3^{rd} Edition

Emirates Robotics Competition (Sustainability Theme)

February 12, 2025

1 Introduction

Robotics has been identified as one of the key technologies that will have a transformative impact in various new markets and on diverse human social aspects. Modern robotic systems are being deployed to tackle multiple application domains such as disaster response, hospitality, healthcare, domestic tasks, transportation, space exploration, manufacturing, and construction. However, there is still a gap between the current state of robotic capabilities and the requirements that must be met to enable practical and impactful robotic deployments in the envisioned applications.

As the world faces increasing environmental challenges, the need for innovative and sustainable solutions has never been more critical. This edition of the Emirates Robotics Competition will focus on Environmental Cleaning. It will serve as a platform for showcasing cutting-edge advancements in robotics and their potential to impact the environment positively. By focusing on environmental initiatives specifically tailored to the unique challenges faced by the UAE, this competition encourages teams to devise creative solutions that contribute to a cleaner and more sustainable future.

This competition brings together talented teams from across the UAE, united by a common goal: harnessing the power of robotics to address the pressing issue of environmental cleaning. Robotic technologies must be developed using a human-centric approach to allow these robots to operate autonomously in dynamic, unstructured environments while collaborating and interacting with other robots and humans. We aim to focus on some of these enabling technologies by providing a demanding set of benchmark robotics challenges. This robotics competition aims to inspire undergraduate students from local universities to work on tackling robotic challenges relevant to modern societal and industrial problems.

2 Objectives

The objectives of this competition are the following:

- Challenge undergraduate students from local universities with relevant robotic problems.
- Encourage more students to advance their practical knowledge in robotics, science, engineering and closely related disciplines.
- Improve students' practical and critical thinking skills by allowing them to apply the theories they learned in real-world challenges.
- Contributing to solving environmental issues by developing systems and solutions that could tackle challenges derived from real-world environmental problems.

3 Challenge 1: Recycling Robot

In a world grappling with the mounting challenges of waste management and environmental sustainability, developing a robot with a manipulator arm capable of sorting rubbish into recycling bins can be highly desirable. As our communities continue to generate an overwhelming volume of waste, finding efficient and effective ways to divert recyclable materials becomes imperative. A robot equipped with an intelligent and dexterous arm capable of swiftly identifying and sorting different types of waste presents a game-changing solution. By automating the sorting process, this robotic arm enhances the accuracy and speed of waste segregation and alleviates the burden on human resources. Recycling and sorting rubbish is dull, dirty, tiring, and repetitive. Many of such tasks primarily involve physical interaction with objects and the environment. Grasping and manipulation are critical functional capabilities that enable a robot to achieve a physical interactive task. Robotic systems utilize robotic arms to perform valuable tasks such as picking and placing, soft robotic gripping, packing, etc. These robots can be deployed to perform rubbish collection and sorting, which could revolutionize the handling and recycling of rubbish.

This challenge builds on the one presented in the previous ERC—2024 iteration. Instead of two tables, a shelf and a table are introduced to challenge the students to acquire more skills required to locate and pick objects from shelves.

3.1 Objectives

In this challenge, competitors will use a manipulator arm to autonomously pick and place static objects. This challenge aims to develop a pick-and-place manipulation robotic system capable of picking objects (simulating typical household rubbish) of different sizes, shapes, and weights from a shelf and sorting them into bins. The objects will be cluttered on the shelf but spaced out and not overlapping. The objects are classified as follows:

- Paper: cardboard boxes, cartons, boxes, etc.
- Glass: drink bottles, jars, etc.
- Plastic: plastic water bottles, toys, etc.
- Metal: cans, tools, etc.
- Soft: a deformable soft object such as a cloth, a soft toy, etc.

Note: no item will exceed 0.5 kg in weight.

3.2 Setup

3.2.1 Manipulator

A manipulator arm will be placed on a table facing a shelf. The manipulator's number of degrees of freedom is not restricted. Once the judge has indicated the start of the trial, the competing team has 10 minutes to complete the sorting task.

3.2.2 Table

On the table provided, there will be a selection of sorting bins. The robot must be situated between the table and the shelf. See Figure 1. Teams can bring their table/stand for their robot or the 60 cm high table provided by the organizers.

