2^{nd} Edition

Emirates Robotics Competition (Sustainability Theme)

August 21, 2023

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 and will serve as a platform for showcasing cutting-edge advancements in robotics and their potential to make a positive impact on the environment. 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 region, 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 garbage 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 pick and place, soft robotic gripping, packing, etc. These robots can be deployed to perform garbage collection and sorting, which will revolutionize the handling and recycling of garbage.

3.1 Objectives

In this challenge, competitors will use a manipulator arm to perform the pick-and-place of static objects autonomously. 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 table and sorting them into bins. The objects will be cluttered 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.

No item will exceed 0.5 kg in weight.

3.2 Setup

3.2.1 Manipulator

A manipulator arm will be placed between two tables. There is no constraint on the number of degrees of freedom of the manipulator. 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

Two tables will be provided for this challenge. One table will be to place the objects on top, and one for the sorting bins. The robot must be situated between the two tables. See Figure 1. Teams can bring their table/stand for their robot or use the generic table provided by the organizers.

The table dimensions can be found here.

3.2.3 Bins

Four bins will be placed on the second table. The bins will be placed as shown in Figure 2. The order of the bins may change. The bins' information can be found here.

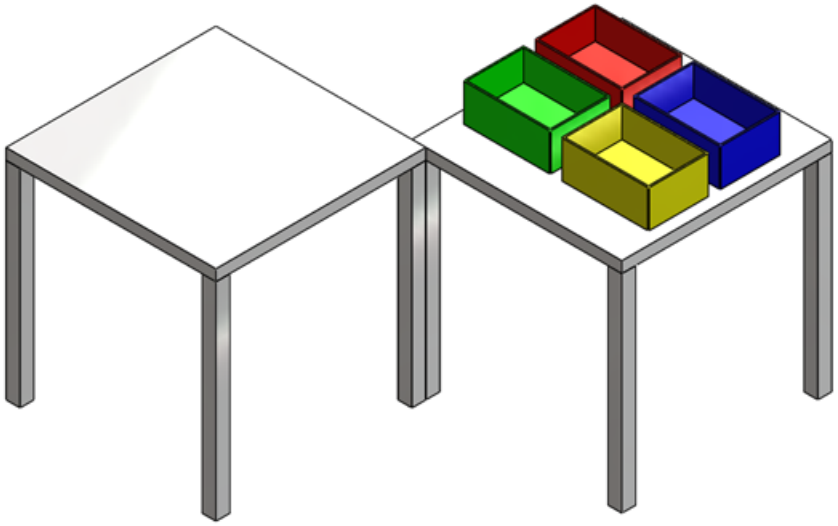

Figure 1: Side view of tables arrangement.

3.3 Objects

On top of the object's table will be a selection of 16 items (4 from each waste category). Sample objects can be seen in Figure XXX.

3.4 Perception

The perceptive sensor(s) 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.

3.5 Grasping

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

3.6 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.

3.7 Specifications

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 run, the team cannot manually or remotely interfere with any

