DEGREE: MSc in Artificial Intelligence

Module: Robotics Software and Programming

Assignment Title: Robotics Simulations Using PyBullet and ROS2

Assignment Type: Set exercise testing practical skills

Word Limit: 2500-3000 words

Weighting: 100%

Issue Date: 4/9/2025

Submission Date: 6/10/2025

Feedback Date: 27/10/2025

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.
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:

This assignment consists of two tasks and must be completed individually. It asks you to design, implement, and test robotic software solutions using simulation tools only. It is structured in two progressive stages:

- A basic simulation project in PyBullet using Google Colab.
- A comprehensive robotics system developed and tested using the ROS2-based simulation environment on TheConstruct.ai.

You will demonstrate your ability to apply programming and robotics principles, plan and build robotic behaviors, and test solutions in a simulated environment — emphasizing software components, motion planning, sensor integration, and autonomous control.

Learning Outcomes:

LO1. Innovate and develop novel robotic software solutions, demonstrating creativity and problem-solving skills to address complex challenges in robotics.

LO2. Conduct in-depth research into emerging robotic software trends and technologies, critically analyzing existing methodologies and proposing new directions to advance the field.

LO3. Conduct collaborative projects demonstrating the ability to apply theoretical knowledge to practical, real-world applications using programming languages.

Assessment Criteria: Weighting 100%
2500 - 3000 words

Assignment Tasks:

Task 1. PyBullet World Building with URDFs

Objective:

Model a static scene in PyBullet, using Google Colab, that includes a simple two-wheel robot and multiple static obstacles. This task assesses your ability to define custom robot components using URDF, to set up scenes using PyBullet The aim is to use custom .urdf objects, arrange them meaningfully, and capture the scene from three different camera angles.

Steps/Requirements:

1. *Define at least one two-wheel robot using URDF.*
2. *Create at least four different custom URDF models* of simple geometric objects (e.g., a box table, a cylinder pillar, a wall, etc.).
3. *Design and instantiate a small virtual scene*, arranging at least seven of these objects, plus the robot, into a spatial configuration (e.g., a mini "room," "warehouse," or "obstacle field").
4. Use *PyBullet's DIRECT mode and set three different camera viewpoints*, capturing rendered images from each, making sure all objects are visible. In each image, no object or robot should extend beyond the image frames but objects can partially overlap, as long as all the objects and robot are at least partially visible (no completely

hidden objects allowed in any view).
5. Across the images, all simple objects should stay in their position, while the robot should be placed in different positions, as if moving between images.
6. Display these images in the notebook, e.g. with Matplotlib or any suitable visualisation library.
7. If applicable, please document any alternative approaches you have experimented with, including failed attempts.

Task 2. Autonomous Robot Simulation with ROS2 (TheConstruct.ai)

Objective:
Design a more complex, interactive robotic system using ROS2 and simulate it in a dynamic world. *You must use TheConstruct.ai platform and provide full instructions on how to access and run the simulation.*

Steps/Requirements:
- Define a simple environment (e.g., maze, hallway, or obstacle course).
- Use a standard simulated TurtleBot or equivalent mobile robot.
- Research methodologies on how to integrate sensors (e.g. LIDAR, camera or IMU) using ROS2 topics and integrate at least two types of sensors.
- Implement real-time obstacle avoidance.
- Use a simple GUI (e.g., keyboard) for HRI.
- Design a state machine for behaviour control (FSM), with at least 5 states.
- Execute full simulation in TheConstruct with recorded logs/screenshots.

Deliverables
- Task 1: One Jupyter Notebook (.ipynb) in Colab with
  - Code for defining URDF files and loading them
  - Scene setup and camera placement
  - Rendered images from three distinct viewpoints
  - *A link to the notebook must be shared in the report PDF submission*
  - *Make sure the notebook is not private and can be accessed publicly.*
- Task 2: One Rosject in app.theconstruct.ai with
  - All code and packages for running the simulation
  - A notebook within the environment, with documentation and instructions
    - As a minimum, this must provide *complete* step-by-step instructions on how to run the simulation, including all commands that need to be run from the shell windows in theconstruct.ai environment
  - *The name of the Rosject should be unique and must be shared in the report PDF submission. To ensure the name is unique, you could generate a 10-digit random alphanumeric string, e.g. using random.org, and use that as your Rosject name.*
- Both tasks: A PDF Report to upload to Canvas which, for each task, should include
  - *Project Definition*
    - Problem statement and objectives
    - Environment and robot/object descriptions
  - *Design and Implementation*
    - Architecture overview (diagrams encouraged)
    - Tools/libraries used
    - Key algorithms (where applicable) and how they're applied