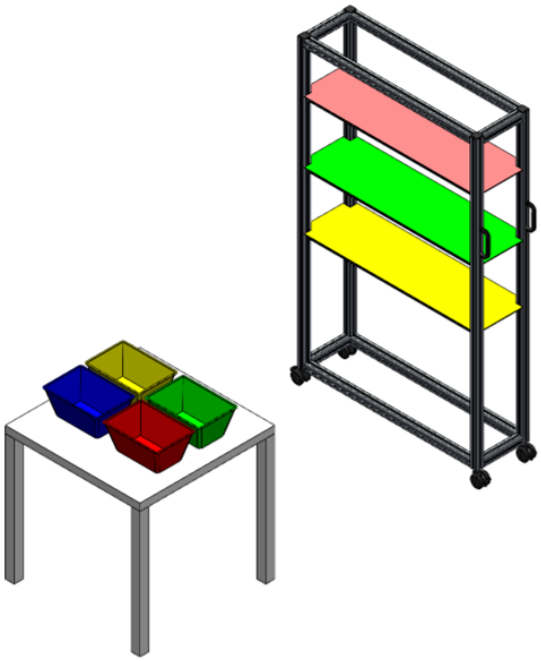


Figure 1: Shelf Placement in front of Table

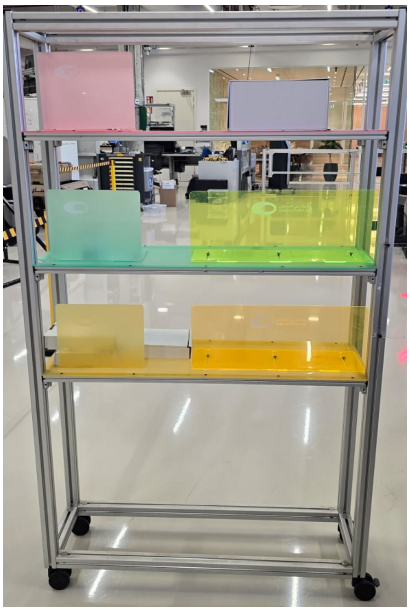


Figure 2: Actual Shelf

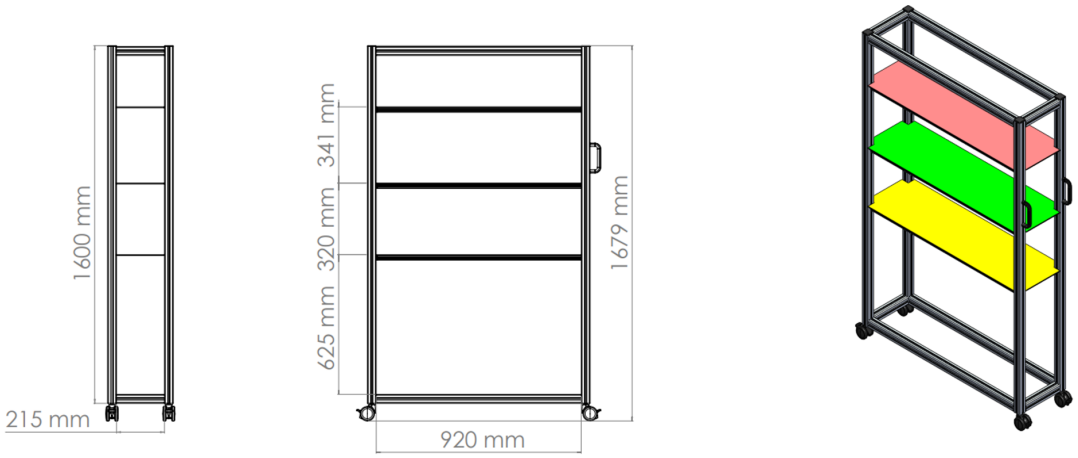
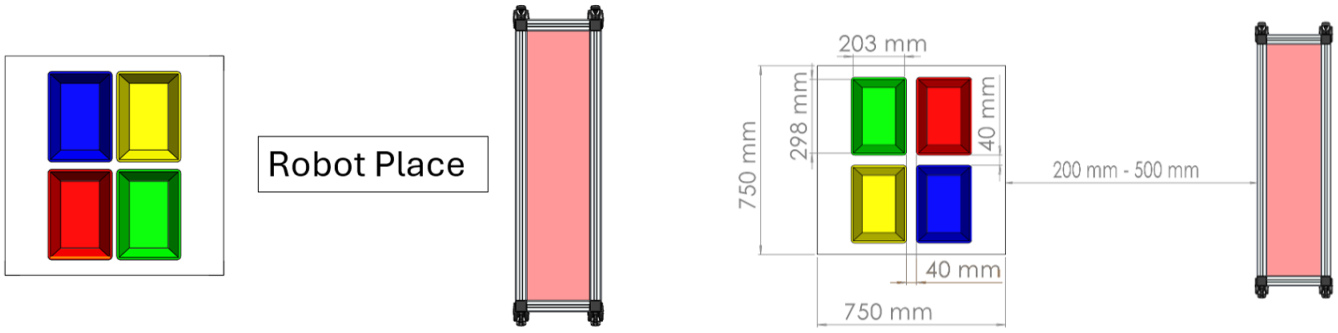


