تحدي محمد بن زايد العالمي للروبوت
Mohamed Bin Zayed International Robotic Challenge
Innovative Minds. Challenging Robotics. عقول تبتكر. روبوتات تتحدى.

Organized by

جامعة خليفة
KHALIFA UNIVERSITY

MBZIRC 2019

Challenge Description

01

Introduction

The Mohamed Bin Zayed International Robotics Challenge (MBZIRC) is a biennial international robotics competition. MBZIRC provides an ambitious and technologically demanding set of challenges, and is open to all teams from all countries. MBZIRC aims to inspire future robotics through innovative solutions and technological excellence.

Robotics is poised to have a transformative impact in a variety of new markets and on various human social aspects. These include robot applications in disaster response, healthcare, domestic tasks, transport, space, manufacturing, and construction. However, there is a gap between current reality in robotic capabilities and the requirements of potential applications. Enabling technologies for such applications include robots working more autonomously in dynamic, unstructured environments, while collaborating and interacting with other robots. MBZIRC aims to focus on some of these applications and enabling technologies, by providing a demanding set of robotics challenges to attract the best international teams to showcase and benchmark their solutions. Similar to other major competitions, MBZIRC aims to provide an environment that fosters innovation and technical excellence, while encouraging spectacular performance with robotics technology.

More information about MBZIRC can be found at the website: http://www.mbzirc.com

The inaugural MBZIRC took place at the YAS Marina Circuit in Abu Dhabi, UAE, in March 2017, with 27 international teams consisting of 275 team members competing over 3 days. The next edition of MBZIRC is provisionally scheduled for Fall 2019 (the exact dates to be confirmed).

This document describes the main Challenges of MBZIRC 2019, and the Call to Participate. The document also includes important dates, deadlines, and the application process for the Call to Participate.

It is noted that the MBZIRC Organizers reserve the right to continue to fine tune the MBZIRC 2019 Challenge Description and Rules leading up to the competition in Fall 2019, based on feedback from the robotics community, participants, and the MBZIRC International Technical Advisory Committee.

02

Competition Overview

MBZIRC 2019 will be based on autonomous aerial and ground robots, carrying out navigation and manipulation tasks, in unstructured, outdoor and indoor environments.

MBZIRC 2019 will consist of three challenges and a triathlon type Grand Challenge

In Challenge 1 a team of UAVs will autonomously track and interact with a set of objects (for example intruder UAVs) following 3D trajectories inside the arena. Challenge 1 is motivated by UAV safety, where the team UAVs will attempt to capture and neutralize intruder UAVs inside the arena.

In Challenge 2 a team of UAVs and a UGV will collaborate to autonomously locate, pick, transport and assemble different types of brick shaped objects to build pre-defined structures, in an outdoor environment. Challenge 2 is motivated by construction automation and autonomous robot based 3D printing of large structures.

In Challenge 3 a team of UAVs and a UGV will collaborate to autonomously extinguish a series of simulated fires in an urban high rise building firefighting scenario. Challenge 3 is motivated by the use of robots for urban firefighting, and requires the team of robots to collaborate to autonomously carry out a series of urban firefighting related tasks in an outdoor-indoor environment.

The **Grand Challenge** requires a team of robots (UAVs and UGVs) to compete in a triathlon type event that combines Challenges 1, 2 and 3.

The MBZIRC 2019 challenges are motivated by pushing technological and application boundaries in robotics. The technological challenges addressed in the MBZIRC 2019 Challenges include, fast autonomous navigation in semi-unstructured, complex, dynamic environments, with reduced visibility (e.g. smoke) and minimal prior knowledge, robust perception and tracking dynamic objects in 3D, sensing and avoiding obstacles, GPS denied navigation in indoor-outdoor environments, physical interactions, complex mobile manipulations, and air-surface collaboration.