    - *Execution and Testing*
        - Screenshots
        - Description of test cases and outcomes
    - *Evaluation and Reflection*
        - Challenges faced and solutions
        - Potential improvements
        - Reflection on how the project maps to real-world robotics

- **Grading Criteria:**
    - Project Description Clarity (15%)
    - Research Depth (15%)
    - Simulation Design & Interaction Quality (20%)
    - Technical Implementation & Sensor Integration (20%)
    - Testing Robustness (15%)
    - Deployment and Documentation (15%)

Submission Guidelines

Prepare a comprehensive report showcasing your projects:

- Include screenshots or embedded visuals illustrating your original contributions.
- Ensure all code is well-commented with clear replication instructions.
- Your report must be clear, organized, and visually appealing, using the BSBI assignment template available on Canvas.
- Upload your submission as a single file (PDF or DOC) on the BSBI portal.
- Jupyter notebooks and Rosjects should be publicly accessible with link/name included.
- Cite all sources using the Harvard Referencing System.
- Submit your assignment electronically by the specified deadline.

GRADING DESCRIPTORS: LEVEL 7

EXPERIMENTATION & INNOVATION								
	FAIL			**PASS**				
Threshold Criteria	**0-29%**	**30-39%**	**40-49%**	**50-59%**	**60-69%**	**70-79%**	**80-89%**	**90-100%**
Deals with complex issues both systematically and creatively demonstrating self-direction and originality in tackling and solving problems	Little to no ability to use techniques to deal with complex issues systematically (including those of ethics and sustainability) and creatively to solve problems and/or make decisions.	Low utilisation of established techniques to deal with complex issues systematically (including those of ethics and sustainability) and creatively to solve problems and/or make decisions, but with limitations in techniques or approach.	Limited research or advanced scholarship to their area of study by using a range of information and established and advanced techniques	Competent understanding of solving problems, through own research or advanced scholarship displaying a comprehensive understanding of established and advanced techniques	Good understanding of solving problems through own research and advanced scholarship critically selecting and displaying a comprehensive understanding of established and advanced techniques.	Very Good problem-solving skills displaying a comprehensive understanding of techniques applicable to their own research or advanced scholarship	Excellent range of extremely well-developed problem-solving displaying an understanding of techniques applicable to their own research or advanced scholarship beyond which is taught.	Exceptional problem-solving skills with sophisticated evaluation and application of a wide range of advanced information and techniques to undertake projects.
Comprehensive understanding of techniques applicable to their own research or advanced scholarship	Little to no understanding of techniques applicable to their own research or advanced scholarship or their limitations and ambiguities.	Low understanding of techniques applicable to their own research or advanced scholarship including their limitations and ambiguities.	Limited understanding of key techniques applicable to their own research or advanced scholarship including their limitations and ambiguities.	Competent understanding of techniques applicable to their own research or advanced scholarship including their limitations and ambiguities	Good understanding of techniques applicable to their own research or advanced scholarship and a some understanding of more specialised techniques.	Very good understanding of techniques applicable to their own research or advanced scholarship and a some understanding of more specialised techniques.	Excellent understanding of techniques applicable to their own research or advanced scholarship and mastery of some more specialised areas.	Exceptional understanding of techniques applicable to their own research or advanced scholarship and mastery of some more specialised areas.