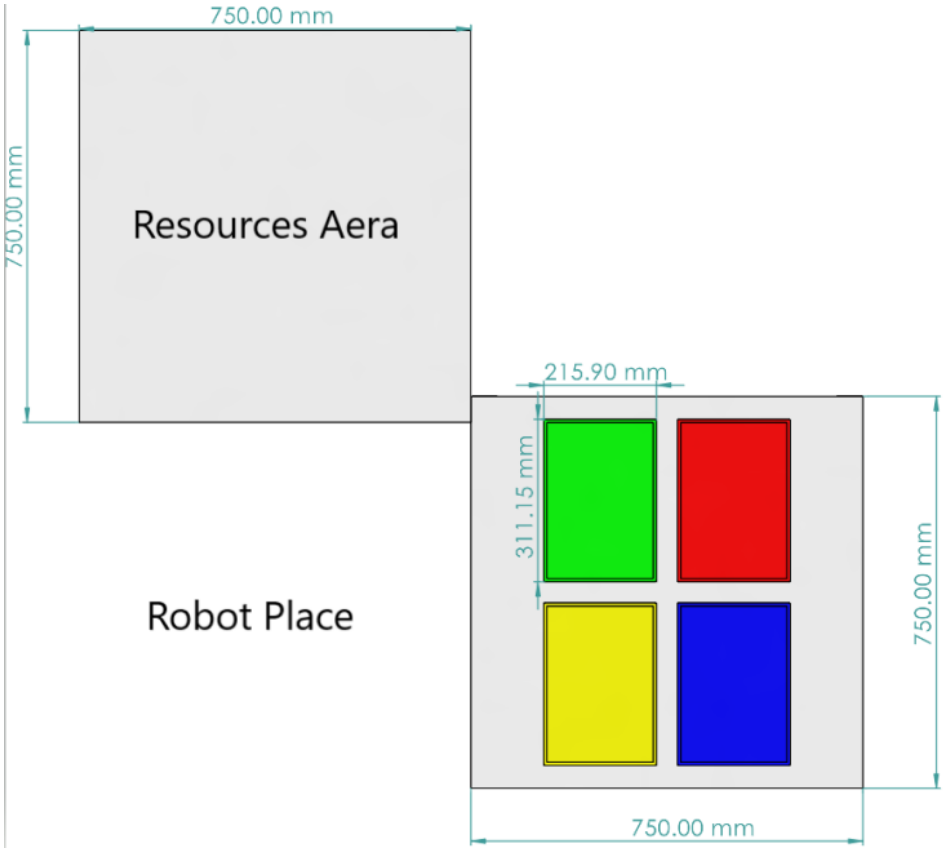

Figure 2: Tables top view.

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 loses any points accumulated during this run.

At any time 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 4.4, and the time will continue during a reset.

During each run, the team will have to detect the objects on the table, 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.

3.8 Scoring

Behavior	**Points**
Successfully grasping and picking up objects	+1
Successful placing/dropping objects in correct bin category	+1
Damaging object (e.g., crushing the bag of chips)	-1
Collision with table	-1
Collision with other objects	-0.5
Challenge reset (max three resets allowed)	-1

4 Challenge 2: Garbage Collecting Mobile Robot

In our ever-expanding urban landscapes, the challenge of efficient waste management looms larger than ever. To tackle this pressing issue, developing a mobile robot capable of autonomous navigation and garbage collection has emerged as a crucial innovation. With urban areas experiencing exponential population growth and an ever-increasing volume of waste generation, traditional waste collection methods are often insufficient and inefficient. However, a mobile robot with autonomous driving capabilities presents a groundbreaking solution. These autonomous robots can collect and transport garbage by seamlessly maneuvering, alleviating human resource burdens and streamlining waste management processes. Beyond its practical benefits, implementing such a mobile robot demonstrates our commitment to embracing cutting-edge technology for sustainable urban development. By leveraging automation, artificial intelligence, and robotics, we can revolutionize waste collection practices and move closer to creating clean, livable cities that prioritize environmental preservation and enhance the quality of life.

4.1 Objectives

The primary objective of the garbage collection competition is to promote and showcase advancements in robotic technologies and autonomous systems related to efficient and effective garbage collection in real-world scenarios. The competition 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 scenario for garbage collection.
- collect multiple garbage items of different sizes, shapes and materials using a customized mechanism.
- dispose the collected garbage items in specific disposing points.
- showcase innovative designs and algorithms for autonomous navigation and efficient garbage collection.

4.2 Setup

The competition arena is divided into different zones, each containing various types of garbage. It consists of interconnected spaces arranged in a structured pattern to create a challenging environment for the robot to navigate. The goal is to simulate real-world scenarios where the robot can efficiently collect garbage items in complex and confined spaces.

4.2.1 Structure

The arena is constructed using walls or partitions, creating different zones. The walls can be made from materials such as plastic, cardboard, or plywood, and they should be sturdy enough to withstand the robot's movement.

4.2.2 Dimensions

To ensure uniformity and fairness, the arena will have a defined floor plan with specified dimensions, including length, width, and height. The dimensions will be communicated to the participants well in advance to allow for accurate design and planning of their robots.