An animated video of the MBZIRC Challenges can be found at:
www.mbzirc.com/challenge/2019/video

Competitors may participate in one or more of these challenges. Competing teams will use un-tethered robots. Teams can attempt any of the challenges either autonomously or with human supervision. Teams performing the tasks fully autonomously will achieve the maximum scores; teams performing the tasks with human supervision can only achieve a partial score. Once a team elects human supervision, that attempt will then be considered supervised, even if the task is later completed in autonomous mode. More details about the scoring scheme will be provided in due course.

The communication between the robots and the human supervisors will use a fixed and standard communication frequency band. More details about the communication protocols, networks and frequencies will be provided in due course.

For safety reasons the speed of the UAV is restricted to a maximum of 30 km/hour and the speed of the UGV is restricted to a maximum of 15 km/hour. The size of the UAVs is restricted to a maximum volume of 1.2m x 1.2m x 0.5m. The size of the UGVs is restricted to a maximum volume of 1.7mx1.5mx2m.

For safety reasons the operation mode of all the team UAVs must be able to be switched from autonomous to manual at any time. More details about the safety protocols that must be followed by all participating teams will be provided in due course.

All four challenges will be performed in outdoor open arenas. The Challenge 1 arena will be approximately the size of a football pitch. The Challenge 2 and 3 arenas will each be approximately the size of half a football pitch. The terrain inside the arena will be relatively smooth and level. The arenas will contain various obstacles. The arena for Challenge 3 will also contain an indoor structure. The arenas will have GPS access, except within the indoor structures (for Challenges 2 and 3). Teams may use RTK/DGPS in any of the arenas; however, teams not using RTK/DGPS will be awarded higher scores. The exact nature of the arenas, obstacles and the indoor structure will be specified in due time.

The MBZIRC 2019 Challenges are designed to explore robot autonomy in unstructured environments with minimal prior knowledge. While we will provide more detailed specifications for some of the challenge parameters in due time, some challenge parameters may remain underspecified, to test the ability to complete the challenges autonomously with minimal prior knowledge. It is noted that these are stretch challenges designed to push boundaries, and that teams can score marks with partial completion of the challenges, since there are multiple tasks within each challenge.

Initial start location for competing robots, of approximately 10mx10m, will be located inside the arena.

All teams will have a designated area (a team 'tent'), located away from the arenas, for preparation purposes.

03

Challenges

3.1 - Challenge 1 – Team of UAVs to Capture Flying Objects

Challenge 1 requires a team of up to 3 UAVs to autonomously locate, track and interact with a set of objects moving in space.

Arena

The Challenge 1 arena will be of approximate size 100m x 60m. It will have a set of randomly placed obstacles; the obstacles will be of sufficient height to obstruct UAV flight. The location and specifications of the obstacles will be provided in due time.

The Challenge 1 arena will also contain a set of target moving objects. The targets will consist of:

(a) A UAV with a detachable target, following a 3D trajectory.

The approximate shape of the trajectory will be specified (e.g. an oval or a figure of 8 shape, for the projection on the ground plane), but its location and orientation will be randomized. The speed of the UAV will be held approximately constant, and will not exceed 10 m/sec. The UAV will have a soft target attached to it by a flexible rope. The target will be of spherical shape of approximate radius less than 250mm, an approximate weight less than 100g. The target will disengage from the UAV when a pre-specified force (e.g. more than 200g) is applied to it. The specifications of the soft target (including material and color), the flexible rope and the UAV will be provided in due time.

(b) Many balloons, tethered to bases, and randomly placed inside the arena.

The balloons will be attached to ropes of varying lengths. They will be randomly distributed inside the arena, and will move with the wind. The colors, radii and other specifications of the balloons will be provided in due time.

A list of Challenge 1 parameters and their specifications are given in Table 1.

Challenge Duration

The Challenge 1 duration is a maximum of 20 minutes.

Task Specification

- Start Condition - The team will position the UAVs in stationary mode on the ground at the start location.
  The UAV with the attached target will start moving starting from a random location inside the arena. The second set of targets, the balloons, will also be randomly placed.
  The judges will then indicate the start of the challenge.
- The team UAVs will take off autonomously (the UAVs can be started with a push of a button or a flick of a switch) and will maneuver through obstacles, sensing and avoiding collisions, to track, reach and interact with objects moving in 3D.
- UAVs will interact with objects moving in space.
  The type of interactions with the target will be
  (a) Physical contact
  (b) Removal of target from tether
  (c) Capture of target
  (d) Capture and safe delivery of target to a pre-specified landing location.

