RoboSoccer Analysis

B.Tech Project

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RoboSoccer Analysis

Part I: Various kinds and Complexities

Introduction:

RoboSoccer has always been an integral part of the development of Robotics around the globe and as such, has been growing at a variable pace throughout.
Today this field harbors the curiosity of a vast range of people with experience starting from that of a beginner, all the way to that of a professional. As a result, one can find various kinds of robots with the specific goal of entertainment through the means of soccer.

This report shall try to cover all the different types of RoboSoccer Bots of varying complexities and applications along with the different methods of handling and their difficulties.

Manually Handled Bots:

The robots playing soccer whose movements are directly monitored and handled by a person are of the category of manual bots. These bots are majorly differentiated over the method of handling, i.e, either wired or wireless.

Regardless of the method of handling, these bots can also be assistive with the use of an active webcam to help the handler.

Wired Manual Bots:

The most common type of wired manual bots come under the category of manual differential drive bot. These types of robots are controlled using DPDT switches and handled from a distance over long cables.

The motors used are usually high powered dc motors and as such, to activate these motors, high voltage is required which is neither safe nor possible through a handheld controller. To overcome this difficulty, relays are used as intermediary switches which can be activated at a lower voltage and can supply a higher voltage to the motors as required.

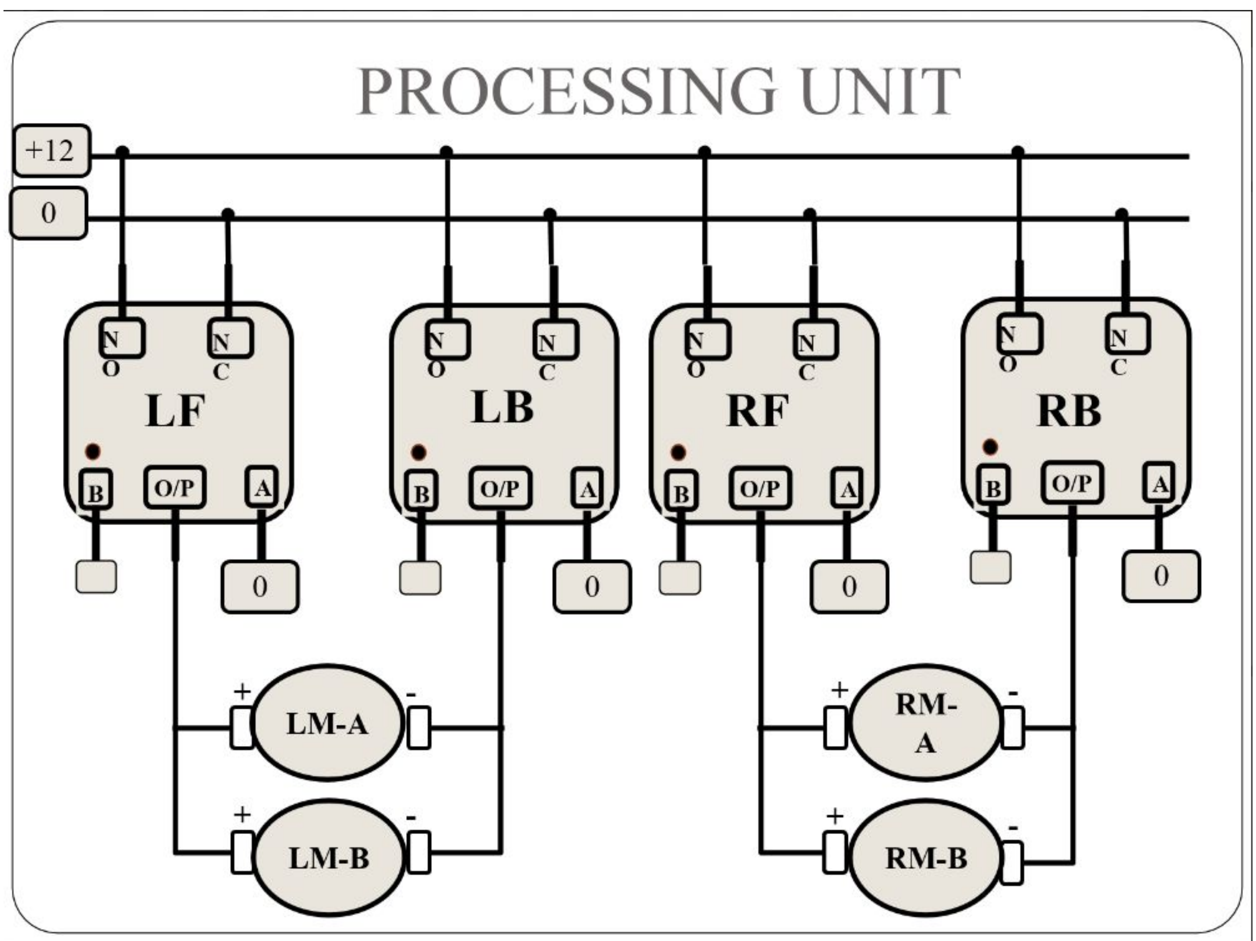


Fig: Simplified circuit for control of motors using Relays

Working:
The above figure shows a simplified circuit for controlling the bot.
The Key is: **L** - Left, **R**- Right, **F**-Forward, **B**-Backwards.
As such for the forward movement, the relay LF and RF should be activated.
Additional Modifications:
To better handle the tackling of opponents as well as capturing of and taking control of the ball, some additional modifications are also used. Usually, some type of contraction is added in the front and additional weight is added to provide better stability albeit bounded by the rules of the tournament.

Difficulties:
The major difficulties faced by these types of bots pertains to the controlling method. These are wired bots and hence not autonomous and the length of the wire, as well as their tangibility, also takes a major role in defining the ease of handling.

