

DEGREE: BSc Computer Science and Digitisation

Module: Advanced Simulation Techniques

Assignment Title: Multi-Method Simulation of Emergency Evacuation in a Smart Building

Assignment Type: Portfolio

Word Limit: 3000 words (+/- 300)

Weighting: 100%

Issue Date: 20/05/2025

Submission Date: 20/06/2025

Feedback Date: 11/07/2025

Plagiarism:

When submitting work for assessment, students should be aware of the InterActive/Canvas guidance and regulations in concerning plagiarism. All submissions should be your own, original work. Please note that you must not submit the same assignment for two different modules within your course.

You must submit an electronic copy of your work. Your submission will be electronically checked.

Learner declaration	
I certify that the work submitted for this assignment is my own and research sources are fully acknowledged.	
Student signature:	Date:

Harvard Referencing:

The Harvard Referencing System must be used. The Wikipedia, UKEssays.com or similar websites must **not** be used or referenced in your work.

Introduction

A smart office building with three floors, two staircases, and various functional areas (meeting rooms, workstations, and a cafeteria) is equipped with smoke and fire detectors and real-time sensors to monitor crowd density. An automated alarm system triggers based on sensor inputs during emergencies.

Your task is to simulate evacuation scenarios during fire emergencies. The model should capture how people evacuate, how alarms and exit choices affect evacuation times, and how congestion forms and can be minimized using advanced simulation techniques.

Learning Outcomes:

LO1. Demonstrate the understanding of basic concepts of modelling layers of society's critical infrastructure networks.

LO2. Implement advanced tools to view and control complex simulations and their results.

LO3. Compare multiple tools and techniques in designing advanced simulations.

Assessment Criteria: Weighting 100%

3000 words

Scenario and Dataset:

Imagine a smart office building that spans three floors, equipped with two staircases, meeting rooms, workstations, and a cafeteria. Each floor is outfitted with smoke and fire detectors, and real-time sensors track crowd density. An automated alarm system is in place, triggered by sensor readings to alert occupants in case of an emergency. Your task is to build a simulation to study how people evacuate under different fire scenarios, the impact of alarm systems and exits on evacuation time, and how congestion forms and can be minimized.

Dataset:

For this assignment, you are required to generate your own synthetic dataset. This dataset should simulate evacuation events and include the following columns:

- **timestamp:** Time of the event.
- **floor:** Floor where the event occurs.
- **person_id:** Unique identifier for each person.
- **location_x:** X-coordinate of the person's location.
- **location_y:** Y-coordinate of the person's location.
- **smoke_level:** Level of smoke detected.
- **alarm_status:** Status of the alarm system.

You can use tools like Python or Excel to generate this dataset, simulating people's movement paths, fire spread timeline, and sensor detection timings.

Assignment Tasks

The assignment is divided into five phases, each focusing on different aspects of the simulation process.

Phase 1: Problem Understanding & System Conceptualization (15 Marks)

Learning Outcome: LO1

- **Describe the Problem Scenario**
 - Explain the scenario in your own words, providing a detailed description of the smart building's components and the emergency situation.
 - Highlight the importance of simulation in optimizing emergency responses.
- **Identify Key System Components**
 - List and describe the main components, such as agents (people), sensors, fire, and exits.
 - Discuss how these components interact within the system.
- **Create a Conceptual Model Diagram**
 - Develop a diagram illustrating how different parts of the system interact.
 - Use this diagram to visualize the flow of information and decisions during the evacuation process.

Phase 2: Technique Selection & Justification (15 Marks)

Learning Outcomes: LO1, LO3

- **Select Simulation Techniques**
 - Choose two simulation techniques, such as Agent-Based Modeling (ABM) and Discrete-Event Simulation (DES).
 - Explain why each technique is suitable for different parts of the system (e.g., movement vs. alarm logic).
- **Justify Technique Relevance**
 - Provide a detailed justification for the selected techniques, highlighting their strengths and relevance to the problem.
- **Compare Strengths**
 - Briefly compare the strengths of the selected techniques in the context of this problem, discussing their advantages and potential limitations.

Phase 3: Simulation Design & Implementation (30 Marks)

Learning Outcomes: LO2, LO3

- **Design the Building Layout**
 - Create a detailed layout of the building, including floors, rooms, and exits.