Figure 3: Shelf Dimensions



(a) Robot Placed between shelf and table

(b) Distance between shelf and table

Figure 4: Relative position of Robot from the self and the table.

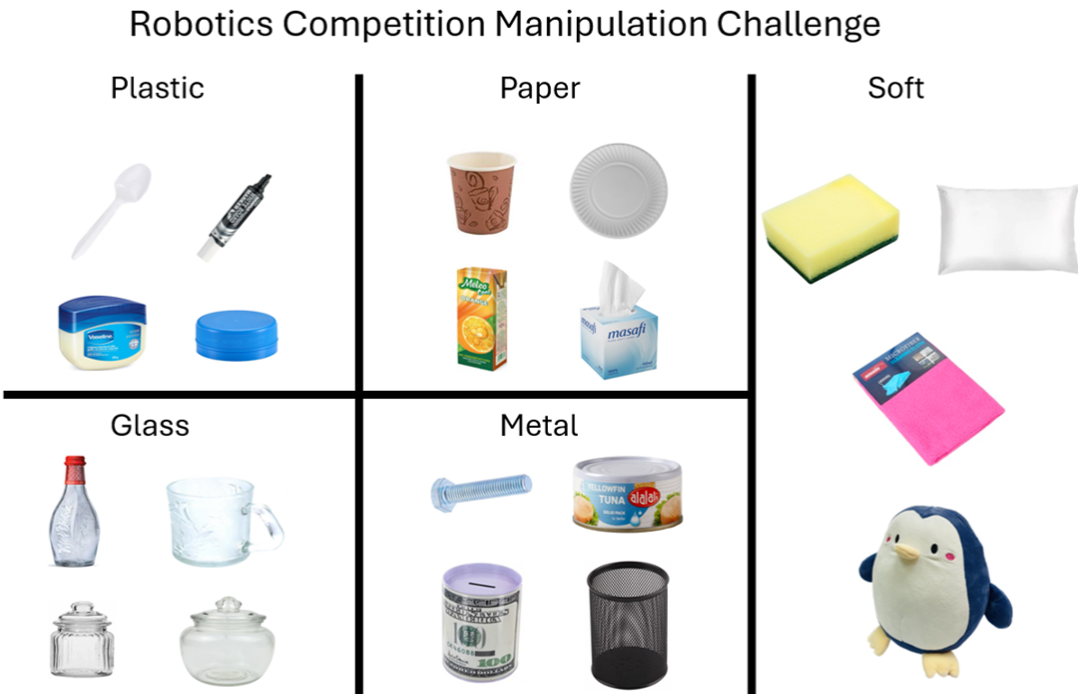


Figure 5: Sample objects for manipulation.

3.2.3 Shelf

A shelf will be provided on which the objects will be placed. The details about the shelf, its dimensions and placement can be shown in Figure 1, Figure 2, Figure 3, and Figure 4.

3.2.4 Bins

Four bins will be placed on the table. The bins will be placed in a location similar to the one shown in Figure 1. The order of the bins may change. The bins' information can be found here.