4.2.3 Garbage Items

Multiple garbage items will be strategically placed throughout the arena to simulate real-world scenarios and challenges. The garbage items will vary in shape, size, material, and weight to test the capabilities of the participants' robots and garbage collection mechanisms. Garbage may include:

- Paper: cardboard boxes, cartons, boxes, etc.
- Glass: drink bottles, jars, etc.
- Plastic: plastic water bottles, toys, etc.
- Metal: cans, tools, etc.

4.2.4 Placement of Garbage Items

To add complexity and variability, the garbage items will be placed in different locations within the arena, including open areas, corners, near walls, or at intersections. The placement of garbage items will be randomized for each round of the competition to ensure unpredictability and prevent reliance on memorization.

4.2.5 Visibility of Garbage Items

The garbage items will be visible to the participants' robots and the competition officials to facilitate identification and collection. The items will be positioned in a way that allows the robots to approach and collect them without causing damage to the walls or other objects.

4.3 Specifications

In this challenge, the design and functionality of the garbage-collecting mobile robot play a crucial role. The robot's ability to efficiently detect, collect, and dispose of garbage items within the arena is essential for a successful performance. The following requirements guide participants in designing their garbage collector robots to ensure fair competition and encourage innovation. These requirements aim to promote autonomous navigation, effective garbage detection, secure collection mechanisms, and reliable disposal methods. By meeting these requirements, participants can showcase their creativity, problem-solving skills, and technical expertise in developing the robot.

4.3.1 Design a Suitable Garbage Collection Mechanism

Develop a mechanism that can effectively pick up and securely hold different types and sizes of garbage items. Consider using a robotic arm, gripper, or suction mechanism, depending on the nature of the garbage items. Ensure the mechanism is robust, reliable, and capable of handling various materials commonly found in garbage.

4.3.2 Incorporate a Garbage Storage System

Design a storage system within the robot to securely hold the collected garbage items until they can be deposited. The storage system should prevent the garbage from falling out during robot movement or when encountering obstacles.

4.3.3 Implement Efficient Routing and Planning

Incorporate path planning algorithms to optimize the robot's navigation within the arena for efficient garbage collection. Consider algorithms that can determine the most optimal paths to minimize travel distance and time.

4.3.4 Identify Disposal Points

The robot should deposit the collected garbage items at designated areas within the arena. Visible markers or indicators will be placed at the disposal points to help the robot identify and accurately deposit the garbage.

4.3.5 Implement a Reliable Disposal Mechanism

Develop a mechanism to dispense garbage from the storage system into the designated disposal points. Ensure the mechanism can release the garbage items in a controlled manner to avoid spillage or damage.

4.4 Scoring

Behavior	**Points**
Successfully picking up objects	+1
Successful placing/dropping objects in disposal point	+1
Damaging object (e.g., crushing the bag of chips)	-1
Collision with wall	-1
Collision with other objects	-0.5
Challenge reset (max three resets allowed)	-1

Competitors will participate in two rounds during the competition. The highest score obtained by each competitor from these two rounds will be taken into consideration for determining the final ranking. In case of tie scores between two or more competitors, the resolution will be based on the fastest time achieved by the robots during their rounds.

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 trash, 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 bodies and serves as a beacon of hope in our collective efforts to preserve the delicate balance of aquatic ecosystems and secure a sustainable future for generations to come.

5.1 Objectives

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

- Autonomous Navigation: USVs should navigate the pool autonomously, avoiding obstacles and efficiently reaching trash collection points.
- Trash Detection: USVs should be equipped with sensors and algorithms to accurately detect and identify trash objects.
- Trash Collection: USVs should be capable of collecting trash 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 takes place in a controlled indoor pool environment with a designated area. The pool dimensions, layout, and obstacles should be specified before the competition. 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 trash. The dimension of the pool is (12m x 8m x2.1 m)
- Trash Objects: Artificial trash objects, such as floating plastic bottles or other debris, are distributed within the pool area in a predetermined pattern.
- Obstacles: Various obstacles, such as floating buoys or simulated floating platforms, may be placed in the pool area to test the USV's obstacle avoidance capabilities.
- Starting and Endpoint: Designated starting and endpoint locations are marked for each USV to begin and finish the assigned task.