GRADING DESCRIPTORS: LEVEL 7

RESEARCH & ANALYSIS								
	FAIL			**PASS**				
Threshold Criteria	**0-29%**	**30-39%**	**40-49%**	**50-59%**	**60-69%**	**70-79%**	**80-89%**	**90-100%**
Systematic understanding of knowledge, and a critical awareness of current problems and/or new insights, much of which is at, or informed by, the forefront of their academic discipline, field of study or area of professional practice	Little to no knowledge of the subject with limited breadth or depth or deficiencies in major areas or currency.	Low knowledge of the subject lacking coherence, breadth, or detail with only some reference to ideas or arguments at the forefront of any part of the subject.	Limited knowledge to deal with terminology, facts and concepts some of which is informed by the forefront of defined areas of the subject.	Competent knowledge of ideas or arguments at the forefront of any part of the subject sufficient to deal with current issues in the discipline, generally more descriptive than critical or analytical.	Good knowledge of ideas or arguments at the forefront of any part of the subject showing a clear, critical insight into the discipline as whole and current issues/problems.	Very good knowledge of ideas or arguments at the forefront of the subject some of which are significantly beyond what has been taught and show a critical insight into the discipline and current issues/problems.	Excellent knowledge of ideas or arguments at the forefront of the subject many of which are significantly beyond what has been taught and show a critical insight into the discipline and current issues/problems.	Exceptional knowledge of ideas or arguments at the forefront of the subject most of which are significantly beyond what has been taught and show a critical insight into the discipline and current issues/problems.
Conceptual understanding that enables the student to display originality in the application of knowledge	Little to no conceptual understanding or argument and a focus on descriptive explanations which do not comment on arguments of others or alternative views.	Low conceptual understanding and arguments are weak or poorly constructed, and the work does not critically evaluate the arguments of others or consider alternative views.	Limited conceptual understanding and argument construction with critical evaluation of alternative views or comment on advanced scholarship.	Competent conceptual understanding and argument construction with critical evaluation of a range of views and consistent engagement with advanced scholarship.	Good conceptual understanding which critically evaluate and synthesise other views and information with a thoughtful interpretation of advanced scholarship.	Very good conceptual understanding which systematically synthesises a wide range of views with a critical insight into advanced scholarship.	Excellent conceptual understanding which critically apply a wide range of views through a perceptive use of advanced scholarship.	Exceptional conceptual understanding of publishable quality with systematic engagement and usage of advanced scholarship.

GRADING DESCRIPTORS: LEVEL 7

ENGAGING WITH PRACTICE								
	FAIL			**PASS**				
Threshold Criteria	**0-29%**	**30-39%**	**40-49%**	**50-59%**	**60-69%**	**70-79%**	**80-89%**	**90-100%**
Practical understanding of how established techniques of research and enquiry are used to create and interpret knowledge in the discipline	Little to no evidence of background investigation, analysis, research, enquiry, ethical awareness, and/or study.	Low evidence of background investigation, analysis, research, enquiry, ethical awareness, and/or study.	Limited background investigation, analysis, research, enquiry , ethical awareness, and/or study using established techniques, with the ability to extract relevant points.	Competent investigation, analysis, research, enquiry, ethical awareness, and/or study using established techniques accurately, and can critically appraise and use academic sources.	Good background investigation, analysis, research, enquiry, ethical awareness, and/or study using established techniques accurately, and possesses a well-developed ability to critically appraise a wide range of sources.	Very good, independent, extensive and appropriate investigation, analysis, research, enquiry, ethical awareness, and/or study beyond the usual range, and critically evaluates this to advance the work and/or direct arguments.	Excellent independent, extensive and appropriate investigation, analysis, research, enquiry, ethical awareness, and/or study well beyond the usual range, and critically evaluates this to advance the work and/or direct arguments.	Exceptional investigation, analysis, research, enquiry, ethical awareness, and/or study which demonstrates carefully considered depth and breadth and critically synthesises this to advance the work and/or direct arguments.
Originality in the application of knowledge	Little to no technical, creative or artistic skills related to their area of study.	Low technical, creative or artistic skills related to their area of study.	Limited technical, creative or artistic skills required for area of study.	Competent technical, creative or artistic skills required for area of study.	Good technical, creative or artistic skills required for area of study.	Very good range of technical, creative or artistic skills.	Excellent range of technical, creative or artistic skills	Exceptional range of technical, creative or artistic skills
Independently advance your own knowledge and understanding, and to develop new skills to a high level.	Little to no contribution to group activity and/or undertaking further training at a high/advanced level.	Low contribution to group activity and/or undertaking further training at a high/advanced level.	Limited contribution to group activity and/or undertaking further training at a high/advanced level.	Competent contribution to group activity and/or independently undertakes further training at a high/advanced level.	Good contribution to group activity and/or independently undertakes further training at a high/advanced level with an understanding of team roles	Very good contribution to group activity and/or independently undertakes further training at a high/advanced level with an understanding of team roles	Excellent contribution to group activity and/or independently undertakes further training at a high/advanced level with teamwork and leadership	Exceptional contribution to group activity and/or independently undertakes further training at a high/advanced level with teamwork and strong leadership.

GRADING DESCRIPTORS: LEVEL 7

REALISATION & COMMUNICATION								
	FAIL			**PASS**				
Threshold Criteria	**0-29%**	**30-39%**	**40-49%**	**50-59%**	**60-69%**	**70-79%**	**80-89%**	**90-100%**
Communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.	Little to no clarity in the communication of ideas, problems and solutions to audiences.	Low clarity in the communication of ideas, problems and solutions to audiences.	Limited clarity in the communication of ideas, problems and solutions to audiences.	Competent communication of ideas, problems and solutions to audiences.	Good, confident and clear communication of ideas, problems and solutions to audiences in a range of means / media.	Very good, confident and clear communication of ideas, problems and solutions to audiences in a range of means / media.	Excellent communication of ideas, problems and solutions to audiences in a range of means / media.	Exceptional communication of ideas, problems and solutions to audiences in a range of means / media.

