

Engineering Design Challenge 5.0

RiFA: Robots in Football Association - EMEA Cup

Rules & Game Description

As the fields of robotics and artificial intelligence advance, the question of whether machines will replace all human jobs has emerged in all industries. This is only aggravated as artificial intelligence enables the automation of even the most creative tasks in the industry like graphic design. With a few industries left untouched by these advances, human eyes turn to sports: Will the next generation of robots powered by artificial intelligence overshadow technical finesse and natural athletic talent? This question is yours to answer as you benchmark the performance of robots you build against your own performance as you compete for the title of EMEA Cup winners.

Date & Location

The challenge will take place on the 13th of June, 2020, at Beirut's Digital District, room 1280.

Eligibility

Teams of 2 to 5 members can be part of the challenge. All team members should be enrolled as either undergraduate or graduate students in a university as of the competition announcement date. These can include teams of a mixture of both graduate and undergraduate students as well.

Guidance and Advising

Teams are recommended, but not required, to have an advisor. An advisor can be anyone who is willing to provide consultancy when needed: a professor, an engineer in a company, or even a university student. Note that EDC organizers and members of the judging panel are not allowed to be advisors.

Advisors should only guide teams throughout the competition, not do their work. They may suggest ideas and provide feedback for teams, however they must not help with any hardware or software implementation.

Teams should inform EDC organizers of their advisor for recognition purposes.

Awards

The team with the highest overall score gets a monetary prize of **1,050,000 L.L.** . The first and second runner ups get prizes of **750,000 L.L.** and **450,000 L.L.** respectively. Other awards will be distributed among teams who demonstrate proficiency in certain aspects of the competition.

General Rules

- 1) The robots are any object that aligns with the rules. No shape, material, or platform are imposed – creativity is encouraged! Teams are expected to take the challenges into consideration when designing their robots.
- 2) All dimensions on game drawings are in mm unless stated otherwise.
- 3) Each team is to use **two** robots to play the games. Minor changes or repairs can be made to the robots between rounds (changing batteries, uploading code, small mechanical changes, etc.).
- 4) The robot(s) cannot be interacted with by hand except when allowed explicitly in the rules (e.g. starting/resetting...)
- 5) The robot(s) should not damage the playing field, damage other teams' robot(s), or pose any safety hazards. Teams who violate this rule risk being disqualified. Refer to the safety regulations for more information.
- 6) Only one team member, designated the operator, can interact with the robots for repositioning on resets (game stoppage). The operator cannot change during the round, but different team members can be operators for different rounds.
- 7) All dimensions in field drawings have a tolerance of 5%. CAD drawings of the field are available on the competition website <http://aubrobotics.com/edc>.
- 8) External processing on team laptops (i.e: streaming video data to the laptop) or cloud services (i.e: Amazon AWS) is permitted. The laptop or cloud service is allowed to communicate with the robots' microcontrollers and/or microprocessors **only if** these devices are not explicitly controlled by team members and/or external users.

- 9) All teams are required to place **ALL** their laptops on an appointed (to be communicated to the teams on the day of the event) table explicitly in front of the judges during match playtime.
- 10) Microcontrollers can be reprogrammed externally on competition day.
- 11) Teams are only allowed to use and modify code available on their microprocessors (and not code available externally, i.e USB) on the day of the event. Exceptions can be allowed if permitted by organizing team members.
- 12) Any changes to the code on the day of the competition should be reported to one of the organizing team members.
- 13) Judges take the final decision in rule matters.
- 14) Teams are advised to bring spare batteries, wheels, motors, microprocessors, microcontrollers, and a backup USB with all the code on the Competition Day in case anything happens.
- 15) Black walls will be available on the outer periphery of the field to enclose the robots as well as minimize visual perturbations should any team feel the need to use vision/optical sensors.
- 16) The ball is a 10 cm diameter spherical ball, whose exact material is to be communicated when it becomes available.

Robot Design Restrictions:

In our mission of making this competition as open ended as possible, we permit any robot designs and machinations that abide by these rules:

- 1) ****All robots must have a flat space on their top side of size at least 20x20cm in order to place a tag that uniquely identifies every robot on the field, these will be provided to you before the contest. **** These tags are called AprilTags and each team will receive two tags, one for each robot. It is recommended that the tags be placed at the center of your robots. The specific tags for each team will be announced at least 3 weeks before the competition. For more information on AprilTags, visit <https://april.eecs.umich.edu/software/apriltag> and <https://github.com/AprilRobotics/apriltag>.
- 2) Flying Drones are (sadly) prohibited due to legal restrictions.
- 3) All pointy, sharp and razor-like components are prohibited from use.
- 4) The robot(s) must fit in a **30x30x30cm** box or else the team will be disqualified. This is to ensure that the robots are to scale with the field and outer walls.