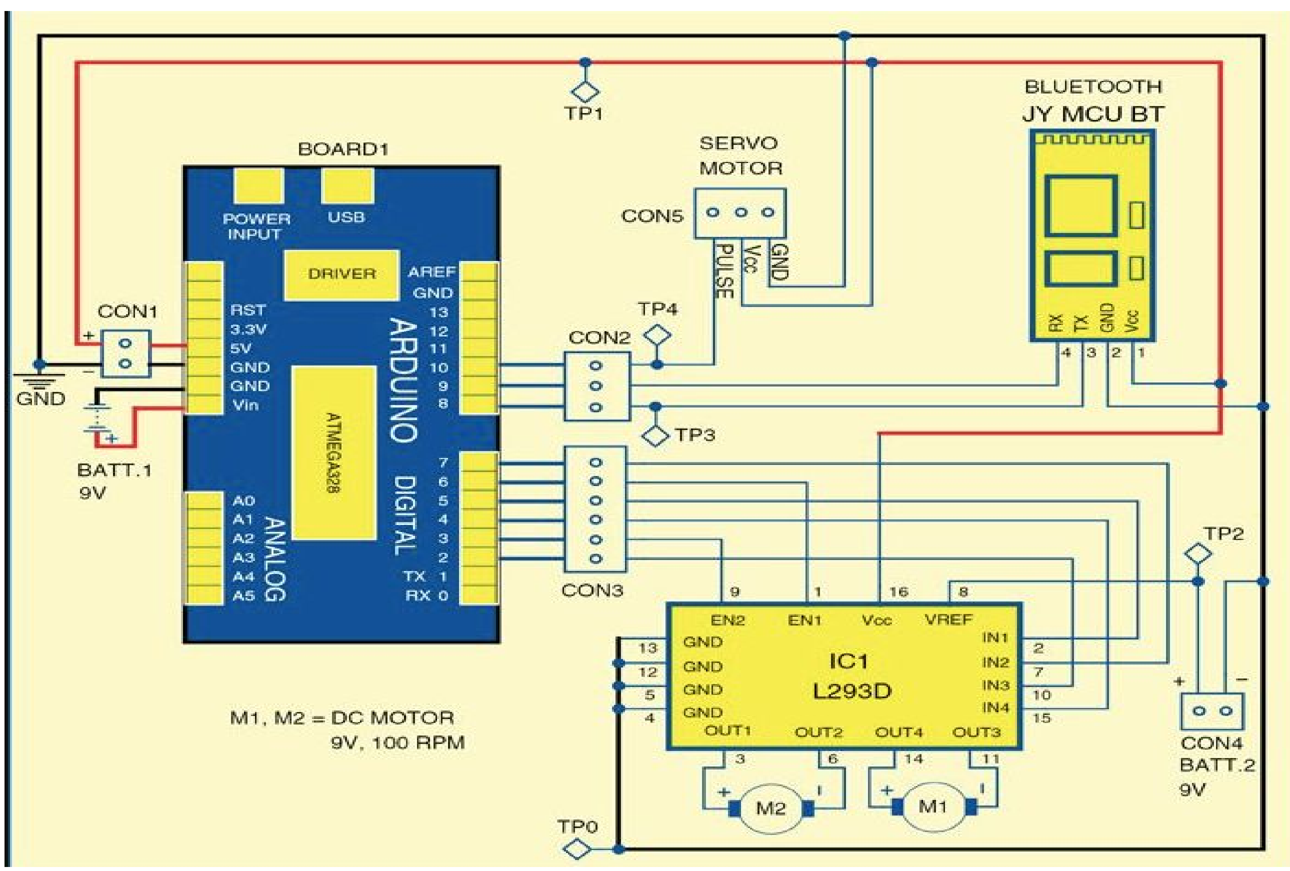
Wireless Manual Bots:

These types of bots try to tackle the difficulties of its predecessor and limit the usage of wire as a medium to control the bot. It still operates the umbrella of manual bots as it is actively controlled by a user but the instructions for movements are provided wirelessly in realtime.

The most common medium for easy wireless transmission is Bluetooth and RF Transmitter. While Bluetooth does require an additional controller to be used for encoding and decoding, usually Arduino and a smartphone as a controller, RF Transmitter can work without one as long as the instruction set for the movements are not too complex.

Bluetooth:

This soccer robot can move forward, reverse, forward-left, forward-right, reverse-left, and reverse-right with the help of an Arduino. The speed of its movement is controlled by the angle of rotation of the phone. The robot also kicks a ball when the phone is shaken.shown below is the circuit of the soccer robot. The circuit is built around an Arduino UNO board, a servo motor Bluetooth module motor driver, and two DC motors.



Functioning of the bot-

As most smartphones contain an accelerometer sensor. A phone with an accelerometer can detect the angle it is being held at. It can also detect rotation and motion gestures such as swinging, shaking, and flicking. The accelerometer can detect whether the phone is upright or sideways, and automatically rotate the graphics on the screen accordingly. Another common use is in controlling games and other applications (such as music players) by moving or shaking the phone. When the phone is rotated in different directions, x,y,z values of accelerometer sensor change. The Phone for this project sends these x,y,z values to the robot via Bluetooth.

The phone sends the sensed data from the accelerometer of the phone to the robot via Bluetooth. Data transmitted by the phone is received by the Bluetooth module on the robot. The received data is fed to a pin of BOARD. The microcontroller on BOARD processes the received data and drives the motors accordingly. The robot also sends back the status.

Difficulty-

The major difficulty in these types of bots is that the power transmission is quite low as is reduces considerably with distance.

The data is also sent through a smartphone and thus poses as an additional requirement.

Autonomous RoboSoccer Bots:

The robots that do not need an active instruction guide for their movement come under the umbrella of Autonomous bots. These bots are given some set of instructions under which they act to complete the task at hand. The majority of these bots use the techniques of image processing to further improve their efficiency.

Raspberry Pi

Robots are thought to understand and interact with the real world through sensors and machine learning processing. Image recognition is one of the popular ways in which robots are thought to understand objects by looking at the real world through a camera just like we do. In this project using **the power of Raspberry Pi to build a Robot that could track the ball and follow it just like the robots that play football.** OpenCV is a very famous and open-source tool that is used for Image processing, but in this project to keep things simple, **the Processing IDE** is used. processing for ARM has also released the GPIO library for processing. will not have to shift between python and processing anymore to work with Raspberry Pi. Two libraries used in these projects are **Hardware I/O** `and` **GL Video**.

Working of bot - Although the intention of the project is to track a ball, they are actually not going to do it. they are just going to identify the ball using its colour. because videos are nothing but continuous frames of pictures. So they take each picture and split it into pixels. Then they compare each pixel colour with the colour of the ball; if a match is found then we can say that we have found the ball. With this information, identifying the position of the ball (pixel colour) on the screen is done. If the position is far left we move the robot to right, if the position is far-right we move the robot to left so that the pixel position always stays at the center of the screen.

Implementation- Connect your Pi to monitor and launch the processing code. video-feed Should be visible on a small window on the screen. Now, bring the ball inside the frame and click on the ball to teach the robot that it should track this particular color. Now move the ball around the screen and you should notice the wheels rotating. If everything is working as expected, release the bot on the ground and start playing with it. **The room should be evenly illuminated** for the best results.

