

FIRA RoboSot Competition - Version 1.0.0

Prof. Jong-Hwan Kim, Dr Daniel J. Stonier, Sunglok Choi, Naveen S. Kuppuswamy
KAIST RIT Lab

August 21, 2006

RoboSot Goals

Research on mobile robot platforms is receiving an increasing share of attention, especially in the area of household domestic appliances. The problems and challenges facing the development of these platforms are many and varied and often significantly different from the problems faced in both the smaller sized and humanoid leagues.

Compared to the smaller sized leagues, these robots are fully autonomous and this brings many challenges in the areas of hardware design, communication, co-operation, intelligence and sensing. While in comparison to the humanoid leagues, they have the flexibility to employ non-human like sensing and motion systems. This creates a much faster platform and this alone brings challenges in sensing, localisation and planning to the fore.

It is our goal that the RoboSot competition will be a dynamic competition that continually shifts its goalposts from year to year to meet the problems and challenges that arise in this field. We also hope that competing teams will also find the challenges along this path both interesting and rewarding.

Recent Changes

This is a list of the recent changes made to this document.

Flags - Chose to leave them non-uniquely identifiable and red. This creates challenges for the vision system (identification/classification/occlusion) but these are challenges we are confident that can be overcome.

Goalkeeper Area - Introduced the goalkeeper area and offside penalties to avoid obstruction problems in front of the goals.

Team Size - Due to possible funding and travel difficulties, the team size has, for now, been reduced to three.

Challenges - To encourage research and focus on key problems in mobile robot platforms, we've introduced the vision/co-operative/motion/creative challenges.

The remainder of this document is a complete list of the rules and includes some comments regarding motivation and direction in *italics*.

1 Competition Structure

The Robosot Competition will consist of a series of challenges as well as the traditional soccer competition. All categories are compulsory except for the Open Creative Challenge.

- Vision Challenge
- Co-operative Challenge
- Motion Challenge
- Open Creative Challenge
- Robosot Soccer Competition

For each category, an award will be presented to the winning team.

2 RoboSot Challenges

The RoboSot challenges will change from year to year to reflect different research goals on a mobile robot platform. Each year, the challenge rules be specified at least 6 months in advance and available with these rules on the FIRA web pages for RoboSot.

2.1 Vision Challenge

The vision challenge requires the robots to develop and exhibit capabilities in one of the areas related to identification, localisation or classification. This may often involve the interaction with other systems on the robot, but the goal is primarily to produce an efficient and effective vision system that enhances the robot's capabilities.

2.1.1 FIRA 2007 - Localisation

Brief: There will be 3 trials. In each trial, a single robot from each team will be expected to start from a random (position and orientation) starting point which will remain the same for all teams in that trial. The robot must then move to a pre-specified target point where it must eventually stop once it has believed it has reached the target point. The target point for each trial will be different and supplied to teams before the challenge begins. Scores for each trial will be based on time and accuracy, with their best chosen as their final score.

Possible Future challenges: Detection of a Black/White Soccer Ball, Occlusion Challenge, Opponent Identification

2.2 Co-operative Challenge

The co-operative challenge requires the robots to develop and exhibit capable communication or co-operative task related skills that are essential for team functionality.

2.2.1 FIRA 2007 - Role Assignment

Brief: Robots will be required to communicate information to each other so they may automatically assign themselves roles for a task. The challenge will involve automation of the *Free Kick* scenario. There will be 3 trials. For each trial, two robots from a single team, and the ball will be placed on the field appropriately for a free kick (this may be near the sidelines). This starting position remains the same for all teams in that trial. Robots must decide who plays the role of *kicker* and who plays the role of *attacker*. The kicker must move and come to a stop in a position behind the ball (in the defender's half of the field) whilst the attacker must move and come to rest at a point at least 1m away from the ball. If either robot collides or touches the ball, they will be immediately disqualified from that trial. If they complete the challenge, their time will be recorded for scoring purposes.

Possible Future challenges: Passing, Ball Triangulation, Role Swapping

2.3 Motion Challenge

The motion challenge requires the Robosot platform to develop and exhibit capabilities in the area of motion control, ball handling or path planning.