- 5) All robots should be paired with a wireless, active **killswitch** or **stop button**. This is a must for correct functioning of the robots on fouls, timeouts, and out-of-bound plays. This can be implemented in any way that teams see fit as long as it is wireless and ensures the safe stopping of the robot.
- 6) Components that lift opponents are prohibited from use. This includes active lifting using actuators or passive lifting using ramps mounted on the front of a robot.
- 7) The rear and front of a robot should be visibly indicated on the top of a robot for judges to be able to judiciously call fouls. Failure to do so can cause the team to be forfeit from the competition should the issue not be resolved by the time the violating team's match is due to play.
- 8) Active and passive grippers are banned from use for gripping the ball. The robots are NOT supposed to grab the ball and go, but rather dribble.
- 9) Passive gripping in the form of mechanically designed robots with inward convexity (like a convex mirror) tight enough to keep the ball enclosed within the robot is prohibited. This restriction is to prevent teams from playing "grab and go" where the football is completely enclosed with no way of taking the ball from the robot without knockout (This is **NOT** robot rugby ... not this year at least). A sample of designs that meet this restriction are provided in **Figure 1**.



Figure 1 - Examples of Allowable Designs vs an Unacceptable Design

- 10) No where, from any and all of the sides of the robot, should the ball be able to be more than 40% inside the robot. This will be tested on competition day before the tournaments commence. Any robot that fails to adhere to this restriction will be disqualified from the competition.
- 11) Sticky surfaces are also banned from use as a form of passive gripping of the ball and/or opponents.

- 12) It is recommended (optional) that teams place some padding to the sides of their robots to soften the blows from bumps.

Scoring

Teams will be assessed based on the following three measures, for a total of **300** points:

- 1) Preliminary Check (**15 points**):

The points will be awarded to teams who demonstrate that their robots have basic functionality around one month before the competition.

The checks are to ensure teams are preparing well for the competition.

Details regarding the requirements and submission methods for the preliminary checks will be communicated later on with the registered teams.

- 2) Game Performance (**220 points**):

Robots will play 2 games, described below, to score points.

- 3) Technical Assessment (**65 points**):

Teams are required to prepare a small cardboard/paper sheet where they will present in 5 minutes key points of their design to be evaluated by a team of judges from different universities/companies, according to the judging rubrics specified in a separate document.

Overview:

The competition will be divided into two tournaments. All participating teams must take part in both tournaments. Each tournament is divided into a group stage and a knockout stage.

In the group stage, teams will be separated into groups and each team will compete against every other team in their same group. From each group, some number of teams will advance to the knockout stages.

The group sizes and qualification criteria will be communicated at a later stage.

In the knockout stage, a team is automatically eliminated after losing a match. The winner of the knockout stage will be named the winner of the corresponding tournament.

Definitions:

- 1) **In Play:** A match is said to be **in play** if the timer for the current match is running. The judge shall alert the teams of any changes in a match's **in play** time. **In Play** can be paused, resumed or extended for any of the following reasons: **Out of bounds**, **Timeouts**, **Goal** score or by a judge's decision. When **In Play**

is paused, teams must immediately suspend all motion of their robots, preferably using a wireless kill/pause switch.

- 2) **Out of bounds:** A ball is said to be out of bounds if any part of its projection on the ground plane lies outside the field.
- 3) **Timeout:** A timeout is a 60 second interval of time that can be requested by a team, during which both teams are allowed to physically interact with their robots.
- 4) **Goal:** A team is said to have scored a goal if any part of the ball crosses the opposing team's goalline.
- 5) **Forfeit:** If a team is forfeited, then it is **disqualified** from the tournament, and the opposing team automatically **wins** with a 3-0 end result.
- 6) **Warning:** Issued by game judge/referee and serves to caution and discern players from using force against each other. Each robot that receives a certain number of warnings will be suspended for the remainder of the match. This number or threshold is as follows:
 - a) 2 warnings for Game 1
 - b) 3 warnings for Game 2
- 7) **Fouls:** A foul is defined as follows: Any physical force applied to an opponent that can move, damage or change the orientation of the opponent. Fouls can be further defined as follows:
 - a) Mild Fouls: bumps or collisions to the side or rear of the opponent that can disorient them.
 - i) These are considered fouls if and only if collisions/bumps are harsh enough to shake a robot.
 - ii) These fouls result in game stoppage only
 - b) Medium Fouls: These are deliberate forces applied by one robot on the other.
 - i) These are especially considered fouls when contact is from the rear or side.
 - ii) Contact from the front can be considered normal contact if the force applied hits the ball first.
 - iii) Rear contact forces can result in a warning given to a robot. These include any physical contact (bumps, hits or others) made by one robot to the rear of an opponent.
 - c) Harsh Fouls: These result in direct suspension of the robot and are categorized by the following:
 - i) Heavy hits applied to opponent robots deliberately, whether they are directed from the side, rear or front. Heavy hits are hits that directly damage the opponent.