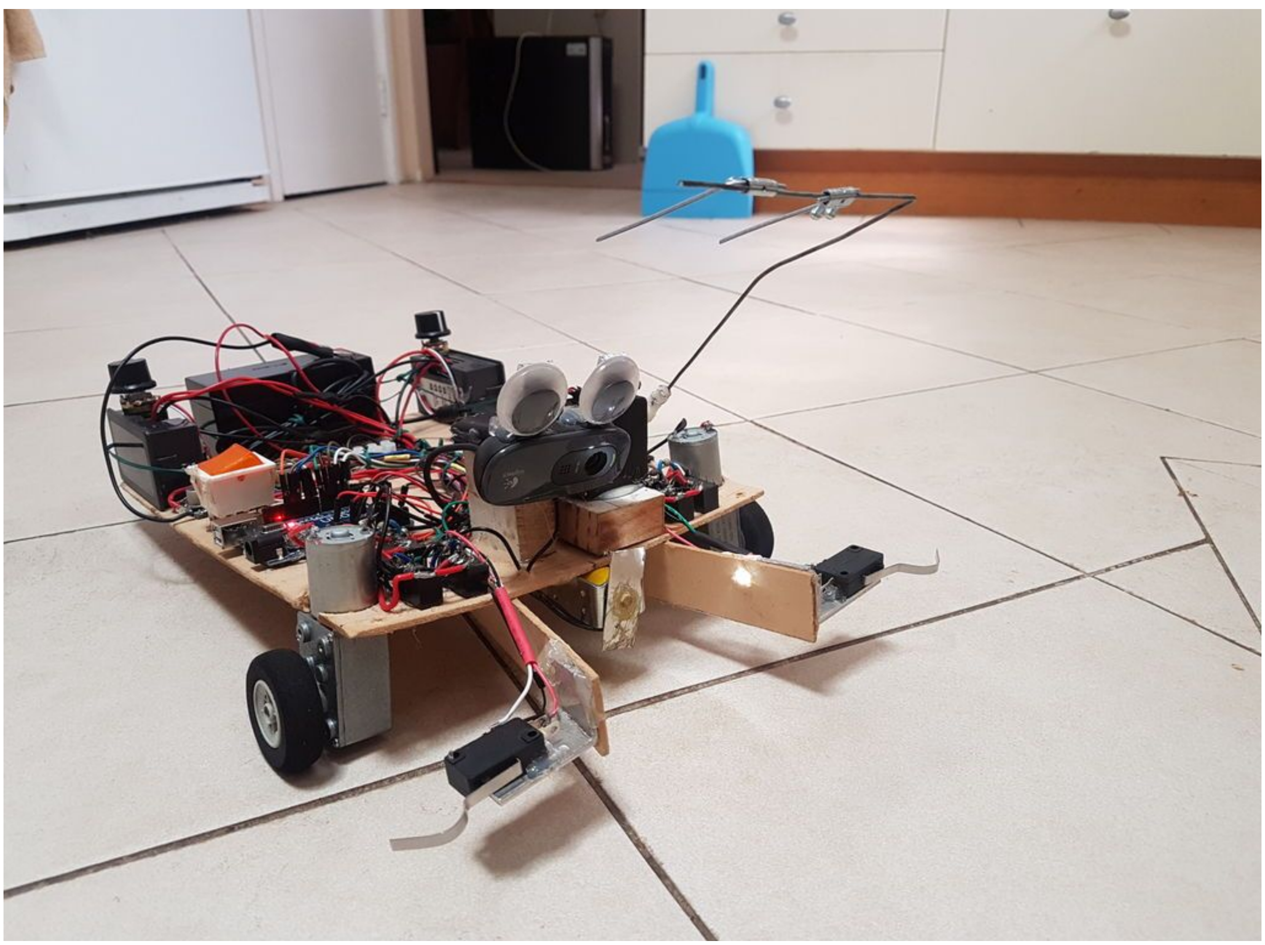
Difficulties-

- Difficulty in recognition of the object if the object is not of contrasting color with the background.
- Using only Raspberry Pi for controlling the movements as well as processing slows down the bot a lot as the bot requires continuous input and output to the motors for proper chasing and capturing of the ball.

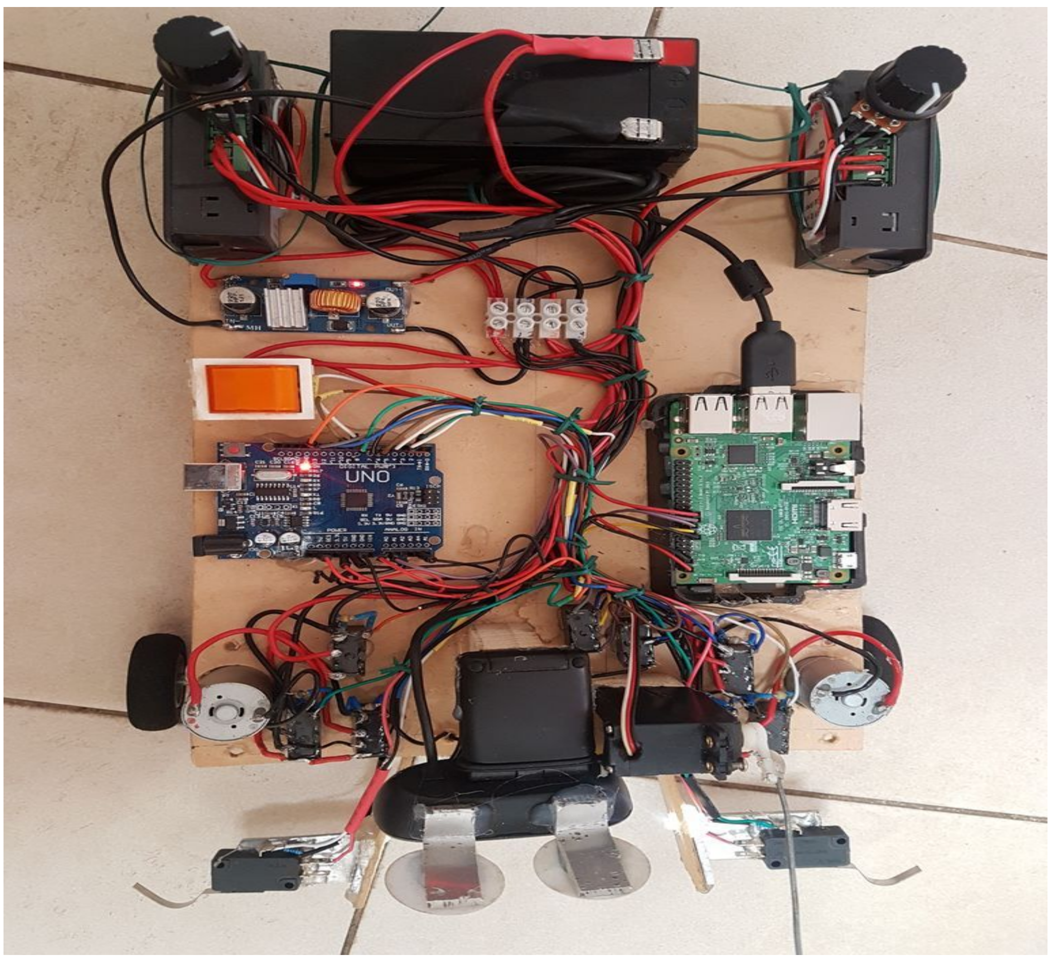
<u>**Raspberry Pi + Arduino**</u>

Functioning:
The concept for this project is to create an autonomous soccer-playing robot (as it requires no human controller input). The robot searches for a ball using the rpi camera. The color(different from the environment) should be specified so that the bot can identify the ball among the surrounding. It tries to center and move to the ball itself, capturing it via an LDR enabled trapping arm. This robot then searches for the goal, the goal can be set using a different color and kicks towards the goal (via a solenoid).

A raspberry pi running an OpenCv python program takes in information from the RPi camera and acts as the brains of the robot. An Arduino is used to control the DC motors, kicking solenoid, and trapping servo.



