied in many domains.

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Some Application Areas

- Medical research, training & support
- Industrial engineering designs & presentations (Factory process design, ...)
- Civil engineering designs & presentations (Building design, city & infrastructure planning, ...)
- Mechanical engineering designs & presentations (Engine designs, Aerodynamic design, ...)
- Nature sciences (Physic, Chemistry, Biology, Meteorology, Astronomy, ...)
- Geographic Information Systems (Earth modeling, ...)
- Military Decision Support (War modeling, ...)
- Training (Simulators, games, ...)
- Entertainment (Games, ...)

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Practical Scope of Course

- **Modeling & Simulation in;**
 - Defense Industry, and
 - Game Programming.
- **Includes:**
 - Earth modeling,
 - Entity modeling,
 - Behavior modeling,
 - Sensor & weapon systems modeling,
 - Distributed simulations,
 - Simulation based optimization and analysis.

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Course Outline

- Introduction To Modeling & Simulation
 - What is Modeling and Simulation?
 - Complexity Types
 - Model Types
 - Simulation Types
 - M&S Terms and Definitions

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Course Outline

- Input Data Analysis
 - Simulation Input Modeling
 - Input Data Collection
 - Data Collection Problems
 - Practical Suggestions
 - Effect of Period of Time
 - Input Modeling Strategy
 - Histograms
 - Probability Distributions
 - Selecting a Probability Distribution
 - Evaluating Goodness of Fit

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Course Outline

- Random Variate Generation
 - Random Numbers
 - Random Number Generators
 - Random Variate Generation
 - Factors to be considered
 - General principles
 - Inverse Transform Method
 - Acceptance-Rejection Method
 - Composition Method
 - Relocate and Rescale Method
 - Specific distributions

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Course Outline

- Output Data Analysis
 - Introduction
 - Types of Simulation With Respect to Output Analysis
 - Stochastic Process and Sample Path
 - Sampling and Systematic Errors
 - Mean, Standard Deviation and Confidence Interval
 - Analysis of Finite-Horizon Simulations
 - Single Run
 - Independent Replications
 - Sequential Estimation
 - Analysis of Steady-State Simulations
 - Removal of Initialization Bias (Warm-up Interval)
 - Replication-Deletion Approach
 - Batch-Means Method

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Course Outline

- Comparing Systems via Simulation
 - Introduction
 - Comparison Problems
 - Comparing Two Systems
 - Screening Problems
 - Selecting the Best
 - Comparison with a Standard
 - Comparison with a Fixed Performance

Course Outline

- Discrete Event Simulations
 - Introduction
 - Next-Event Time Advance
 - Arithmetic and Logical Relationships
 - Discrete-Event Modeling Approaches
 - Event-Scheduling Approach
 - Process-Interaction Approach

Course Outline

- Specific Practices
 - Overview of Some M&S Tools and Systems
 - Well-Known Simulation Modeling Tools
 - GPPS
 - Arena
 - Well-Known International M&S Systems
 - JTLS
 - Janus
 - JCats
 - Items
 - SAF
 - JSAF
 - OneSAF
 - National M&S Systems
 - Sensim
 - Ramos
 - Baskin
 - Kama
 - Mühatem

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Course Outline

- Surrounding Environment Modeling
 - Common Data Representation Types
 - Raster Maps
 - Vector Maps
 - Earth Modeling
 - Terrain Surface Modeling
 - Source Data Formats
 - Data representations
 - Remote Sensing
 - Water Surface Modeling
 - Source Data Formats
 - Data representations
 - Underwater Modeling
 - Source Data Formats
 - Data representations
 - Meteorological Modeling
 - Source Data Formats
 - Data representations
 - Meteorological computations
 - Astronomical Modeling
 - Data representations
 - Astronomical computations
 - Earth Visualization
 - What is DirectX & OpenGL?
 - Terrain Surface rendering
 - Water Surface rendering
 - Underwater rendering
 - Atmosphere rendering
 - Astronomical rendering

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Course Outline

- Entity Modeling
 - Entity Body Modeling
 - Entity Body Visualization
 - Entity Body Animation
 - Entity Interaction Modeling
 - Building Modeling

Course Outline

- Distributed Simulation
 - High Level Architecture (HLA)
 - Federation Development and Execution Process (FEDEP)
 - SISO RPR FOM

Course Outline

- Behavior Modeling
 - General AI Algorithms
 - Decision Trees
 - Neural Networks
 - Finite State Machines
 - Logic Programming
 - Production Systems
 - Path Planning
 - Off-Line Path Planning
 - Incremental Path Planning
 - Real-Time Path Planning
 - Script Programming
 - Script Parsing
 - Script Execution

