جامـــــعة المـــــستقبل
AL MUSTAQBAL UNIVERSITY

كلية العلـوم

قسـم الأنظمة الطبية الذكية

المحاضرة الاولى

المادة: Simulation and Modeling
المرحلة: الرابعة
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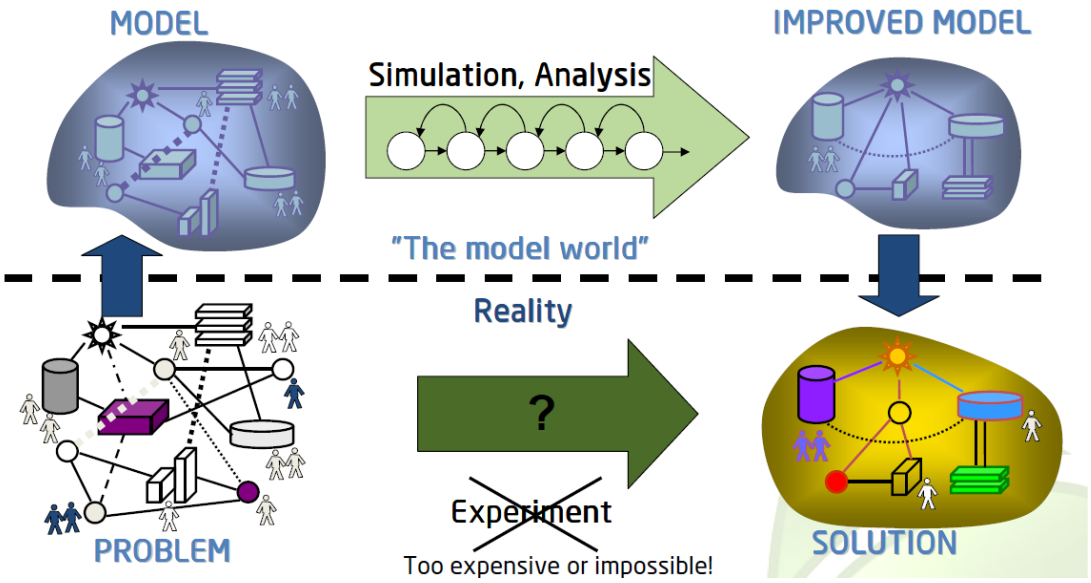
What is Simulation and Modeling?

Modeling: The mathematical formulation or conceptual framework used to simulate real systems.

Simulation: Creating a virtual representation of real-world processes.



Why is Simulation Important in Medicine

- Reduces risk to patients.
- Allows for safe testing of new procedures.
- Helps in training medical professionals.
- Reduces cost and time in clinical trials

The future of healthcare education bridges the gap between theory and practice.

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Source: https://www.eaglegatecollege.edu/blog/how-nursing-simulation-labs-are-transforming-healthcare-education/	

Key Application Area

- Drug Discovery
- Diagnostic Imaging
- Surgery Planning
- Patient-Specific Treatment
- Outcome Prediction

Types of Medical Simulations

1. **Discrete Event Simulation (DES)**
2. **Agent-Based Modeling (ABM)**
3. **System Dynamics (SD)**
4. **Monte Carlo Simulation (MCS)**

1. **Discrete Event Simulation (DES)**

This type of simulation models processes step by step. Each event happens at a specific time .

For example, patients entering the emergency room one by one each patient is treated as a separate "event."

Example: Simulating a waiting line in the ER (Emergency Room).

2. **Agent-Based Modeling (ABM)**

In this simulation:

Each person (like a patient, doctor, or nurse) is an independent agent.

Each agent has its own behavior and rules for interacting with others.

The simulation shows how agents act and react in a given environment.

Why use it?

It helps us understand how the behavior of a whole system changes based on how individuals behave.

Example (Simulating the spread of a virus (like COVID-19)):

Each person is an "agent". If they get close to someone infected, they might catch the virus depending on conditions (like distance or wearing a mask). The simulation shows how the virus spreads over time.

3. **System Dynamics (SD)**

This uses mathematical models to study how systems change over time. It focuses on feedback loops and delays. It is useful for modeling chronic diseases.

Example: Tracking how a diabetic patient's blood sugar level changes throughout the year.