Implementation: The python code runs OpenCV to transform a normal RPI camera image into a black and white image highlighting the location of a certain color. If the ball is not visible the robot rotates in either direction until it finds it again. The area and x position of this transformed image is calculated and used to determine how close the robot is to the ball. If it is too far away then the robot moves towards or rotates to try and center the ball.
When the ball gets close enough it casts a shadow on the LDR, which is implemented using an LED, which in turn causes the trapping arm to come down controlled by the Arduino. This sends a signal back to the raspberry pi which transitions the robot into goal finding mode, which is just to locate another color.
The robot then moves with the ball until the goal color is a certain size and centered, then the raspberry pi sends a signal to the Arduino that the soccer bot should kick. The Arduino then raises the catching arm, actuates the 5V relay which causes the solenoid to fire, kicking the ball to the goal. The loop then continues indefinitely.



Difficulties :

- A robot cannot snatch the ball once it is captured by another robot.
- If there is an object of the same color as ball or goal then the robot might not be able to differentiate between the object and ball (or goal).

RoboSoccer Analysis

Part II: Communication Methods and Strategies

Introduction:

An integral and necessary part of anything that needs a team needs to have effective communication amongst its members and this philosophy transcendents into robotics as well, where any project with more than one robot needs an effective way of communication and hence a proper communication protocol.

Communication, or rather ways to communicate, would result in nothing if it is unknown what is the objective of communication and what is it that is to be communicated.
That is to say that without a proper and common goal in the mind, any perfect team might not be able to demonstrate its true capabilities and that is where Strategies play an important role.

This report shall try to cover all the different types of Communication Protocols, Technologies, and Strategies, that are applicable in the field of RoboSoccer, of varying complexities and applications along with the different methods of handling and their difficulties.

Wired Communication Protocols:

There exist a plethora of communication protocols that need a physical medium such as a wire to send and receive data in their defined formats such as industry standardized EtherNet, ControlNet, MODBus, etc. but are not feasible for application in the field of wireless and autonomous moving robots and therefore would not be discussed further in this report.

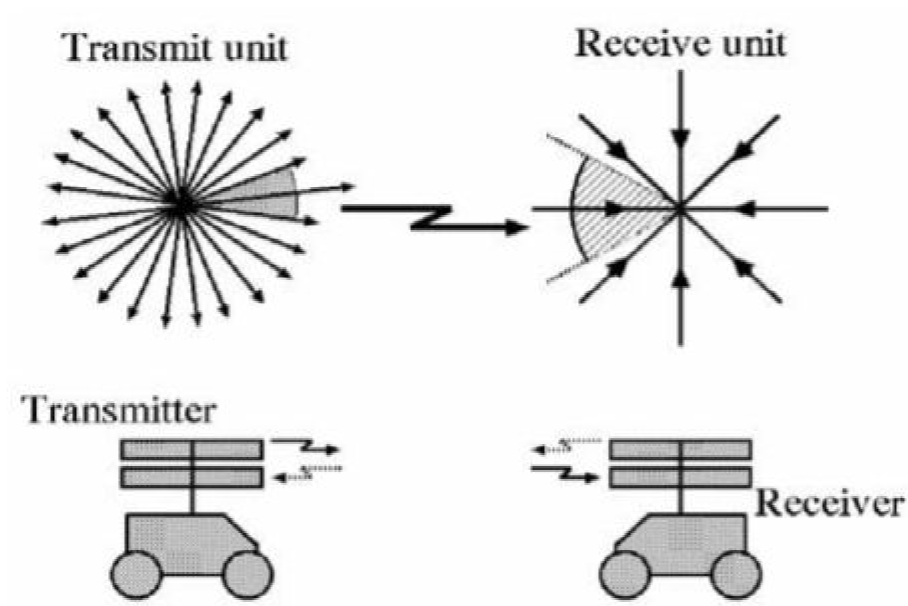


Fig: Inter - Robot Communication

Wireless Communication Protocols and Technologies:

As for robots that have fixed and specified tasks designated to them, and in order for their proper function, needs to communicate either amongst other robots or with a central control unit, there are many suitable and reliable methods of communication that are often used in conjunction with one another to get the desired results.

Machine Learning Assisted Object Detection

A simple yet effective way of communicating a robot's current location and distance to another bot is through object detection. The basics of Object detection consists of Representation, how to represent an object, and Recognition, to recognize the represented object.
Object detection is usually done using video sequence by the process of detecting the moving objects in frame sequence using digital image processing techniques.

This process can be highly optimized and improved with the assistance of machine learning and introducing a learning step in between Representation and Recognition.
A simple example is to use the Gabor filter for the target robot features representation alongside a supervised learning method of support vector machine (SVM) that is used for classification and recognition of the target robot.

Note: In image processing, a Gabor filter, named after Dennis Gabor, is a linear filter used for object detection. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave. The Gabor filters are self-similar: all filters can be generated from one mother wavelet by dilation and rotation. A set of Gabor filters with different frequencies and orientations may be helpful for extracting useful features from an image

Support Vector Machine
A support vector machine (SVM) is a concept in computer science for a set of related supervised learning methods that analyze data and recognize patterns, used for classification and regression analysis. The standard SVM takes a set of input data and predicts, for each given input, which of two possible classes. The input is a member of, which makes the SVM a non-probabilistic binary linear classifier.

ZigBee

ZigBee is a rather new wireless technology that looks to have applications in a variety of fields. ZigBee is a technological standard based on the IEEE 802.15.4 specification for low data rates in the industrial, scientific, and medical radio bands. The technology allows for devices to communicate with one another with very low power consumption and enables them to run on simple batteries for several years.

The vision from a bot can be processed on board as well as remotely on a control unit. The data from the bot as well as the instructions to the bot use ZigBee as its communication medium. ZigBee also allows for inter robot communication which results in faster instruction processing.

ZigBee is the only standards-based wireless technology
designed to address the unique needs of low-cost, low-power, long battery life capability, robust security, and high data reliability for wireless sensor and control networks. ZigBee also connects the widest variety of devices into easy-to-use networks, giving unprecedented control of the used devices.

Dedicated Short Range Communication (DSRC)

DSRC is based on the 802.11 family of Carrier Sense Multiple Access with Collision Avoidance (CSMA-CA) protocol. In this protocol, the device listens to the channel before sending a packet, and any packet is sent only if the channel is clear.
Originally, DSRC was designed for autonomous automotive but due to its capabilities in the short-range, it can be easily used for scaled-down models and robots.

WiFi

WiFi is one of the most popular wireless communication technologies in the industry which are compliant to IEEE 802.11 standards.

It can be easily added to a bot with the help of a wireless module, usually 2.4GHz, which is compliant to WiFi standards and helps convert the radio signals to digital data.
An additional feature of WiFi is that it can not only be controlled remotely in the local area network but can also send and receive data over the internet.
WiFi also reduces the complexity of the overall project as most devices would already be equipped with WiFi compliant modules.

InfraRed Sensor System

Another simple technology is the InfraRed Sensor System. It is easy to understand and implement. A transmitter in your controller transmits IR light (or pulses) and an IR receiver on your robot receives the signal, which is decoded with the help of a microcontroller. IR requires a line of sight control and best suited for applications that require a shorter control range. However, care must be taken while designing IR transceivers, because the sunlight, or any heat-generating objects gives out infrared light.