- ii) Bumps and collisions from the rear or sides that move the opponent at least 15 cm in any direction.
- iii) Any action that can flip the opponent robot.

8) Penalty Kick: A penalty kick is defined as a shot taken by a (ONE) team's robot against one of the opposing team's robots. The ball is placed at the center of the 165cm radius semi-circle in at the top of the 665cm x 1300cm box of the opposing team's goal. A **penalty kick** occurs if the following happens:

- a) A team member interacts with their robot physically while the match is **in play**. This will result in a penalty kick given against that team.
- b) One team's robot commits a foul (Medium or Harsh) inside their own 650cm x 1300cm box against another team. This will result in a penalty kick against that team.

Game 1: Human Team Test (60 Points)

How good are you humans as a team?

How good are you humans as a team of robots?

Take control of your robots in this remote-controlled tournament! This game will serve as a test of your hardware functionality as well as your cooperation as a team of human players.

Rules:

- 1) Each team assigns 2 members of the team as controllers to play during the whole match.
- 2) Controllers can be changed in between matches, given that the judges and the organizing committee are informed of this change. **Any unannounced change in controllers will result in forfeit of the team from the tournament.**
- 3) If any (one or both) of the team's designated representatives fails to show up within 2 minutes of match start-time, or the team fails to be ready within 2 minutes, then that team is **forfeit**.
- 4) The robots are remotely controlled using any form of wireless communication that the team chooses: WiFi, Bluetooth, ZigBee ...
- 5) Only **wireless** communication with the robots is permitted.
- 6) Each team must initially place each of their robots anywhere on their own halves, outside of the center circle. The ball starts in the middle of the field.
- 7) The robots should start playing as soon as the referee calls for the start of the match:
 - a) The robots should remain completely stationary prior to the calling of the start of the match.

- b) As soon as the referee calls for a start, teams are responsible for any delay in startup on their part.
 - c) The referee is ordered to make sure that both teams are ready before the match starts. This means that both teams are present with their robots, their controllers, as well as being prepared and signaling for the referee to be ready.
- 8) No team may physically interact with any of their robots while they are still **in play**. Doing so will result in a **penalty kick** awarded to the other team.
- 9) Each match lasts for 3 minutes of in play time.
- 10) In the case of a tie (both teams have the same number of goals (0 or more), then the playing time is extended for one additional minute as extra time.
- 11) If the tie is not resolved after extra time then the match is extended for an additional extra minute of golden goal, where the team that scores the first goal during this period wins the match.
- 12) A reset can be allowed if both teams' robots are stuck in places on the field where "stuck" is involuntary immobility due to the environment.
- 13) Each team is allowed only **ONE Timeout** per match, during which **in play** is paused for 60 seconds.
- 14) A team can call a timeout only if the ball is outside the penalty box of the other team.
- 15) Teams can replace/reposition their robots if any of the following occur:
- a) A timeout is called.
 - b) A foul occurs.
 - c) Both teams agree to a reset if a reset is allowed.
 - d) A goal is scored.
 - e) The ball goes out of bounds
- 16) The ball is placed back at the center if any of the following occurs:
- a) A timeout is called.
 - b) A reset occurs.
 - c) A goal is scored.
 - d) The ball goes out of bounds.
- 17) In the occurrence of a foul the following happens:
- a) The autonomous robots are stopped manually by the team operator awaiting repositioning under these constraints:
 - i) The team that committed the foul is to be positioned anywhere as long as no part of the robot is inside a 60 cm radius centered at the location of the foul.