5.3 Specifications

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

- Size and Weight: The USV should meet specific size and weight limitations defined by the competition organizers.

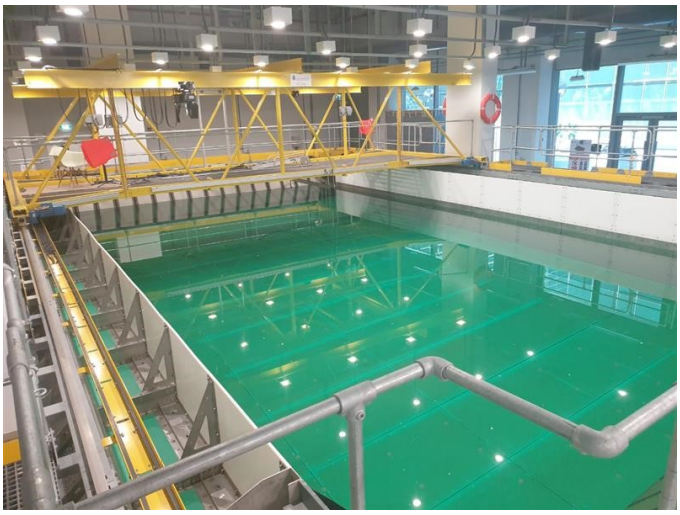

Figure 3: Khalifa University Indoor Research Pool

- 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.
- Sensor Suite: The USV should be equipped with appropriate sensors, such as cameras, lidar, or sonar, to detect and identify trash objects and obstacles accurately.
- Propulsion System: The USV should have a reliable propulsion system capable of maneuvering efficiently through the water.
- Power Source: The USV should have a self-contained power source or be tethered to an external power supply, ensuring uninterrupted operation throughout the competition.
- Communication: The USV may have communication capabilities to transmit data or receive instructions, although it should not rely on external communication during the competition.

5.4 Scoring Criteria

The performance of the USVs will be evaluated based on the following scoring criteria:

- Trash Detection and Collection: The USV's ability to detect and collect trash objects accurately and efficiently will be assessed. Points may be awarded based on the number of trash objects successfully collected and the time taken to complete the task.
- Autonomous Navigation: The USV's navigation skills, including obstacle avoidance and path planning, will be evaluated. Efficient navigation, minimal collisions with obstacles, and adherence to predefined paths will earn higher scores.
- Efficiency and Speed: The time taken by the USV to complete the task will be a crucial factor in scoring. Faster completion with successful trash collection will result in higher scores.
- Technical Innovation: Additional points may be awarded for innovative designs, novel trash detection and collection approaches, or advancements in autonomous capabilities.

- Reliability and Robustness: The USV's reliability and robustness, including its ability to handle unexpected situations or failures, will be considered during scoring.
- Presentation and Documentation: Participants may be required to provide technical documentation, including system design, algorithms, and approaches used. A presentation or demonstration of the USV's capabilities may contribute to the overall score.

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

- Team members with their field of study and their CVs
- 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 3. Please note that all prizes are in AED currency.

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

Table 3: Prize money distribution

Winners will also be provided scholarships from RIT for master's degrees. 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 to replicate these systems and build on them.

8 Organizing Entities

The competition is organized and sponsored by:

- Khalifa University (KU)
- Rochester Institute of Technology (RIT)
- Dubai Future Labs (DFL)
- Robotics and Automation Society (RAS)

9 Sponsorship

There are four sponsorship tiers for this event:

	Bronze	**Silver**	**Gold**	**Platinum**
Logo on registration page	Yes	Yes	Yes	Yes
Logo on banners	Yes	Yes	Yes	Yes
Logo on any giveaways	Yes	Yes	Yes	Yes
Logo on social media assets	No	No	Yes	Yes
Access to winning teams' CVs	No	Yes	Yes	Yes
Booth space	No	No	Yes	Yes
Amount (AED)	10K	25K	50K	100K