2.3.1 FIRA 2007 - Navigational Orientation Control

Brief: There will be 3 trials. In each trial, a single robot from each team will be expected to move through a sequence of points whilst maintaining their orientation in a pre-specified manner. Failure to maintain orientation, or not move through the sequence of points in the correct order will immediately disqualify them from that trial. If the robot completes the challenge their time will be recorded for scoring purposes.

Possible Future challenges: Obstacle Avoidance, Optimal Path Planning, Omninavigability, Acceleration (Maximal), Slip-Awareness

2.4 Open Creative Challenge

The open creative challenge is a little different from the previous three challenges. The task is unspecified and teams may use this category to demonstrate their mobile robot platform's use for an application or research area not necessarily directly related to robot soccer. This is specifically designed to allow teams to exhibit their work on mobile robot platforms in general.

Each team participating in this challenge is allotted 20 minutes for presentation. The best presentation will be awarded as winner of the category.

Detailed challenge rules will be forthcoming on the FIRA server.

3 Robosot Soccer

3.1 The Field and the Ball

3.1.1 Playground Dimensions

The playground must contain both a rectangular playing field 6m x 4m in size surrounded by a bordering region of minimum width 75cm. The playground and bordering region should be green in colour.

3.1.2 Markings on the PlayGround

The field of play shall be marked as shown on the diagram in the Appendix.

- All *line markings* will be painted with a 3cm thickness and must be white in colour.
- The *centre-circle* will have a radius of 60cm.
- The *goalkeeper area* will be 1m wide, 0.35m deep and positioned directly in front of each goal.
- The *goal area* will be 2m wide, 0.75m deep and positioned centrally in front of each goal.
- The *goal kick semi-circles* will have a radius of 50cm and are centred on the lines marking the goal areas parallel to each goal.
- Four *free ball positions* must be placed on the field as shown. Two are placed in the middle of each half and these are spaced 1m inside either touch line. These are marked as small circles (approximately 5-10cm in diameter) and painted grey in colour.

3.1.3 The Goal

The goals must be in the form of a wooden box with open front and top. The dimensions of the field should be 1m x 0.5m x 0.75m (width, depth, height). A 5cm x 5cm crossbar is placed across the front top of the box representing the upper bar of a soccer goal. To distinguish and identify them, the goals shall be painted in blue (navy blue) and yellow colours.

3.1.4 Flags

Four flags will be placed 0.5m behind each corner of the playing field. Each flag is to be 0.75m high with a radius of 10cm. They must be red in colour.

The flags are placed behind the corner so they do not obstruct play and to accommodate future rulings for corner-kicks. Uniquely identifying each corner with patterns on the flag posts may be introduced in future competitions if the vision system is restricted - for the present time, omni-vision systems should be able to localise, though there will be challenges to do this successfully without uniquely identifiable patterns.

3.1.5 The ball

Until a standardised version can be found, a soccer ball of approximately 10-12cm in diameter and FIFA orange in colour will be used. Future entrants may request to be sent one or more of these balls for developmental purposes.

3.1.6 Field Location and Lighting

The field should be located indoors. Lighting for the competition should be fixed at around approximately 1000 Lux.

3.2 The Teams

3.2.1 Human Personnel

Three human team members are permitted to participate actively in a match. This includes a *manager*, a *coach* and a *trainer*

3.2.2 Team Size

A match shall be played by two teams, each consisting of two to three robots. Additional robots may be used as substitutes.

If competing teams become firmly established and are looking for further challenges, we may consider expanding the competition to five robots per side at some point in the future. This will be reviewed on a year to year basis.

3.2.3 GoalKeeper

One of the robots must be designated as the goalkeeper. The goalkeeper may only catch or hold the ball when it is inside its own goal or the goal area.

3.2.4 Remote Computer

Each team is also permitted a remote computer/control to transmit procedural information upon stoppages in play. This is covered in detail in Section 3.4.

3.3 The Robots

3.3.1 Robot Size

The size of each robot shall be limited to a maximum of 35cm X 35cm (widthxheight). The height is unrestricted. The robot must be in a fully extended state when being measurement.

3.3.2 Robot Color

The base colour of a robot's body must be somewhere between black and dark grey (50% grayscale). The paint or material used to achieve this must be matte to minimise reflectivity. Some areas of the robot cannot obviously comply to this rule (the camera lens) but in all cases, teams must minimise the use of shiny materials and/or materials similar in colour to colours used in the game.