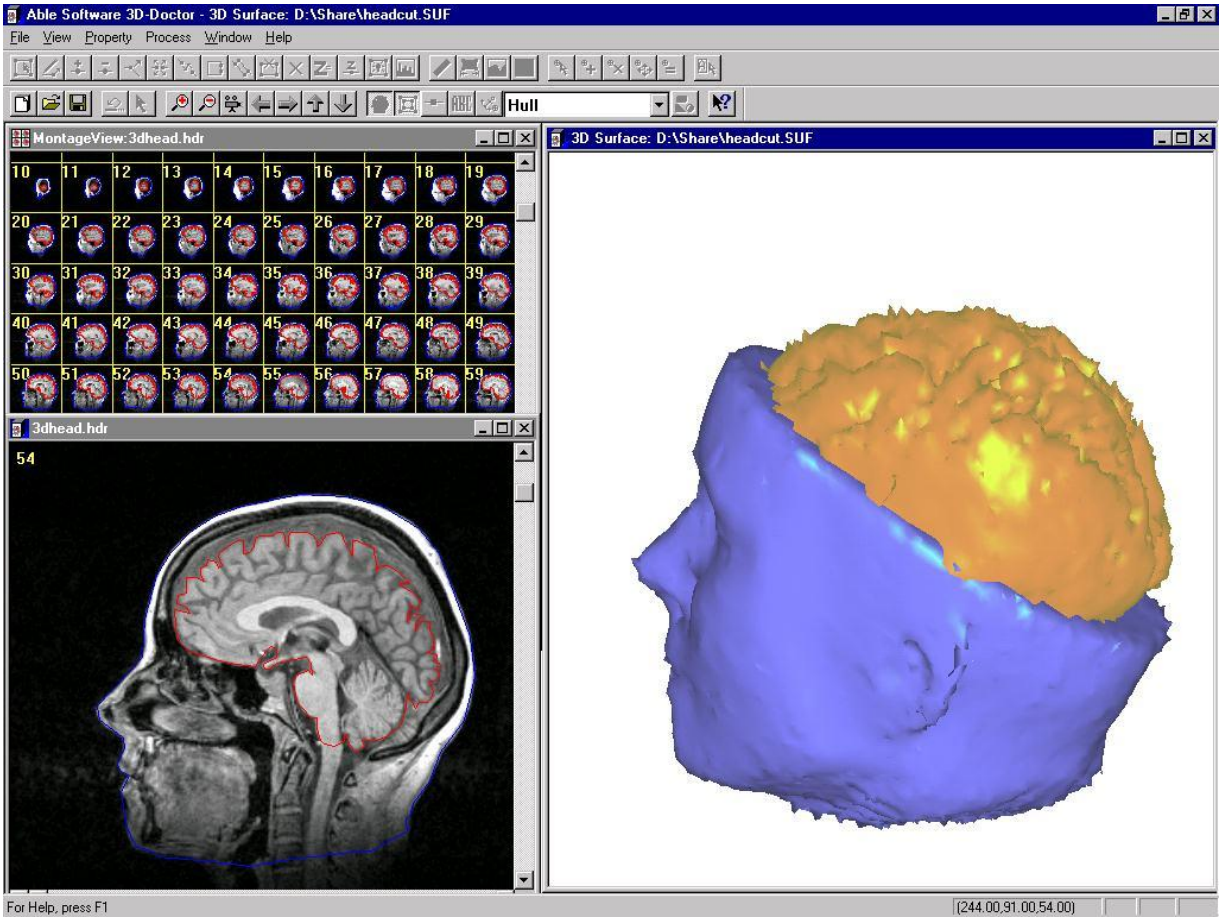
4. **Monte Carlo Simulation (MCS)**

This method runs the same scenario thousands of times using random values. It is helpful when there is uncertainty or many possible outcomes.

Example: Predicting the success rate of a surgery by simulating thousands of possible results.

Real-World Case Study

- In some complex surgical operations, doctors use:
- 3D modeling of the body or the affected organ, using medical imaging techniques like CT scans or MRI.
- Then, an intelligent system analyzes these 3D models using tools from:
- Machine Learning (ML): to detect patterns and predict possible outcomes.
- Deep Learning (DL): to recognize and analyze medical images (e.g., identifying a tumor in a CT scan).
- Data Mining: to extract useful information from patient records and medical history.



Component	Role in the Model
ML / DL	Detect tissue boundaries, classify tumors, predict outcomes
Modeling	Build a 3D model from medical scan images
Simulation	Run different scenarios on the model without touching the patient

Challenges in Medical Simulation:

- Data accuracy and availability
- High computational cost
- Ethical issues in patient modeling

Future of Medical Simulation:

- Integration with AI and Machine Learning
- Personalized medicine
- Virtual Reality (VR) and Augmented Reality (AR)

VR-based medical simulation:

Surgeons can interact with patient-specific 3D models to plan complex operations using virtual reality and AI.

References

[1] Banks, J., et al. (2010). Discrete-Event System Simulation.

[2] Marshall, D. A., et al. (2005). Applying simulation modeling to healthcare: review and recommendations.

[3] https://www.sciencedirect.com/topics/medicine-and-dentistry/medical-simulation