- Ensure the layout is realistic and reflects the complexity of a smart office building.
- **Implement Evacuation Logic**
 - Use tools such as Python (Mesa, SimPy), NetLogo, AnyLogic, or similar to implement the simulation.
 - Focus on simulating people movement and decision-making, fire or smoke spread, sensor-triggered alarm systems, and exit selection and congestion.
- **Simulate Key Aspects**
 - Model the dynamics of people movement and decision-making under stress.
 - Simulate the spread of fire or smoke and its impact on evacuation routes.
 - Implement sensor-triggered alarm systems and analyze their effectiveness.
 - Study exit selection and congestion to identify bottlenecks and optimize evacuation paths.

Phase 5: Error Analysis & Validation (20 Marks)

Learning Outcomes: LO2, LO3

- **Identify Assumptions**
 - List and discuss key assumptions in your model, explaining their impact on the simulation.
- **Discuss Potential Errors**
 - Analyze possible sources of error and their impact on the simulation, using error analysis techniques from the course.
 - Discuss how these errors might affect the validity of your results.
- **Propose Validation Approaches**
 - Suggest methods for validating your model, such as comparing it with real evacuation times or drill patterns.
 - Explain how these validation approaches can enhance the reliability of your simulation.

Phase 5: Visualization & Final Report (20 Marks)

Learning Outcome: LO2

- **Create Visualizations**
 - Develop meaningful visualizations, including evacuation flow maps, heatmaps of congestion, and floor layouts with agent traces.
 - Ensure these visualizations provide insights into the evacuation process and highlight areas for improvement.
- **Results and Discussion:** Present and analyze your findings, discussing their implications.
- **Limitations and Future Improvements:** Reflect on the limitations of your model and suggest future improvements.

Submission Instructions

- **Document Format:**
 - Submit your assignment as a single document following the BSBI assignment template provided in Canvas.
 - Ensure the document is in PDF format for consistency and ease of review.
- **Writing Quality:**
 - Ensure clear and concise writing with proper grammar and spelling.
 - Use formal and academic language throughout the document.
- **Organization:**
 - Use headings and subheadings to organize your work logically according to the tasks outlined above.
 - Each section should correspond to a specific phase of the assignment, making it easy to navigate.
- **Visuals:**
 - Include visuals like diagrams (process flow, conceptual model sketches), tables (data assumptions, results), and graphs (simulation output) where appropriate to enhance understanding.
 - Ensure all visuals are labeled and referenced within the text.
- **Referencing:**
 - Use the Harvard referencing style for your bibliography.
 - Ensure all sources are properly cited within the text and listed in the reference section at the end of the document.
- **Analysis and Discussion:**
 - Discuss your findings, insights, and the implications of your recommendations.
 - Reflect on the strengths and limitations of your simulation model and suggest potential improvements.

GUIDANCE ON ASSESSMENT

All materials must be properly referenced under Harvard conventions. The length required is 3000 words with tasks equally weighted. The writing style should be formal academic / report writing style with in-text referencing to support your comments and observations. Originality, quality of argument and good structure are required. The report should demonstrate sound understanding and ability to apply knowledge and theory of Simulation Techniques. Additional marks being awarded for juxtaposition and insight of issues.