A color patch, either magenta or cyan as assigned by the organizers before a game, will identify the robots in a team. All the robots must have a 10cm wide color strip of their team color patch visible all around their body. The bottom side of this color strip should be at a height of **10-20cm** from the surface of the playground. Holes less than 1cm in diameter are allowed on the patch for the sensors including the camera. A team's identification color will change from game to game, and the team color patch used should be detachable. When assigned with one of the team colors, the robots must not have any visible patches of those colors used by an opponent team.

3.3.3 Autonomous System

Each robot must be fully independent, with vision system, powering and motoring mechanisms self-contained. Image processing must be done on board the robot. No global vision system is allowed. Communications are described in Section 3.4.

3.4 Communication

3.4.1 Remote Computer/Control

A remote computer or control may be used to transmit procedural information to and from the robots whenever there is a stoppage in play or upon explicit instruction from the referee. Permissible commands include:

- Start/Stop Commands.
- Formation/Setup Commands

Commands may not transmit any positional data. Positional data must only be stored on the robots themselves. These commands are executed via a button-press on a remote control, or a key-press/mouse click on a host computer. Examples of the use of such commands would be automating the positioning of robots for kick-offs, free/penalty/goal kicks, corner kicks and throw-ins.

Teams must be able to start and stop the robots from the remote computer/control. Formation and setup functionality is desirable but not essential. Repositioning may alternatively be done by a human handler.

These will make the game more autonomous (reduced robot handing) and improve the event visually for spectators. For now, this functionality is transitional. Eventually it is hoped that these can also be automated by detecting pre-specified cues from either a human or remote electronic referee.

3.4.2 Inter-Robot Communication

Robots may freely transmit information between one another.

3.5 The Game

3.5.1 Game Setup

Teams must meet at least 15 minutes prior to the game to resolve communication issues and colour patch designations.

Communications

Any communication conflicts must be resolved prior to the commencement of the coin toss to initiate the game. This is especially the case for teams using RF communication.

Colour Patches

Colour patches will be randomly assigned to each team on the basis of a coin toss by the referee.

Coin Toss

A coin toss will be made by the referee immediately prior to the commencement of the game. The winner of the toss shall choose which goal it will attack in the first half of the match. The other team takes the kick-off to start the match. The team which wins the toss takes the kick-off to start the second half of the match and both sides switch directions.

3.5.2 Game Duration

The duration of a game shall be two equal periods of 5 minutes each, with a half time interval for 10 minutes. An official timekeeper will pause the clock during substitutions, while transporting an injured robot from the field, during time-out and during such situations that deem to be right as per the discretion of the timekeeper.

If a team is not ready to resume the game after the half time, an additional 5 minutes shall be allowed. If the team is still not ready to continue the game, that team will be disqualified from the game.

3.5.3 Kick-Offs

The team with the kick-off will be allowed to position their robots freely within their own half or anywhere within the centre circle. The defending team can then place their robots anywhere in their own half except within the centre circle. Robots can be positioned either with the designated human handler or via instruction from the remote computer. The ball should be placed in the centre of the centre circle.

When given the signal from the referee, the game shall be started. The ball should be kicked or passed towards the team's own side. Thereafter the robots may move freely.

3.5.4 Winning the Game

A goal shall be scored when the whole of the ball passes over the goal line. The winner of a game shall be decided on the basis of the number of goals scored.

In the event of scores being level after the second half, the game will proceed into *extra time* after a 5 minute break. Extra time will be a maximum of three minutes. The team that scores first in extra time will be immediately declared as the winner. If the tie persists after 3 minutes, the winner shall be decided through penalty shootout. Each team shall take 3 penalty kicks. These differ only from Section 3.8.2 in that only a kicker and a goalkeeper shall be allowed on the field. A penalty-kick will be completed, when any one of the following happens:

- The goalkeeper catches the ball with its appendages (if any) in the goal area.
- The ball comes out of goal area.
- Thirty seconds pass after the penalty kick has commenced..

In case of a tie even after three penalty-kicks, additional penalty kicks shall be allowed one by one, until the winner is decided.

3.6 Interruptions

The following list represents events that trigger certain actions in the course of play.