The bins are color-coded as follows:

- Yellow bin: For metal items.
- Blue bin: For paper and plastic items.
- Green bin: For glass items.
- Red bin: For soft items.

3.2.5 Objects

A list of objects on the shelf will be placed randomly (4 from each waste category). Sample objects can be seen in Figure 5. Please remember that this is a representative set, and the actual items might change during the competition.

3.2.6 Perception

The perception sensor(s) (e.g., cameras, lidars, etc.) used for object detection may be mounted on the robot or placed on the robot's table. No additional sensors or hardware can be placed outside the robot's table footprint.

3.2.7 Grasping

Any gripper (default grippers or custom-built grippers) and any gripping method (fingers, suction, etc.) may be used.

3.2.8 Manipulation

The manipulator has to successfully grasp objects using the gripper, lift the object and move it towards the designated bin without colliding with other objects, and finally drop it in the bin.

3.3 Trial Run Specifications

The following steps and instructions will be followed during each run (this could be updated closer to the competition date):

- Each team will be given 10 minutes to finish the challenge run.
- After the judge gives the starting signal, the team can press the start button or run the code.
- During the trial run, the team cannot manually or remotely interfere with any system components (e.g., P.C., gripper, manipulator, joystick, or software).
- If any interference in the robotic system is detected, the judge will be forced to cancel the run, and the team will lose any points accumulated during this run.
- During the challenge run, a team can request a reset. The reset allows the team to adjust their setup and ask the judge to start the run again. Each reset will be subject to a penalty as specified in the scoring Table 1, and the time will continue during a reset.
- During each run, the team will have to detect the objects on the shelf, select an item they would like to manipulate, pick it using their manipulator's arm, and place it inside the bin corresponding to the category of the object on the side of the table.

3.4 Scoring Criteria

The scoring criteria defined in Table 1 will be used during this challenge.

Behaviour	**Points**
Successfully grasping and picking up objects	+2
Successful placing/dropping objects in correct bin category	+2
Collision with table or shelf	-1
Collision with other objects	-0.5
Each challenge reset (max three resets allowed)	-1

Table 1: Challenge 1 Scoring Criteria

During the competition, competitors will participate in two rounds. The highest score obtained by each competitor from these two rounds will be considered for determining the final ranking. In case of tie scores between two or more competitors, the fastest time will be used as a tiebreaker.

4 Challenge 2: Rubbish Collecting Mobile Robot

In the rapidly evolving landscape of smart cities, the demand for efficient and sustainable solutions to urban challenges is becoming increasingly critical. One such challenge is waste management, particularly in public areas such as parks, streets, and beaches. Autonomous navigation robots offer a highly effective and innovative approach to tackling this issue. These robots are equipped with advanced sensors, artificial intelligence, and sophisticated navigation systems, allowing them to navigate various environments and identify, collect autonomously, and sort rubbish. Their deployment will reduce reliance on manual labour and ensure timely and precise waste collection, contributing to cleaner and healthier public spaces. Moreover, these robots can optimize waste sorting, facilitate recycling processes and promote sustainability, aligning with smart cities' environmental goals. Autonomous robots for waste management represent a leap toward efficient urban living, helping to keep cities cleaner, smarter, and more sustainable.

4.1 Objectives

The primary objective of the rubbish collection challenge is to promote and showcase advancements in robotic technologies and autonomous systems related to efficient and effective rubbish collection in real-world scenarios. The challenge aims to foster innovation and problem-solving skills among participants while addressing the pressing global issue of waste management and environmental sustainability. In this challenge, competitors are required to achieve the following objectives:

- Design and develop an autonomous mobile robot capable of navigating through a designated arena that simulates a real-world cleaning scenario, addressing the specific challenges of operating in an outdoor terrain.
- Collect rubbish items using a customized mechanism to gather and sort the items efficiently. These items are of different sizes, shapes, and materials and have three main colours: yellow, red, and blue.
- Dispose of the collected rubbish into three designated bins, each marked with a different colour—yellow, red, and blue. The disposal will be done in a controlled manner to prevent spillage or damage.
- Showcase innovative designs and algorithms for autonomous navigation and efficient rubbish collection, sorting, and disposal.