Grading Criteria

	Generic Criteria	90 - 100	80 - 89	70 - 79	60 - 69	50 - 59	40 - 49	30 - 39	0 - 29
Level 6	Knowledge of contexts, concepts, technologies and processes The extent to which: <i>relevant contextual or theoretical issues are identified, defined and described</i> <i>historical or contemporary practices are identified, defined and described</i> <i>appropriate technologies, methods and processes are identified defined and described</i>	Exceptional breadth and depth of knowledge of contextual and theoretical issues, some of which are at the forefront of the discipline, and their relationship to a range of historical and contemporary practices Exceptional knowledge of a range of relevant specialist techniques and processes	Outstanding breadth and depth of knowledge of contextual and theoretical issues, some of which are at the forefront of the discipline, and their relationship to a range of historical and contemporary practices Extensive knowledge of a range of relevant specialist techniques and processes	A breadth and depth of knowledge of contextual and theoretical issues, some of which are at the forefront of the discipline, and their relationship to a range of historical and contemporary practices Significant knowledge of a range of relevant specialist techniques and processes	Confident knowledge of a range of contextual and theoretical issues, some of which are at the forefront of the discipline, and their relationship to a range of historical and contemporary practices Confident knowledge of a range of relevant specialist techniques and processes	Familiar with a range of contextual and theoretical issues, at least some of which are at the forefront of the discipline, and their relationship to a range of historical and contemporary practices Sound knowledge of a range of relevant specialist techniques and processes	Familiar with a range of contextual and theoretical issues and their relationship to a range of historical and contemporary practices Adequate knowledge of a range of relevant specialist techniques and processes	Some knowledge of a range of contextual and theoretical issues and their relationship to a range of historical and contemporary practices Limited knowledge of a range of relevant specialist techniques and processes	Limited knowledge of contextual and theoretical issues and their relationship to a range of historical and contemporary practices No significant knowledge of a range of relevant specialist techniques or processes
	Understanding through application of knowledge The degree to which research methods are demonstrated: <i>relevant knowledge and information is compared, contrasted, manipulated, translated and interpreted</i> <i>knowledge and information is selected, analysed, synthesized and evaluated in order to generate creative ideas, practices, solutions, arguments or hypotheses</i>	Exceptional application of a range of research methodologies to projects and problems and hypotheses, with evidence of highly focused independent thought and some new insights into the subject Exceptional ability to produce a range of creative practices and to critically evaluate them in a wider context, generating sustainable arguments and highly effective and individual results	Systematic and thorough application of a range of research methodologies to projects and problems and hypotheses, with evidence of highly focused independent thought and some new insights into the subject Outstanding ability to produce a range of creative practices and to critically evaluate them in a wider context, generating sustainable arguments and highly effective and original results	Rigorous application of a range of research methodologies to projects, problems and hypotheses with evidence of highly focused independent thought and critical analysis Strong ability to produce a range of creative practices and to critically evaluate them in a wider context, generating sustainable arguments and highly effective results	Confident ability to apply a range of research methodologies to projects, problems and hypotheses with clear evidence of independent thought and critical analysis Strong ability to produce a range of creative practices and to evaluate them in a wider context, generating effective results	Sound ability to apply a range of research methodologies to projects, problems and hypotheses and to demonstrate independent thought and critical analysis Sound ability to produce a range of creative practices and to evaluate them in a wider context, generating effective results	Competent ability to apply a range of research methodologies to projects, problems and hypotheses with some element of independent thought and critical analysis Competent ability to produce a range of creative practices and evaluate them in a wider context to generate effective results	Ability to apply a limited range of research methodologies to projects, problems and hypotheses with little evidence of independent thought or critical analysis Limited ability to produce a range of creative practices and to evaluate them in a wider context to generate effective results	No significant ability to apply research methodologies to projects, problems and hypotheses, and no evidence of independent thought or critical analysis No significant ability to produce a range of creative practices or to evaluate them in a wider context to generate effective results

	Application of technical and professional skills The degree to which: <i>appropriate materials and media are selected, tested and utilised to realise and present ideas and solutions</i> <i>appropriate technologies, methods and processes are demonstrated</i> <i>transferable, professional skills are effectively demonstrated</i> <i>self management and independent learning are demonstrated</i>	Exceptional, individual and fluent application of a range of specialist practical and technical skills Outstanding accomplishment of a range of advanced transferable and professional skills applied to complex situations and problems Exceptional ability to manage own learning in a sustained manner and to critically evaluate own progress, making use of a wide range of feedback sources	Accomplished, original and fluent application of a range of specialist practical and technical skills Outstanding accomplishment of a range of advanced transferable and professional skills applied to complex situations and problems Outstanding ability to manage own learning in a sustained manner and to critically evaluate own progress, making use of a wide range of feedback sources	Accomplished and original application of a range of specialist practical and technical skills Accomplished application of advanced transferable and professional skills to complex situations and problems Very high ability to manage own learning in a sustained manner and critically evaluate own progress making effective use of feedback	Confident and imaginative application of a range of specialist practical and technical skills Confident application of advanced transferable and professional skills to challenging situations and problems Strong ability to manage own learning in a sustained manner and to critically evaluate own progress making effective use of feedback	Sound application of a range of specialist practical and technical skills Sound application of advanced transferable and professional skills Sound ability to manage own learning in a sustained manner and critically evaluate own progress making effective use of feedback	Competent application of a range of specialist practical and technical skills Competent application of advanced transferable professional skills Competent ability to manage own learning in a sustained manner and make effective use of feedback	Basic application of a range of specialist practical and technical skills Limited application of advanced transferable and professional skills Basic ability to manage own learning in a sustained manner and make use of feedback	Rudimentary application of a range of specialist practical and technical skills Ineffective application of advanced transferable and professional skills Evidence of a basic ability to manage own learning
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