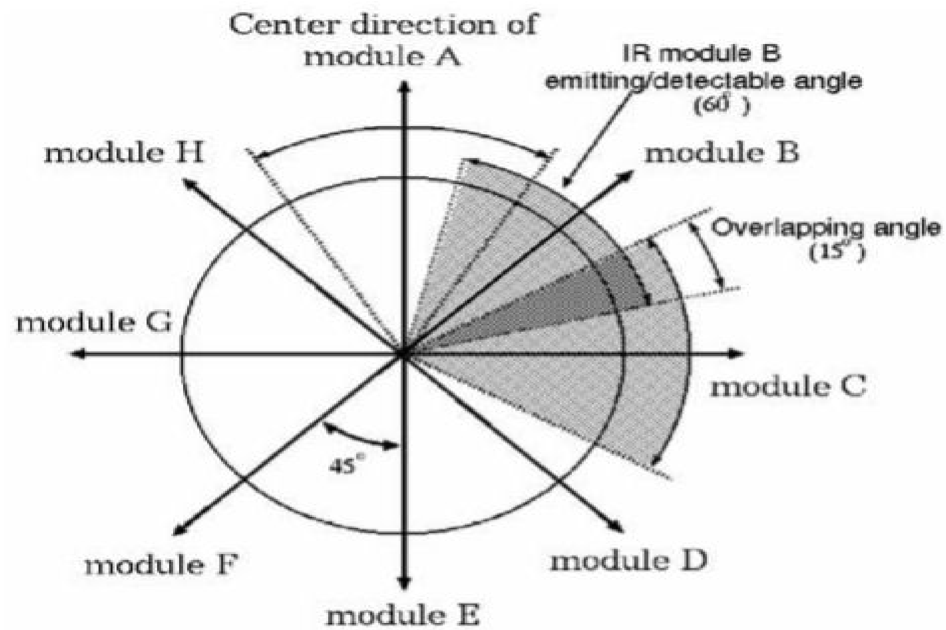


Fig: Arrangements of the Transceivers

The IR system can be just utilized for sending and receiving data amongst the bots or can be developed to improve localization of other bots as well. This can be done using a space-division optical wireless inter-robot communication system for multiple mobile robots. Infrared optical wireless communication is suitable for mobile robots, because of its low level of interference in multiple directions. However, optical wireless communication is lost when either of the robots runs and/or rotates due to the nature of infrared rays. The proposed communication system has a set of infrared transceivers, which face all directions. The system can maintain circuit connections by exchanging transceivers. Furthermore, it can communicate at the same time with more than one robot in different positions by using different transceivers.

Additional Assisting Components:

Additionally, a few more components can be added to the robot for better localization and communication of the bot such as a Compass System.

An electronic compass TDCM3 is placed on the top center of the robot to obtain the terrestrial magnetism data. The terrestrial magnetism data is invisible in nature. Based on the obtained compass data, the direction of the soccer field and the main direction of the robot are determined. In the self-localization design, the environmental information about the field obtained from the compass system and the vision system are considered simultaneously so that the strategy design is more flexible.

Various RoboSoccer Strategies

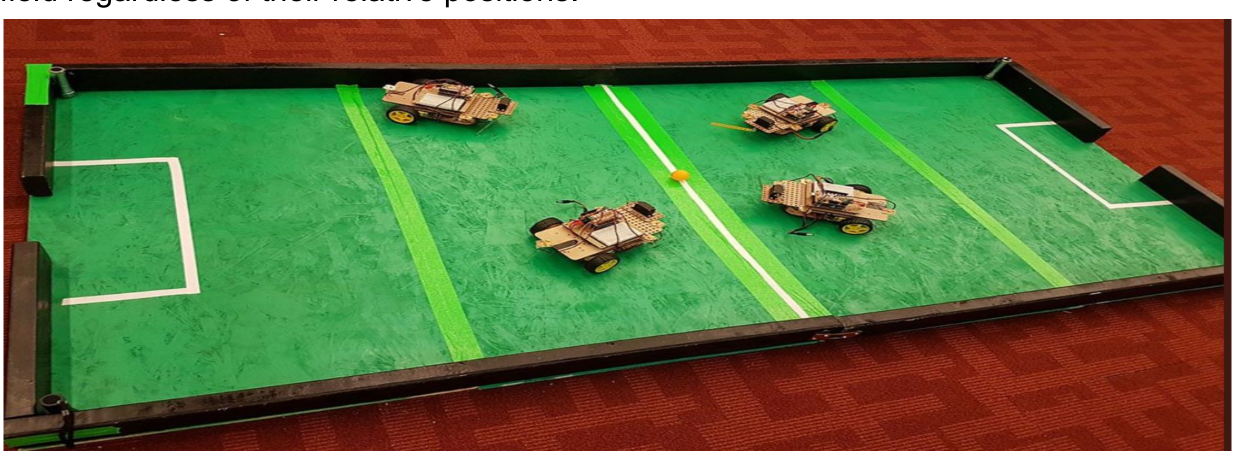
In recent years RoboSoccer, as a field of robotics and sports, has seen a lot of growth. This has resulted in an outburst of enthusiasts who want to compete and test their abilities against the world, which transformed into numerous ideas and innovations, from fairly simple, all the way to humanoid level complexities, diversifying and improving as they progress.
Most of the strategies can be implemented with or without remote processing. Some of the basic strategies that are widely used in the field are as follows:

Score the Goal

This very basic strategy is to just obtain the ball and push it towards the Goal. This kind of strategy requires a minimalistic bot without any inter-robot communication method, with just basic detection techniques to capture the ball.