  The landing location will be a square of dimensions 10mx10m, and will be located inside the arena.

Scoring

The Challenge 1 score will be based on the tasks completed, and the speed of completion. More details about the scoring scheme, including the scores awarded for each type of interactions above, will be specified in the MBZIRC 'Scoring Scheme' Document, in due time.

Table 1 – List of Challenge 1 Parameters

Parameter	Specification
Arena size	100mx60m
Number of UAVs per team	Maximum of 3
Speed of UAV with attached moving target	Less than 10m/sec
Moving target trajectory profile	Randomly selected from a pre-determined set (e.g. figures of 8). More details to follow.
Type of target attached to UAV	Soft sphere
Size of target attached to UAV	Less than 250mm in diameter
Weight of target attached to UAV	Less than 100g
Attachment mechanism of target attached to UAV	Flexible rope
Detachment force required for target attached to UAV	Less than 200g
Challenge duration	20 minutes
Landing area size	10mx10m
Environment	Outdoor
Mode of operation	Autonomous; manual allowed but penalized
RTK/DGPS	Allowed but penalized
Communications	To be determined (TBD)
Number of balloons	TBD
Size and color of balloons	TBD
Obstacles	TBD

3.2 - Challenge 2 – Team of Robots to Construct a Structure using Bricks

Challenge 2 requires a team of up to 3 UAVs and an UGV to autonomously collaborate to locate, pick, and assemble a set of brick shaped objects, in order to construct a digitally pre-specified structure.

Arena

The Challenge 2 arena will be approximately 50mx60m.

The arena will also have four randomly located piles of bricks, with each pile consisting of similar sized bricks. The brick sizes of three of the piles will be in the range 60x40x15cm to 15x10x15cm, and will be color coded red, green and blue respectively. The fourth pile, colored orange, will have relatively long bricks, of approximate dimensions 120x40x15cm, to be picked and placed collaboratively by two or more UAVs. More details on the shapes, sizes, weights and material of the bricks will be specified in due time.

A list of Challenge 2 parameters and their specifications are given in Table 2.

Challenge Duration

The Challenge 2 duration is a maximum of 30 minutes.

Task Specification

- Start Condition - The team will position the UAVs and UGV (hence referred to as the 'Robots') in stationary mode on the ground at the start location.
  The judges will then indicate the start of the challenge.
- The UGV will start to move and the UAVs will take off autonomously (the UGV and the UAVs can be started with a push of a button or a flick of a switch), to locate and reach the bricks.
- The robots will then collaborate to pick and place appropriate bricks to assemble a structure composed of walls.
  The robots will assemble the bricks in a pre-specified sequence (R, G, B, O).
  Some bricks (e.g. Blue) may need to be assembled only by the UAVs. Bricks assembled by the UAVs will gain higher marks. Two or more UAVs may collaborate to carry heavier bricks (e.g. Orange bricks) and gain more marks.
  The blueprints for the structures to be assembled will be provided in due time.

Scoring

The Challenge 2 score will be based on the tasks completed and the speed of completion. More details about the scoring scheme, including the scores awarded for each type of bricks assembled by the UAVs and the UGV, will be specified in the MBZIRC 'Scoring Scheme' Document, in due time.

Table 2 - List of Challenge 2 Parameters

Parameter	Specification
Number of UAVs per team	Maximum of 3
Number of UGVs per team	1
Arena size	50mx60m
Bricks size (R, G, B)	Between 15x10x15cm and 60x40x15cm
Bricks size (O)	120x40x15cm
Brick colors	Red, Green, Blue, Orange
Structure specification format	TBD
Environment	Outdoor
Mode of operation	Autonomous; manual allowed but penalized
RTK/DGPS	Allowed but penalized
Challenge duration	30 minutes
Communications	TBD
Brick gripping mechanism	TBD
Weight of bricks	TBD
Brick shapes and material	TBD

3.3 - Challenge 3 – Team of Robots to Fight Fire in High Rise Building

Challenge 3 requires a team of up to 3 UAVs and an UGV to collaborate to fight fire in a simulated high rise building.