- ii) The other team's robots are split between one robot taking the foul at the foul location, and another free to be positioned anywhere inside the field.
 - b) The ball is placed at the location of the foul.
 - c) The team whose robot was fouled against takes a fixed shot or pass.
 - d) The robot taking the foul's shot is to take the shot within a maximum of 10 seconds after the referee calls for the shot. If no action is taken within this timeframe, the foul is handed to the opposing team.
- 18) A match terminates if any of the below is applicable:
- a) The time limit passes.
 - b) Damage is done to the field.
 - c) The goal difference exceeds 4 goals.
 - d) One of the team chooses to **forfeit** from the match, accepting the penalties that a **forfeit** entices.
- 19) A team is allowed to opt for **forfeit** if and only if at least 1 and a half minutes on **in play** time have passed. Otherwise, the game can only terminate as per the rules above.
- 20) If any team member enters the arena during **in play** time, the team of that member is **forfeit**.
- 21) If any of the team's designated controllers fails to show up within 2 minutes of match start-time the team of the missing designated controller is **forfeit**.

Game 2: Autonomous Team Test (160 Points)

Overview:

Let's see how smart your robots really are. Can they figure out how to get the ball into your opponent's net without your help? Can they outperform you in their league?

Rules:

- 1) Each team assigns **one and only one** member of their team as a controller throughout the whole match, responsible for handling the robots (Stopping/repositioning/...) during on match stoppages (Timeout, Out-of-Bounds, Fouls,...)
- 2) Controllers can be changed in between matches, given that the judges and the organizing committee are informed of this change. **Any unannounced change in controllers will result in forfeit of the team from the tournament.**
- 3) If the team's designated representative fails to show up within 2 minutes of match start-time, or the team fails to be ready within 2 minutes, then that team is **forfeit**.

- 4) The robots should be fully autonomous with the exception of external data processing done on external hardware or cloud services.
- 5) Only **wireless** communication between the external data processors and the robots is allowed.
- 6) Each team must initially place each of their robots anywhere on their own halves, outside of the center circle. The ball starts in the middle of the field.
- 7) The robots should start playing as soon as the referee calls for the start of the match:
 - a) The robots should remain completely stationary prior to the calling of the start of the match.
 - b) As soon as the referee calls for a start, teams are responsible for any delay in startup on their part.
 - c) The referee is ordered to make sure that both teams are ready before the match starts. This means that both teams are present with their robots, their controllers, as well as being prepared and signaling for the referee to be ready.
- 8) No team may physically interact with any of their robots while they are still **in play**. Doing so will result in a **penalty kick** awarded to the other team.
- 9) Each match lasts for 3 minutes of **in play** time.
- 10) In the case of a tie (both teams have the same number of goals (0 or more), then the match is **stopped**, robots are **reset**, and then playing time is continued for one additional minute as **extra time**.
- 11) If the tie is not resolved after **extra time** then the match is extended for an additional extra minute of golden goal, where the team that scores the first goal during this period wins the match.
- 12) A reset can be allowed if both teams' robots are stuck in places on the field where "stuck" is involuntary immobility due to the environment.
- 13) Each team is allowed only **ONE Timeout** per match, during which **in play** is paused for 60 seconds.
- 14) A team can call a timeout only if the ball is outside the penalty box of the other team.
- 15) Teams can replace/reposition their robots if any of the following occur:
 - a) A timeout is called.
 - b) A foul occurs.
 - c) Both teams agree to a reset if a reset is allowed.
 - d) A goal is scored.
 - e) The ball goes out of bounds
- 16) The ball is placed back at the center if any of the following occurs:
 - a) A timeout is called.

- b) A reset occurs.
 - c) A goal is scored.
 - d) The ball goes out of bounds.
- 17) In the occurrence of a foul the following happens:
- a) The autonomous robots are stopped manually by the team operator awaiting repositioning under these constraints:
 - i) The team that committed the foul is to be positioned anywhere as long as the no part of the robot is inside a 60 cm radius centered at the location of the foul.
 - ii) The other team's robots are split between one robot taking the foul at the foul location, and another free to be positioned anywhere inside the field.
 - b) The ball is placed at the location of the foul.
 - c) The team whose robot was fouled against takes a fixed shot or pass.
 - d) The robot taking the foul's shot is to take the shot within a maximum of 5 seconds after the referee calls for the shot. If no action is taken within this timeframe, the foul is handed to the opposing team.
- 18) A trial terminates if any of the below is applicable:
- a) The time limit passes.
 - b) Damage is done to the field.
 - c) The goal difference exceeds 4 goals.
 - d) Two of a team's robots are completely stationary and the team wishes to terminate the round.
 - e) One of the team chooses to **forfeit** from the match, accepting the penalties that a **forfeit** entices.
- 19) A team is allowed to opt for **forfeit** if and only if at least 1 and a half minutes on **in play** time have passed. Otherwise, the game can only terminate as per the rules above.
- 20) Each team is allowed only **ONE Timeout** per match, during which **in play** is paused for 60 seconds.
- 21) If any team member enters the arena during **in play** time, the team of that member is **forfeit**.