3.6.1 Substitutions

Three substitutes shall be permitted while a game is in progress. At half time, unlimited substitutions can be made. When a substitution is desired while the game is in progress, the concerned team manager should call 'time-out' to notify the referee, and the referee will stop the game at an appropriate moment for up to two minutes. The game will restart, with all the robots and the ball placed at the same positions as they were occupying at the time of interrupting the game.

3.6.2 Fallen Robot

When a robot that has fallen in such a way to block the goal or directly affect the course of the game, the referee will call a halt to play whilst the fallen robot is righted (restored to a standing position) or removed (if broken). All remaining robots must come to a halt when the call is made. The ball is also positioned in the exact position it was located in when play was halted. Upon signal from the referee, play restarts and the robots may move freely.

3.6.3 A Goal is Scored

Play is halted and robots are set up for the next kickoff (Section 3.5.3).

3.6.4 Ball Leaving the Field of Play

If the ball leaves the field of play, the referee will call a *throw-in* immediately. Note that there will be no stoppage of play when a throw-in occurs. See Section 3.8 for details on throw-ins.

3.6.5 Stalemate

A referee will call a stalemate whenever the ball remains stationary for more than 10 seconds. If it occurs within the goal area, a *goalkeeper kick* is awarded to the defending team. If it occurs anywhere outside the goal area, a *free ball* repositioning is made. See Section 3.8 for details on goalkeeper kicks and free balls.

3.7 Fouls

A foul will be called for the following cases. In each case the subsequent action is indicated. Refer to Section 3.8.

3.7.1 Collision

Colliding with a robot of the opposite team, either intentionally or otherwise. The referee will call such collisions that directly affect the game or that appear to have potential to harm a robot. If the collision is called by the referee outside the goal areas a *free kick* will be awarded to the team whose robot has been charged/pushed. If the collision is called inside the goal area a *penalty kick* will be awarded. Note that it is permitted to push the ball and an opponent player backwards provided the pushing player is always in contact with the ball.

3.7.2 Goalkeeper Push

It is only permitted to push the goalkeeper robot in the goal area if the ball is between the pushing robot and the goalkeeper. However, pushing the goalkeeper into the goal along with the ball is not allowed. Subsequently, if the goalkeeper is pushed directly, or if the goalkeeper is pushed along with the ball into the goal area as described, then the referee shall call a foul and award a *goalkeeper kick* to the defending team.

3.7.3 Obstruction

The goalkeeper is the only defender allowed in the goalkeeper area at all times. If another defender is present within the goalkeeper area whilst the ball is in the defender's goal area, an obstruction is called and a *penalty kick* is awarded to the attacking team.

3.7.4 Offside

Only one attacker is allowed into the opposition's goalkeeper area at any point in time. If two attackers are present in the goalkeeper area, the second attacking player is called offside and a *goalkeeper kick* is awarded to the defending team.

3.7.5 Handling

It is referred to as handling when a robot other than the goalkeeper catches the ball. A ball is considered to be caught by a robot if 30% of the ball is out of view from the top or sides and is held fast and held in such a way that it is not possible for other robots to take possession of the ball. If a robot other than the goalkeeper catches the ball or if the goalkeeper catches the ball whilst outside its goal area, the referee will call that robot for handling. If a handling foul is called outside the goal areas a *free kick* is awarded. If the handling foul is called inside the goal areas a *penalty kick* is awarded.

3.7.6 Touch

If any human from either team should touch the robots against the referees permission, a *penalty kick* will be awarded to the opposing team. Note that only one person from each team may touch the robots when given permission by the referee.

3.8 Actions

The following actions for the previously described interruptions are outlined in detail here. Where robots are required to be repositioned, the task may be done by either the designated human handler or autonomously via command from the remote computer as described in Section 3.4.1. In all cases, resumption of play is signalled by the referee blowing a whistle.

3.8.1 Free Kick

When a free kick is awarded, all robots must immediately halt. The referee then places the ball at the position where the call was made. The team that was awarded the free kick may place the involved robot behind the ball. Any other robots must move at least 1m away from the ball. Upon signal from the referee, play restarts and the robots may move freely.

3.8.2 Penalty Kick

When a penalty kick is awarded, all robots must immediately halt. The referee places the ball in the centre of the semi-circle attached to the goal area in which the penalty occurred. The attacking team is then allowed to move one robot (the kicker) behind the ball. All other attackers must move behind the free ball marks. The defending team may then move the goalkeeper into position anywhere in the goal area so long as one part of the goalkeeper remains in touch with the goal line. All other defenders must move outside the goal area. Upon signal from the referee, play restarts and the robots may move freely. If a goal is scored, play resumes with a kick-off.