Arena

The Challenge 3 arena will be approximately 50mx60m, and will contain a tall indoor structure (up to 20m in height) simulating a high-rise building. Fires will be simulated at various random locations at ground level in the arena (indoor and outdoor), and at different heights (in the range of 5m to 18m) of the building, to simulate a fire fighting scenario in a high-rise building.

The location and specifications of the indoor structure, and the locations and nature of the fires, will be specified in due time.

Challenge Duration

The Challenge 3 duration is a maximum of 20 minutes.

Task Specification

- Start Condition - The team will position the UAVs and UGV (hence referred to as the 'Robots') in stationary mode on the ground at the start location. The simulated fire extinguishers (these may be pressurized water containers) and fire extinguisher covers (more details about the simulated fire extinguishers and fire extinguisher covers to be provided in due time) can be attached to the UAVs and UGV, prior to the start of the challenge.
  The judges will then indicate the start of the challenge.
- The UGV will start to move and the UAVs will take off autonomously (the UGV and the UAVs can be started with a push of a button or a flick of a switch), and collaborate to find and reach the fire locations (both indoor and outdoor), and extinguish fires. Some of the fire locations can only be reached by the UAVs (e.g. higher floors). The fire affected building will be hollow inside. The UGV (and UAVs) can enter inside the ground floor through an open door(s). The UAVs can also enter inside the higher floors through open windows.

- The fires may be extinguished in one of two ways:
  (a) Using simulated fire extinguishers (these may be pressurized water containers, and marks will be based on volume of water ejected at the target fire) and
  (b) Using simulated 'Fire Extinguisher Covers'
- Smoke and wind conditions likely in high rise buildings fires will also be physically simulated.

Scoring

The Challenge 3 score will be based on the number of tasks completed (fires extinguished), locations of extinguished fires, the mode of task completion (UAV, UGV, Extinguisher, Extinguisher Covers), and the speed of completion. More details about the scoring scheme will be provided in the MBZIRC 'Scoring Scheme' Document in due time.

Table 3 - List of Challenge 3 Parameters

Parameter	Specification
Number of UAVs per team	Maximum of 3
Number of UGVs per team	1
Arena size	50mx60m
Tower height	Maximum of 20 m
Simulated fire height	Up to 18 m
Environment	Outdoor and indoor
Mode of operation	Autonomous; manual allowed but penalized
RTK/DGPS positioning	Allowed but penalized
Challenge duration	20 minutes
Communications	TBD
Extinguisher attachment mechanism	TBD
Nature of fire simulation	TBD

3.4 - Grand Challenge – Triathlon

The Grand Challenge will require a team of 3 UAVs and 1 UGV to compete in a triathlon type event combining the three challenges described above. All three challenges will run simultaneously.

Arena

The Grand Challenge arena will be approximately 150mx60m.

Challenge Duration

The Grand Challenge duration is a maximum of 30 minutes.

04

Prizes and Sponsorships

A total sum of US $5 million will be allocated for prizes and sponsorship. The division of this fund (US $5 million) between team sponsorship and prize money will be specified when the team selection is finalized (scheduled for April 2018).

05

Call to Participate

Teams who intend to participate in MBZIRC 2019 are requested to submit an online application by visiting: www.mbzirc.com/register

The deadline for submission of applications is, **12 midnight UAE time, on 15th March 2018.**

06

Important Dates

A list of important dates and deadlines leading up to the main event in 2019 are given below.

Call for Proposals	December 2017
Submission of Proposals	15th March 2018
Selection of Finalists	April 2018
MBZIRC 2019	November 2019

Version	Date	Descriptions
V1	01 Dec. 2017	MBZIRC Challenge Description