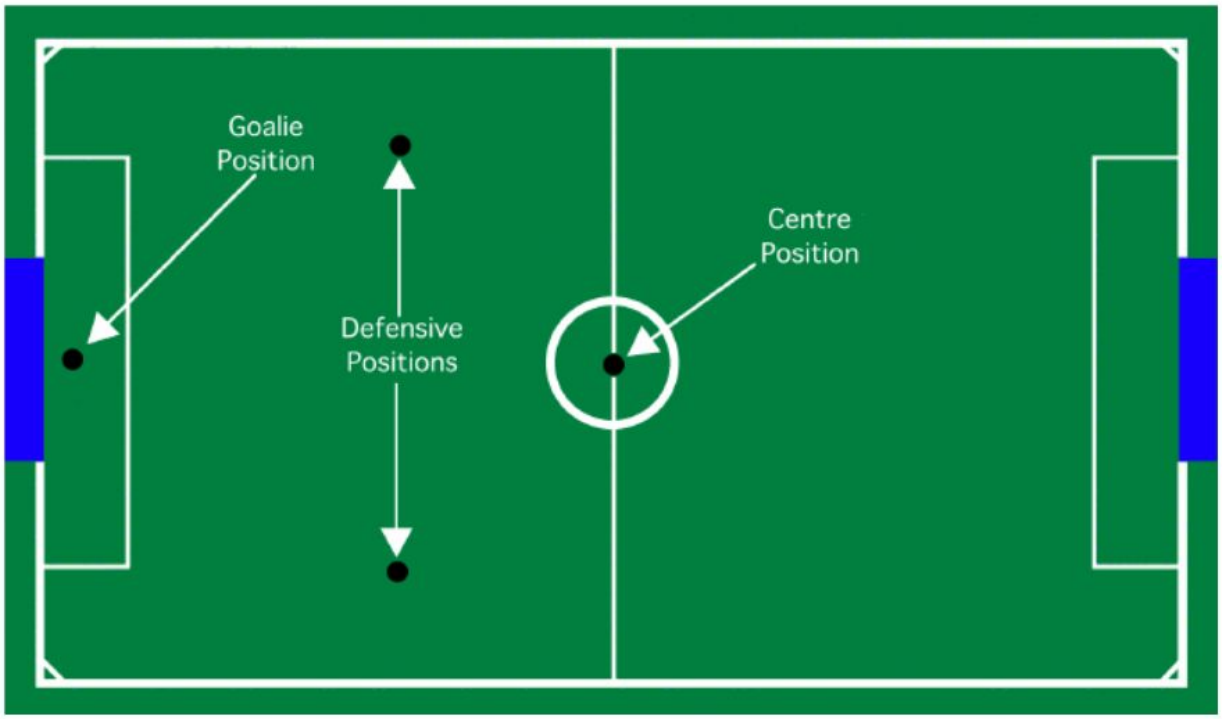
Nearest Target

This strategy improves upon the previous one by adding inter-robot communication in its arsenal.
It optimises the ball-obtaining task by instructing the robot that is nearest to the ball, avoiding unnecessary collision of teammates.
When the ball is in possession, it can process whether a teammate is closer or the goal and pass the ball accordingly.
The inter-robot communication can be implemented using any of the previously stated technologies like ZigBee and the process of the visual data can be done remotely or onboard using various microcontrollers like NSP or Raspberry Pi.
This type of arrangement assumes that each of the bots is having a common role in the field regardless of their relative positions.



Knowledge-Based Role Allocation - KOBRA

Increasing the complexity of Nearest Target, this strategy inherits the roles of players from real-life soccer and integrates positional roles to the robots.
The addition of various roles restricts the number of operations a bot might perform in a particular situation and hence drastically optimizing their processing speed.
Roles may have variations depending on the bot to run as well as compatibility, objectives, and their own algorithms. The prospective roles are Cover, Ball Attack, Defender, Barrier, Defensive Penalty, and Offensive Penalty.

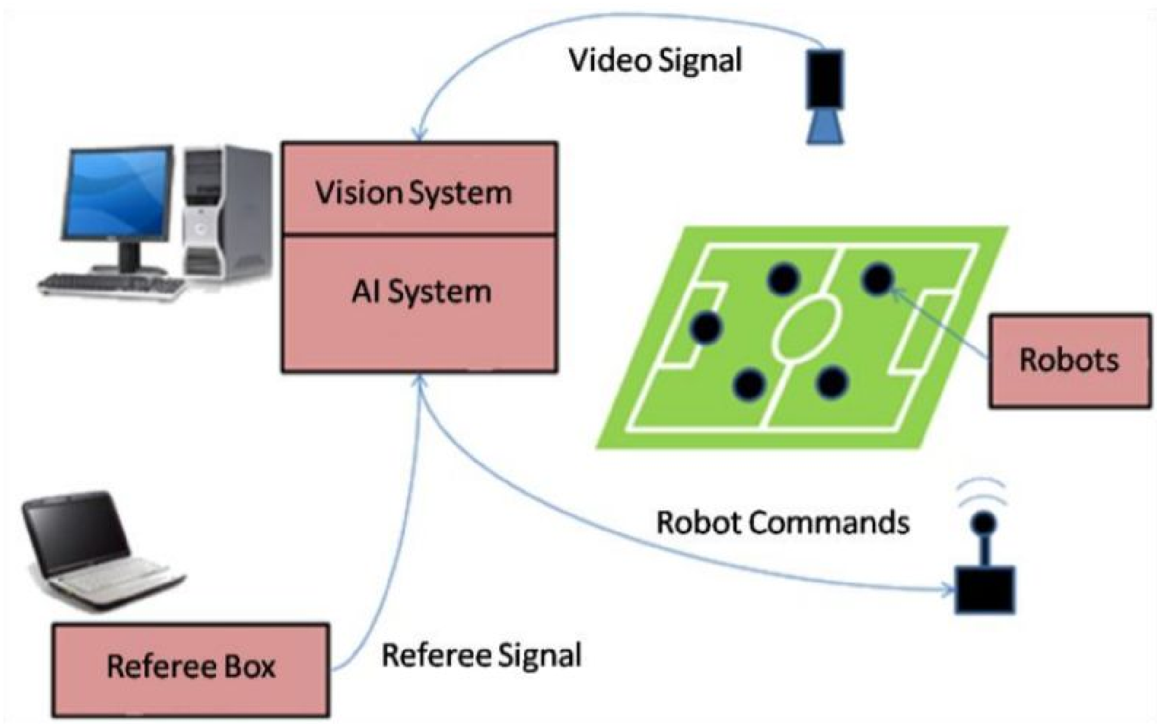


An illustration of the positions used by the KOBRA system roles on the robot soccer playing field.

One feature of KOBRA is that by changing the roles assigned to the robots and the priority of those roles, KOBRA can be used to implement different strategies.
These strategies can be used to make the team perform differently in its entirety based on the state of the game and improve the performance of the team
The defensive strategy is designed to protect the goal at all costs and try to force the ball back over to the other side of the field. The offensive strategy is designed to take more risks and to attack the enemy's goal more aggressively. The offensive strategy also keeps some robots back to defend the goal should the attack on the opponent's goal be unsuccessful.
KOBRA decides which strategy to use by analysing the positions of the robots in relation to the ball and the goals and determines threat values for each robot.

Introducing Artificial Intelligence

Along with using machine learning to improve object detection, Artificial Intelligence is also implemented to further improve the gameplay of the team.
Most of the strategies that come under the umbrella of using assisted computation, need the help of an extra remote control unit, to handle the processing while still remaining autonomous.



The advantage of using AI is the ability to predict the movement of the ball and the opposing team based on past experience.

Furthermore, it improves the detection and avoidance of obstacles using the study of the path.
This study is to determine if the path that will take the agent is positioned by one or more robots and how far is the agent.
Within the algorithm there are several cases:
Case 1: The agent has one or more obstacles but is located a long distance.
In this case, there are obstacles in the path of the agent, but they are not coming, then the agent follows its normal path, hoping that the obstacle will disappear or be closer to take evasive action.
Case 2: The agent has one or more nearby obstacles.
In this case, the obstacles satisfy the condition of closeness and need to avoid them. To evade two points are generated perpendicular to the path equidistant from obstacle position. This creates a change of a target position of agent that is generated by a point closest to the target. This position is held until the agent stops detecting the obstacle, to reallocate the original target position.

These kinds of strategies can be implemented via additional hardware that is probably supported in the field to provide extra visual information.