Games Scoring Rubric:

1. Each Game is a tournament comprised of a group stage followed by a knockout stage.

2. The group stage pairs teams of 4 against each other with the top 2 teams qualifying to the knockout stage.
3. The knockout stage is a series of knockout matches, each between 2 teams from the previous stage. Only the winner of that match qualifies to the next round of knockout.
4. The full detailed match schedule with the group stage group allocation will be communicated to all teams a month prior to competition day.

Points will be allocated based on certain tasks as well as matches completed. This scoring will be given based on the following criteria:

Task	Points Received	
	Game 1	Game 2
Group Stage	5/match	10/match
Knockout Stages	10/match	15/match
Final	15	25
Shots	N/A	1
Passes	N/A	2
Tackles	N/A	2
Goals	N/A	4
Saves	N/A	4

Note, however, that the maximum bonus 'action' points that can be gained in one match is limited as follows:

Task	Threshold
Shots	5 points max
Passes	10 points max
Tackles	10 points max
Goals	20 points max

The Field:

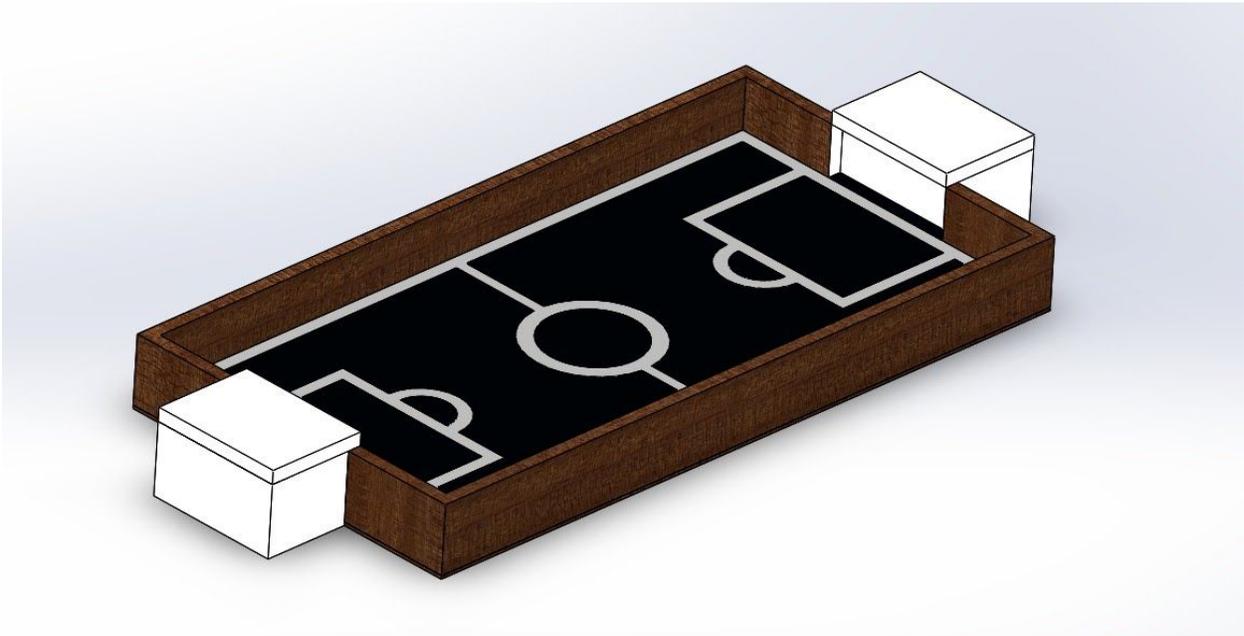


Figure 2 - 3D CAD Model of the Field Showing Black Flooring and Wooden Walls.

- 1) The field will consist of a 4000x2000 walled area, with black floor and white lining on the floor as limit indicators.
- 2) The black flooring is introduced to minimize visual noise for any team wishing to utilize computer vision algorithms.
- 3) The walling of the field will be all around the boundaries of the 4000x2000 field, of 60cm height. The walls are provided to make it easier to keep the ball and robots in play.
- 4) Teams are responsible for the efficient design of their robots to enable them to reach all areas of the field (should they need it) with the walls set-up.
- 5) Figure 1 shows all the dimensions of the field including goal dimensions as well as the dimensions of the limit areas (penalty box, center circle, penalty box half-circle, ...).
- 6) The red boxes shown in Figure 1 resemble the tow team's robots to scale to show the relative scale of the field.