This rule ensures the attacking team obtains the penalty advantage whilst also simplifying and speeding up the penalty kick process.

3.8.3 Goalkeeper Kick

When a goalkeeper kick is called, all robots must immediately halt. All robots from both teams except for the defending goalkeeper must move out of the goal area. The defending team may then position the ball and the goalkeeper anywhere inside the goal area. Upon signal from the referee, play restarts and the robots may move freely.

3.8.4 Throw-in

When a throw-in is called, the referee or assistant referee will collect the ball and return the ball to the field of play as quickly as possible. There will be no stoppage in play. When returning the ball to the field of play, the referee will endeavour to roll the ball back onto the field at exactly the point (or as close as is feasible) where the ball left the field of play. When rolling the ball back onto the field, the direction should be perpendicular to the sideline (touch line or goal line) and with enough force so that the ball will travel approximately 1-2m in from the touch line if left untouched.

This rule has been implemented in this way to ensure smooth progress of the game with as few stoppages as possible.

3.8.5 Free Ball

When a free ball is called, the referee repositions the ball as swiftly as possible on the closest available free ball mark. See the diagram labelling field markings in the Appendix. Note that play is not stopped in these instances.

3.9 Appendix

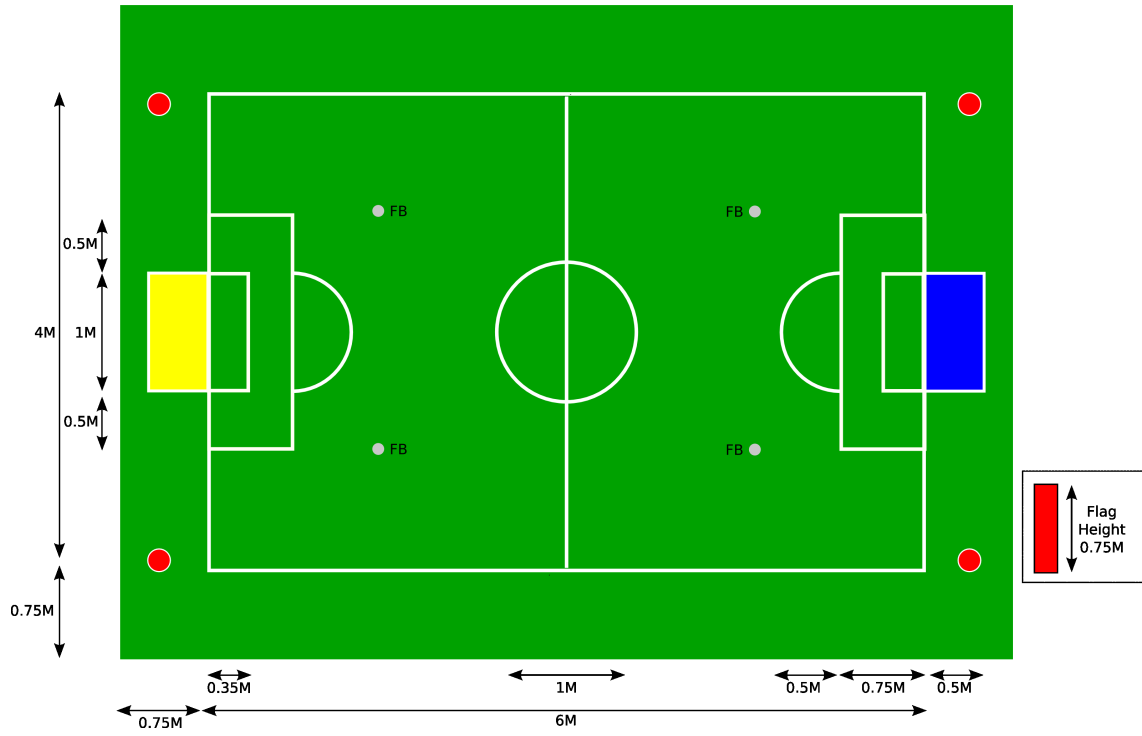


Figure 1: Field Markings