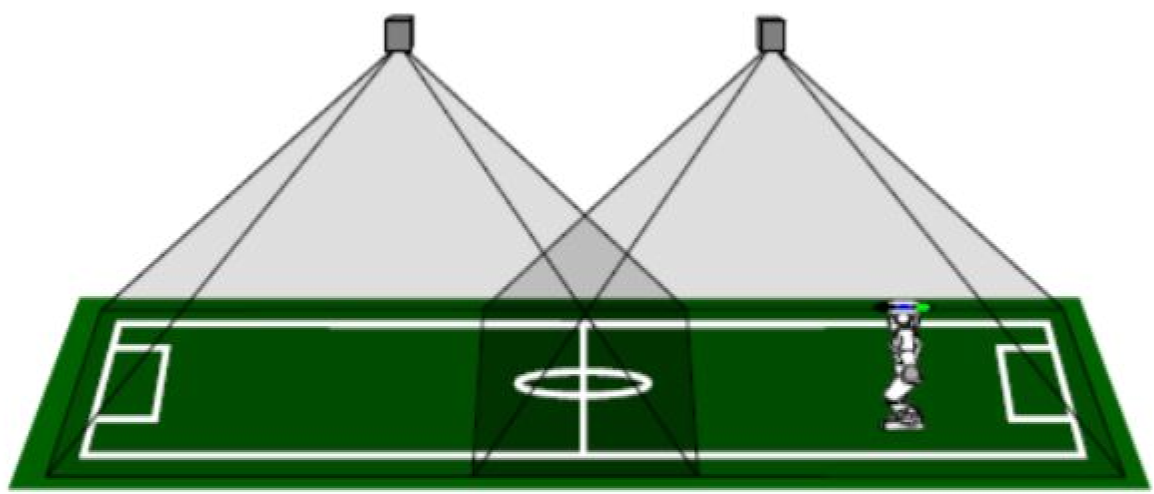


Figure 1: Illustration of how the camera should be placed. In real situation both camera are placed over the goal line.

RoboSoccer Analysis

Part III: The Past, The Present and The Future

Introduction:

The Field of RoboSoccer has seen interest and development for over two decades, but its speed is nowhere near to be slowed.
RoboSoccer has grown, both in technical areas as well as a community. Where in the Past, any feasible path of entertainment was limited and even difficult in terms of team play, it is now very well-considered normal to have multiple bots in sync, autonomously handling complex tasks which would have required a room-sized computer a few decades ago. Not only the technical aspect but in terms of community, there are now many competitions, even on the international level as a branch of sports, with all of them having a common goal for the future, Humans versus Robots.

This report would try to provide a brief overview of what is the current pace of RoboSoccer as a field of Interest, with competitions pushing it further, as well divulge into what the future might hold.

The Past

In 1997, when IBM Deep Blue defeated a Chess GrandMaster, RoboCup was organised as the first-ever international event for RoboSoccer, with over 40 teams.
The idea of robots playing soccer was first mentioned by Professor Alan Mackworth (University of British Columbia, Canada) in a paper entitled “On Seeing Robots” presented at VI-92, 1992. and later published in a book Computer Vision: System, Theory, and Applications, pages 1-13, World Scientific Press, Singapore, 1993. A series of papers on the Dynamo robot soccer project was published by his group.

Independently, a group of Japanese researchers organized a Workshop on Grand Challenges in Artificial Intelligence in October 1992 in Tokyo, discussing possible grand challenge problems. This workshop led to a serious discussion of using the game of soccer for promoting science and technology. A series of investigations were carried out, including a technology feasibility study, a social impact assessment, and a financial feasibility study. In addition, rules were drafted, as well as prototype development of soccer robots and simulator systems. As a result of these studies, the researchers concluded that the project was feasible and desirable. In June 1993, a group of researchers, including Minoru Asada, Yasuo Kuniyoshi, and Hiroaki Kitano, decided to launch a robot competition, tentatively named the Robot J-League (J-League is the name of the newly established Japanese Professional soccer league). Within a month, however, they received overwhelming reactions from researchers outside of Japan, requesting that the initiative be extended as an international joint project. Accordingly, they renamed the project as the Robot World Cup Initiative, “RoboCup” for short

The Present

RoboCup

RoboCup is an annual international robotics competition proposed and founded in 1996 by a group of university professors. The aim of the competition is to promote robotics and AI research by offering a publicly appealing – but formidable – challenge.

The official goal of the project:

> **By the middle of the 21st century, a team of fully autonomous humanoid robot soccer players shall win a soccer game, complying with the official rules of FIFA, against the winner of the most recent World Cup.**

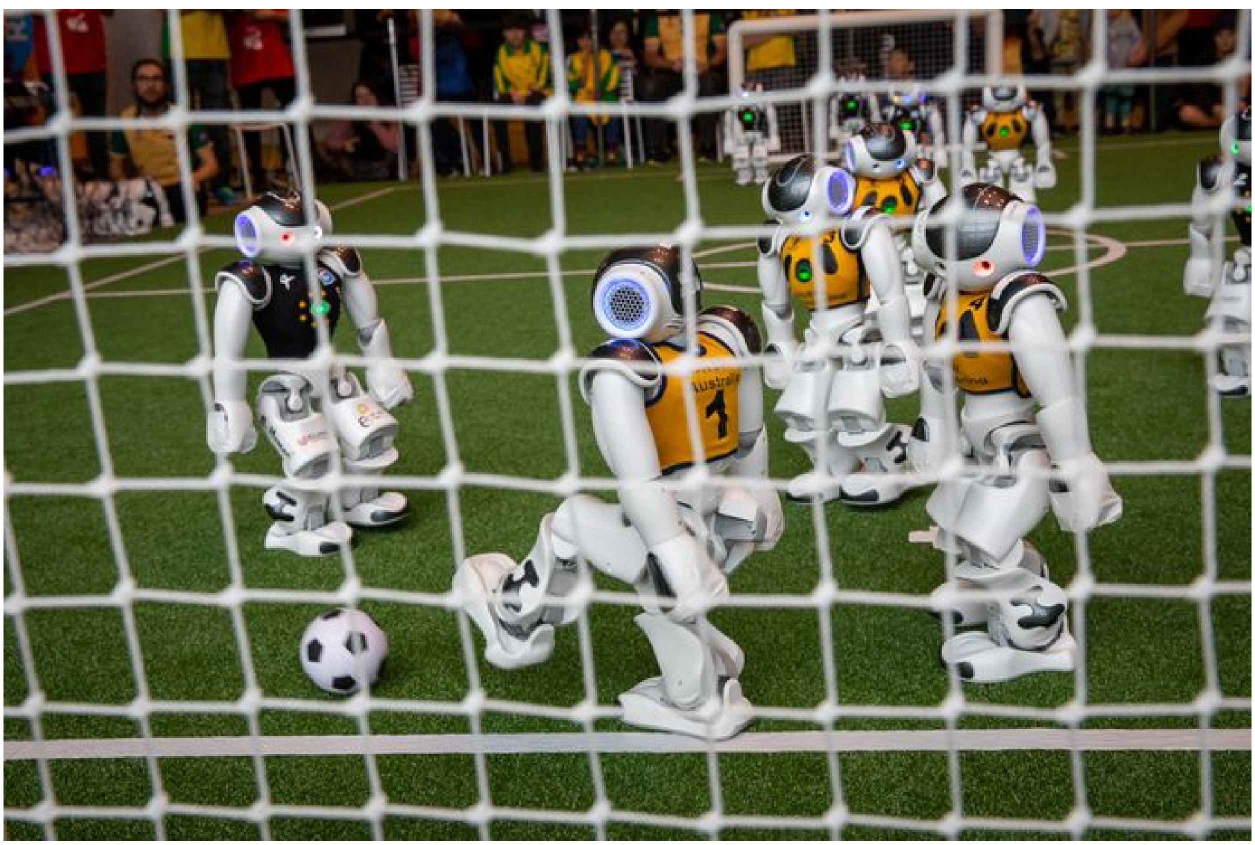
RoboCup is a research and education initiative. It is based on the attempt to promote intelligent robotics research by providing a standard problem where a wide range of technologies can be integrated and examined. In addition, RoboCup is being used for oriented educational projects. For a robot team that will be able to enforce a real soccer game, various technologies must be incorporated, including: design of autonomous agents, multi-agent collaboration and strategy acquisition in real-time, robotics and vision systems.
RoboCup is an activity for a team of multiple fast-moving robots under a dynamic environment. Although soccer is the standard problem, they will concentrate and integrate a wide range of efforts, competition is only part of the activity of RoboCup.