4.2 Setup

The challenge arena simulates an outdoor environment featuring various types of rubbish items in yellow, red, and blue, as well as obstacles, all enclosed by border barriers. The goal is to mimic a real-world cleanup scenario where the robot must efficiently collect rubbish in a confined space, as shown in Figure 6.

4.2.1 Challenge Environment

The arena constitutes a rectangular space measuring 8 meters by 8 meters, enclosed by border barriers constructed from durable materials like plastic, cardboard, or plywood, capable of withstanding the robot's movements. The arena's flooring is covered with a multitextured surface material that can include rubber, artificial grass, and foam.

4.2.2 Rubbish Items

Multiple coloured rubbish items will be strategically placed throughout the arena to simulate real-world scenarios and challenges. The rubbish items will vary in shape, size, material, and weight to test the capabilities of the participants' robots and rubbish collection mechanisms. Rubbish items will be included as listed below:

- Glass (yellow): drink bottles, jars, etc.

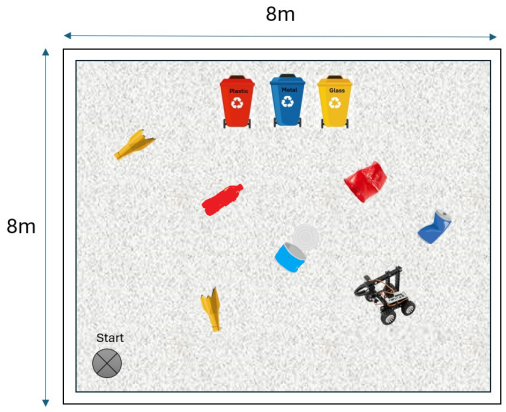


Figure 6: Challenge 2 Navigation Arena.

- Plastic (red): plastic water bottles, toys, etc.
- Metal (blue): cans, tools, etc.

To add variability and ensure fairness, the rubbish items will be placed in different locations within the arena, including areas near the border. The placement of the other items will be randomized for each round of the competition to ensure unpredictability and prevent reliance on memorization.

4.2.3 Obstacles

In the autonomous navigation arena, which simulates an outdoor environment, participants can expect to encounter various challenging obstacles that mimic real-world scenarios. Participants must demonstrate their robot's ability to navigate safely and efficiently through this diverse and dynamic beach environment.

4.2.4 Rubbish Disposal Bins

The robot should deposit the collected rubbish items at designated areas within the arena. Three open rubbish bins, each with a height of 43.5 cm, will be placed next to each other, as illustrated in 6. Visible signage that marks the rubbish bins in three different colours helps the robot identify and accurately deposit the rubbish, as shown in Figure 7.

4.3 Trial Run Specifications

The following steps and instructions will be followed during each run (this could be updated closer to the competition date):

- Each team will have a 10-minute time limit to complete their challenge run.
- The robot should be positioned within the designated start zone defined in the navigation arena.
- Once the judge initiates the start signal, the team can activate their robot by pressing the start button or running the preloaded code.

Figure 7: Disposal Rubbish Bins.

- During the trial run, no manual or remote interference with any system components (e.g. PC, controller, joystick, or software) is allowed.
- Any detected interference will lead to the immediate cancellation of the run, resulting in the forfeiture of any accumulated points during that attempt.
- Teams participating in the challenge run can request a reset.
- This reset permits teams to adjust their setup and request the judge to restart the run. However, each reset will incur a penalty, as outlined in the scoring Table 2, and the timer will continue to run during the reset period.
- Each team can request a maximum of three resets; exceeding this limit will eliminate the team from the challenge run.
- In each run, the team's task is to identify the rubbish items within the arena, choose an item for collection, employ the robot's grasping mechanism to retrieve it, and then deposit it into one of the bins positioned in the arena's corners.
- To avoid incurring penalties, the robot should avoid collisions with both obstacles and the arena's border, as specified in Table 2.

4.4 Scoring Criteria

The scoring criteria defined in Table 2 will be used during this challenge.