GRADING DESCRIPTORS: LEVEL 7

PERSONAL & PROFESSIONAL CONNECTIVITY								
	FAIL			**PASS**				
Threshold Criteria	**0-29%**	**30-39%**	**40-49%**	**50-59%**	**60-69%**	**70-79%**	**80-89%**	**90-100%**
Independently advance your own knowledge and understanding, and develop new skills to a high level.	Little to no contribution to group activity and/or undertaking further training at a high/advanced level.	Low contribution to group activity and/or undertaking further training at a high/advanced level.	Limited contribution to group activity and/or undertaking further training at a high/advanced level.	Competent contribution to group activity and/or independently undertakes further training at a high/advanced level.	Good contribution to group activity and/or independently undertakes further training at a high/advanced level with an understanding of team roles	Very good contribution to group activity and/or independently undertakes further training at a high/advanced level with an understanding of team roles	Excellent contribution to group activity and/or independently undertakes further training at a high/advanced level with teamwork and leadership	Exceptional contribution to group activity and/or independently undertakes further training at a high/advanced level with teamwork and strong leadership.
Qualities and transferable skills necessary for employment requiring: (a) the exercise of initiative, ethical and personal responsibility (b) decision-making in complex and unpredictable contexts	Little to no ability to manage learning and/or exercise initiative, ethical and personal responsibility and/or decision-making in complex and unpredictable situations	Low ability to manage learning and/or exercise initiative, ethical and personal responsibility and/or decision-making in complex and unpredictable situations	Limited ability to manage learning and exercise initiative, ethical and personal responsibility, and decision-making in complex and unpredictable situations	Competent ability to manage learning, and exercise initiative, ethical and personal responsibility, and decision-making in complex and unpredictable situations	Good ability to systematically manage learning, and exercise initiative, ethical and personal responsibility, and decision-making in complex and unpredictable situations	Very good ability to systematically manage learning, and exercise initiative, ethical and personal responsibility, and decision-making in complex and unpredictable situations.	Excellent ability to manage learning on own initiative, and exercise initiative, ethical and personal responsibility, and decision-making in complex and unpredictable situations	Exceptional ability to manage learning on own initiative, and exercise initiative, ethical and personal responsibility, and decision-making in complex and unpredictable situations
	Little to no use of appropriate terminology, limited vocabulary and many errors in spelling, grammar and syntax.	Low use of appropriate terminology, with many errors in spelling, vocabulary and syntax.	Limited expression, style and appropriate vocabulary with errors in spelling, grammar and syntax which affect understanding.	Competent expression, style, and appropriate vocabulary with some errors in spelling, grammar and syntax which do not affect understanding.	Good expression, style and appropriate vocabulary with some errors in spelling, grammar and syntax.	Very good expression, style and appropriate vocabulary with minimal errors in spelling, grammar and syntax.	Excellent expression, style and appropriate vocabulary with minimal errors in spelling, grammar and syntax.	Exceptional expression, style and appropriate vocabulary with no errors in spelling, grammar and syntax.

GRADING DESCRIPTORS: LEVEL 7

	Little to no evidence of basic numeracy or digital literacy, hardware and software skills	Low evidence of basic numeracy or digital literacy, hardware and software skills competency.	Limited evidence of numeracy or digital literacy, hardware and software skills competency.	Adequate evidence of numeracy or digital literacy, hardware and software skills competency.	Good evidence of numeracy or digital literacy, hardware and software skills competency.	Very good evidence of numeracy or digital literacy, hardware and software skills	Excellent evidence of numeracy or digital literacy, hardware and software skills competency.	Exceptional evidence of numeracy or digital literacy, hardware and software skills competency.

	competency.					competency.		
	Does not demonstrate achievement of professional competence when assessed against the requirements of a professional, statutory or regulatory body (PSRB).			The student has demonstrated achievement of professional competence when assessed against the requirements of a PSRB.				
	Inaccurate use of terminology with limited vocabulary and many errors in spelling, grammar and syntax. Inaccurate terminology, with many errors in spelling, vocabulary and syntax.			The student has adhered to the appropriate rules and/or conventions set by regulators or the industry.				