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Course Outline

- Optimization Algorithms
 - Genetic Algorithms
 - Simulated Annealing

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Course Outline

- Sensor Systems Modeling
 - Human Eye Modeling
 - Optical Sensor Modeling
 - Radar Modeling

Course Outline

- Weapon Systems Modeling
 - Target Acquisition & Engagement
 - Target Movement Estimation
 - Direct Fire Modeling
 - Indirect Fire Modeling
 - Damage Assessment

Course Requirements

- Develop a small-scale M&S project with a team of preferably at most three people.
- The project will include:
 - Documentation,
 - Implementation and
 - A class presentation.

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Course Requirements

- The project topic can be either;
 - Proposed by the team or
 - Selected from a list of projects provided by the lecturer,
 - Which will be towards the development of an experimental game development environment on Windows platform.

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Course Requirements

- Preferred:
 - Microsoft Word, and
 - C++ programming language:
 - (1) Borland C++ Builder or
 - (2) Microsoft Visual Studio.

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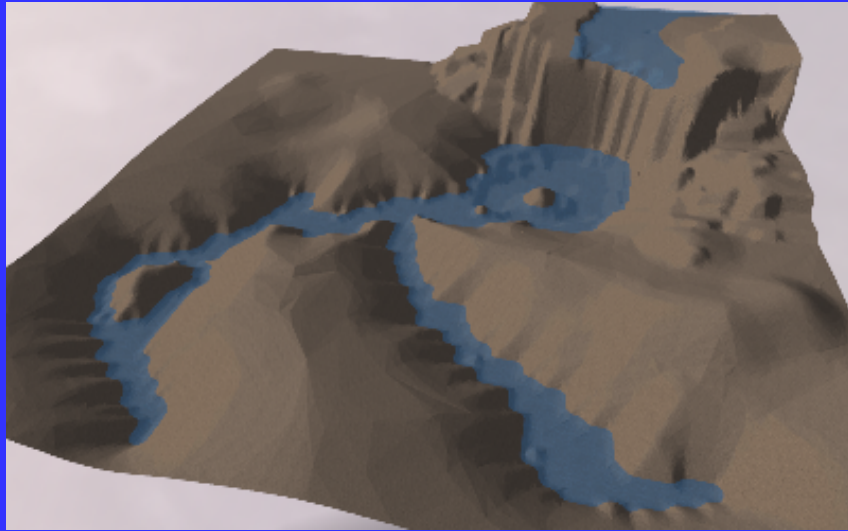
Project Topics Proposed

- Topics proposed will be towards the development of an experimental game environment.
- Basic implementation will be provided with the source code by the lecturer in Borland C++ Builder 6.0 or Microsoft Visual Studio 2005.

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Project Topics Proposed



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Basic implementation environment

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Project Topics Proposed

- 1) Environment modeling
 - 1.1) Waterfall modeling
 - 1.2) Water surface modeling
 - 1.3) Grassland modeling
 - 1.4) Scrubland modeling
 - 1.5) Tree modeling
 - 1.5.1) Needle leaf tree modeling
 - 1.5.2) Broad leaf tree modeling
 - 1.5.3) Leafless tree modeling
 - 1.6) Sky modeling
 - 1.7) 3D game world modeling

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Project Topics Proposed (Environment Modeling)

Snapshots
From 



Waterfall modeling



3D game world modeling



Sky modeling



Tree modeling



Scrubland modeling



Wind effects modeling



Water surface modeling



Ground surface modeling



Grassland modeling

CS Call of Duty: Warzone 2.0 31

Project Topics Proposed

- 2) Behavior modeling
 - 2.1) Fish behavior modeling
 - 2.2) Bird behavior modeling
 - 2.3) Land animal behavior modeling
 - 2.4) Attack behavior modeling
 - 2.5) Defense behavior modeling
 - 2.6) Head/looking direction modeling

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Project Topics Proposed (Behaviour Modeling)