Behaviour	**Points**
Successfully picking up objects	+2

Successful placing/dropping objects in the correct coloured disposal bin	+3
Successful placing/dropping objects in the incorrect coloured disposal bin	+1
Collision with border or obstacles	-1
Challenge reset (max three resets allowed)	-1

Table 2: Challenge 2 Scoring Criteria

Note: Negative scores will be adjusted to 0. Teams with a score of 0 will not be eligible to win.

During the competition, competitors will participate in two runs. The highest score obtained by each competitor from these two runs will be considered for determining the final ranking. In case of tie scores between two or more competitors, the fastest time will be used as a tiebreaker in case of task completion or the highest number of collected items if the task is incomplete.

5 Challenge 3: Water Cleaning Surface Robot

In an era where the health of our planet's water bodies is increasingly threatened, developing advanced robotics capable of swimming and cleaning the water surface has become an urgent necessity. Water pollution, caused by the accumulation of debris, plastic waste, and other pollutants, poses significant risks to aquatic ecosystems, wildlife, and human health. As we stand at the forefront of innovation, we must harness the potential of robotics to combat this pressing issue. A robot capable of navigating water surfaces with agility and efficiency, equipped to detect and collect rubbish, holds immense promise in mitigating the harmful consequences of water pollution. Such a robotic solution offers a practical and scalable approach to cleaning vast water surfaces. It will contribute to preserving the delicate balance of aquatic ecosystems and securing a sustainable future for future generations.

5.1 Objectives

The primary objective of the competition is to design and develop an autonomous Unmanned Surface Vehicle (USV) capable of efficiently collecting rubbish floating on the surface of an indoor pool. The competition aims to foster innovation and advancements in autonomous navigation, rubbish detection, and collection technologies. The specific objectives are as follows:

- Autonomous Navigation: USVs should navigate the pool autonomously, avoiding obstacles and efficiently reaching rubbish collection points.
- Rubbish Detection: USVs should be equipped with sensors and algorithms to detect and identify rubbish objects accurately.
- Rubbish Collection: USVs should be capable of collecting rubbish objects effectively, using appropriate mechanisms or tools.
- Efficiency: The competition evaluates the speed and efficiency of the USVs in completing the assigned tasks.

5.2 Setup

The competition will occur in a controlled indoor pool with a designated area. The pool dimensions and layout are shown in Figure 8, but a smaller pool section will be used to develop the challenge layout. The setup includes the following components:

- Pool Area: A section of the indoor pool is cordoned off for the competition, ensuring sufficient space for the USVs to navigate and collect rubbish. The dimensions of the pool are (12.5m x 12.5m x 2.1 m)
- Trash Objects: Plastic balls with a 6.5 cm diameter in various colours will symbolize different trash objects. Each colour will carry its unique score when collected, as detailed in the Scoring Criteria section.
- Ball placement: The balls will be randomly scattered on the water surface.
- Collection Site: two corners will be designated as the collection site. Plastic balls must be dropped into the net to gain points.
- Starting and Endpoint: Designated starting and endpoint locations are marked for each USV to begin and finish the assigned task.
- Obstacles: the walls of the pool are considered obstacles, and colliding with them will incur penalties.

Figure 8: AUS's Indoor Pool

5.3 USV Specifications

The USVs participating in the competition should adhere to the following specifications,

- **Weight**: The weight of the USV should not exceed *10 kg*.
- Size: The maximum allowable dimensions should not exceed *80cm x80cm x40cm*. If a manipulator arm is installed on the USV, it will not be included in the robot's overall dimensions.
- **Kill Switch**: The USV must have a remote kill switch that, when actuated, must disconnect power from motors.
- **Autonomous Capability**: The USV must be capable of autonomous navigation, trash detection, and trash collection. It should operate without any remote control or human intervention during the competition.
- **Power Source**: The USV should have a self-contained power source
- **Safety**: The USV should not have any possible loose part that may fall in the water, which may damage the pool filtration system.

5.4 Trial Run Specifications

The following steps and instructions will be followed during each run (this could be updated closer to the competition date):

- Each team will have a 10-minute time limit to complete their challenge run.
- The robot should be positioned within the designated start zone defined in the pool with the assistance of assigned staff.