Attack behavior modeling

Defense behavior modeling

Bird behavior modeling

Land animal behavior modeling

Fish behavior modeling

Attack behavior modeling

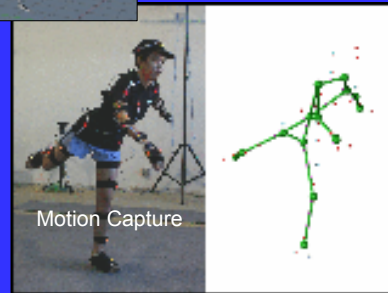
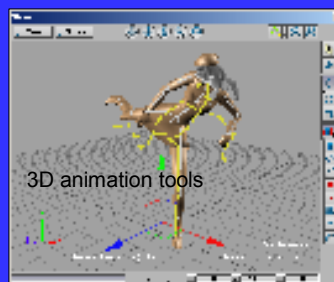
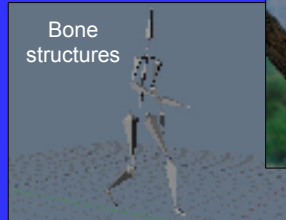
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Project Topics Proposed

- 3) Body movement (bone structure) modeling
 - 3.1) Human body movement modeling
 - 3.2) Land animal body movement modeling

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Project Topics Proposed (Body Movement Modeling)



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Project Topics Proposed

- 4) Effects modeling (wind effect integrated)
 - 4.1) Particle effect modeling (smoke, flame, explosion, missile trail)
 - 4.2) Rain and snow modeling
 - 4.3) Volumetric cloud modeling

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Project Topics Proposed (Effects Modeling)



Explosion modeling



Partical effects modeling

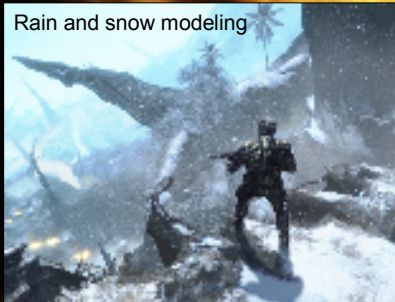


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Project Topics Proposed (Effects Modeling)

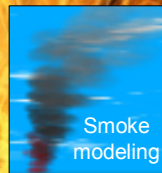
Rain and snow modeling



Helicopter rotor modeling



Flame/fire modeling



Smoke modeling

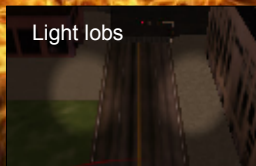
Aircraft/misssile trail modeling



Effect of wind



Light lobs



cognitivedistortion.com

Project Topics Proposed

5) Physics modeling

5.1) Rigid body collision detection and avoidance

5.2) Parachute modeling

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Project Topics Proposed (Effects Modeling)



Rigid body collision detection

Parachute modeling

Explosion effects and damage modeling

Breaking into pieces

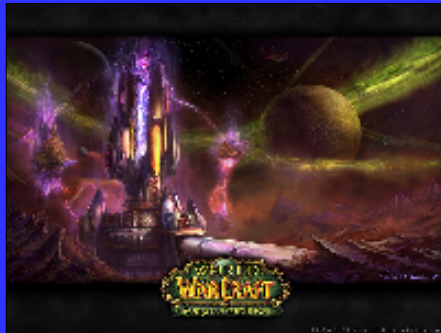
Collision avoidance

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Project Topics Proposed

- 6) Distributed simulation
 - 6.1) Multi player land vehicle modeling with HLA
 - 6.2) Massive multi player role playing game environment modeling

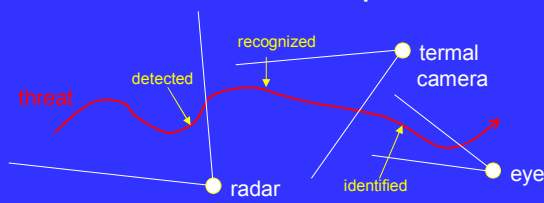


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Project Topics Proposed

- 7) Sensor Modeling
 - 7.1) Night vision goggles modeling
 - 7.2) Analysis of sensor detection, recognition and identification performance



- 8) Sound programming
 - 8.1) 3D sound effects modeling

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Assessment Method

- A project will be developed including:
 - Project Progress Report 10%
 - Project Final Report 25%
 - Project Demo & Source Code 30%
 - Project Presentation 30%
- Attendance to M&S Seminar (6-10 October) 5%
Prof.Dr. Tuncer Ören
Ottawa University, Canada
See www.modsim.org.tr > Modsim Platform > Aktiviteler

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References

- [1] Jerry Banks, “Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice”, John Wiley & Sons, Inc., 1998.
- [2] George S. Fishman, “Discrete-Event Simulation: Modeling, Programming and Analysis”, Springer-Verlag New York, Inc., 2001.
- [3] Andrew F. Seila, Vlatko Ceric, Pandu Tadikamalla, “Applied Simulation Modeling”, Thomson Learning Inc., 2003.

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