- Once the judge initiates the start signal, the team can activate their USV by pressing the start button or running the preloaded code.
- It's important to note that during the trial run, no manual or remote interference with any system components (e.g. PC, controller, joystick, or software) is allowed.
- Any detected interference will lead to the immediate cancellation of the run, resulting in losing any accumulated points during that attempt.
- Teams participating in the challenge run can request a reset.
- This reset permits teams to adjust their setup and request the judge to restart the run. However, each reset will incur a penalty, as outlined in the scoring Table 3, and the timer will continue to run during the reset period.
- Each team can request a maximum of three resets; exceeding this limit will eliminate the team from the challenge run.
- Organizers will retrieve the contestant's USV if it cannot return to the start area.
- In each run, the team's task is to identify the rubbish items within the arena, choose an item for collection, employ the robot's grasping mechanism to retrieve it, and then deposit it into one of the collection nets positioned in the arena's corners.
- To avoid incurring penalties, the robot should avoid collisions with pool walls, as specified in Table 3.

5.5 Scoring Criteria

The scoring criteria defined in Table 3 will be used during this challenge.

Behaviour	**Points**
Ball collection	+1 point/each
Green ball disposal	+3 points
Yellow ball disposal	+2 points
Blue ball disposal	+1 point
Red ball disposal	-1 point
Collision with pool walls	-0.5 points
Collision with obstacle	-0.5 points

Table 3: Challenge 3 Scoring Criteria

During the competition, competitors will participate in two rounds. The highest score obtained by each competitor from these two rounds will be considered for determining the final ranking. In case of tie scores between two or more competitors, the fastest time will be used as a tiebreaker.

6 Application Process

Teams interested in participating in this competition should follow the requirements below.

Requirements

- Registering teams must consist of 3-6 members.
- At least half the team members should be from a local UAE-based university.
- Members must be enrolled in a bachelor's degree at the university.
- Teams must be supervised by a faculty member from the same university.

Application Form Information

- Proposed team name
- The faculty member supervising the team
- University affiliation(s)
- List any previous experience with building robotic systems
- List any previous experience in participating in competitions
- List of robotic systems the team intends to use, or if the team will build their own

7 Prizes

The total prize money for the challenges will be AED 90K, distributed as shown in Table 4. Please note that all prizes are in AED currency.

Challenge	**1st Place**	**2nd Place**	**3rd Place**
Recycling Manipulator Robot	15K	10K	5K
Rubbish Collecting Mobile Robot	15K	10K	5K
Water Cleaning Swimming Robot	15K	10K	5K

Table 4: Prize money distribution

This competition encourages collaboration and open innovation. As such, a condition for accepting the prize money is that winning teams should open-source and document their code and designs on an online platform (e.g., GitHub, GitLab, etc.) and provide access to anyone who wants to replicate these systems and build on them.

8 Timeline

Milestone	Date
Announcement	11/11/2024
Registration deadline	22/11/2024
Selected Teams Announcement	02/12/2024
Progress update 1	31/01/2025
Progress update 2	28/02/2025
Final Short-listed teams	07/03/2025
Trials 1	15/03/2025
Trials 2	22/03/2025
Competition Date	04/04/2025

9 Organizing Entities

This year's competition will be hosted by the American University of Sharjah (AUS) and co-organized with:

- Dubai Future Labs (DFL)
- Khalifa University (KU)
- Rochester Institute of Technology (RIT)

The prize money will be sponsored by Dubai Future Labs (DFL).

9.1 Emirates Robotics Competition Committee

- Dr. Jinane Mounsef, RIT
- Dr. Tarek Taha, DFL
- Dr. Ahmed Al Attar, DFL
- Dr. Hamad Karki, KU
- Dr. Mohammad Jaradat, AUS

9.2 AUS Local Organizing Committee

- Dr. Mohammad Jaradat
- Dr. Bara Emran
- Dr. Noha M Hassan
- Eng. Ahmed Elsergany
- Eng. Wasil El Tahir
- Ms. Dana Abdul Khalek

10 Document History

Version	Date	Authors	Comments
1.0	30/10/2024	Organizing Committee	Initial draft of the competition
2.0	06/11/2024	Organizing Committee	Updated the competition document
3.0	26/12/2024	Organizing Committee	Updated Challenge 1 shelf and table details