RoboCup has also been a favorite for the community as a testing ground for new ideas and concepts that might later define the very future of Robotics.
One such idea, which is now realized, is the Multi-Agent Planning System.
The system operates without explicit communication of strategy between agents, relying upon observation of team members to produce meaningful coordinated behavior. Each robot is coordinated with the others by MAPS choosing goal actions that most benefit the team.
The system was used on the UQ RoboRoos robot soccer team that came second in the small size league of RoboCup '98 in Paris and third at the Pacific Rim Series of RoboCup in 1998.

RoboCup has various kinds of Leagues that allow a team to strategize and develop in a particular way to improve their chance, as well as allow people from all levels of expertise to enjoy the experience.
The Leagues are divided as follows:

- **Standard Platform League (formerly Four-Legged League)**

  The RoboCup Standard Platform League is a soccer league where all teams participate using the same robot, the NAO robot from SoftBank Robotics. These robots play completely autonomously and each one takes decisions separately from the others, but they still have to play as a team by using communications. The teams play on a green field with white lines and goal posts, with no other landmarks, and the ball consists of a realistic white and black soccer one. These game characteristics generate a very challenging scenario, which allows improving the league every year.



- **Middle Size League**

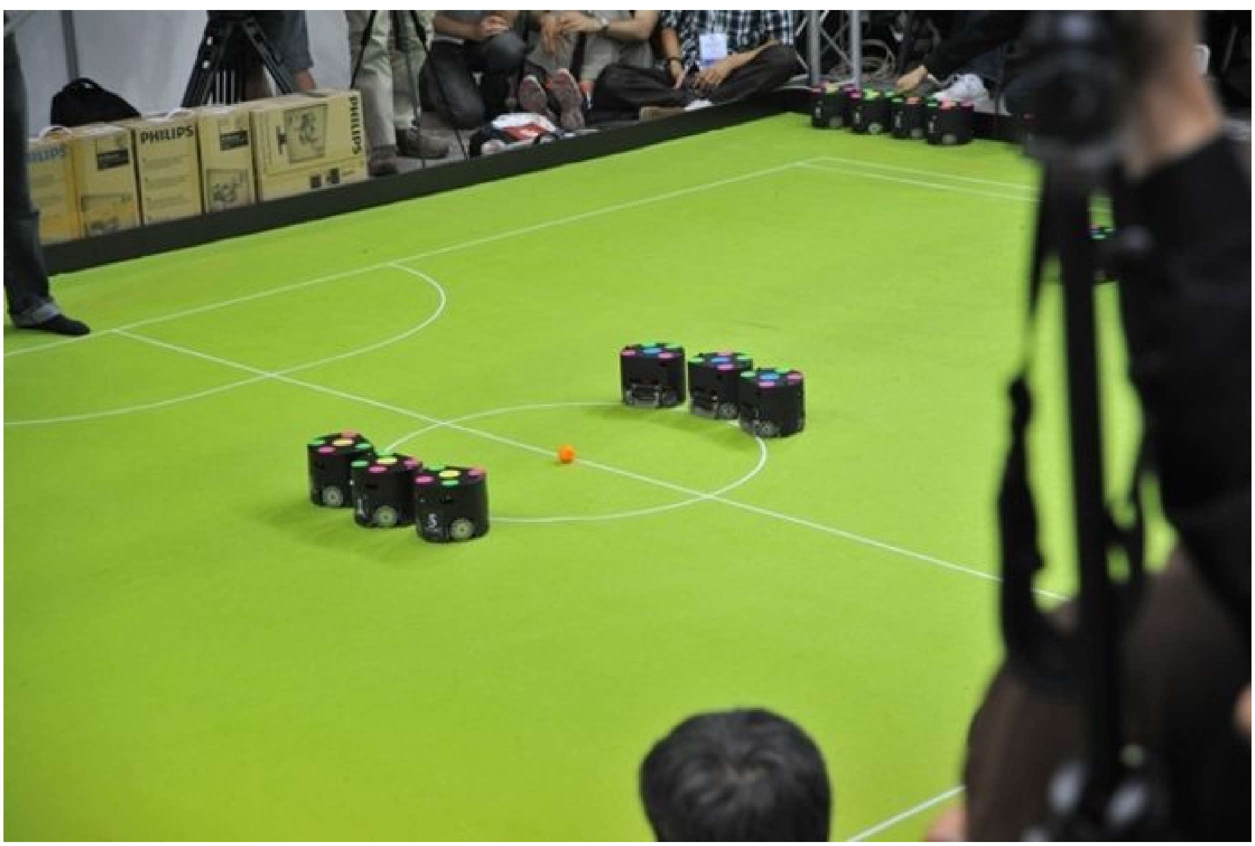
  In RoboCup middle size league teams of five fully autonomous robots play soccer with a regular size FIFA soccer ball. Teams are free to design their own hardware but all sensors have to be on-board and there is a maximum size and weight for the robots. The research focus is on mechatronics design, control, and multi-agent cooperation at plan and perception levels.

- **Small Size League**

The Small Size league or F180 league as it is otherwise known, is one of the oldest RoboCup Soccer leagues. It focuses on the problem of intelligent multi-robot/agent cooperation and control in a highly dynamic environment with a hybrid centralized/distributed system.

A Small Size robot soccer game takes place between two teams of six robots each. Each robot must conform to the dimensions as specified in the F180 rules: the robot must fit within a 180 mm diameter circle and must be no higher than 15 cm. The robots play soccer with an orange golf ball on a green carpeted field that is 9 m long by 6 m wide.
All objects on the field are tracked by a standardized vision system that processes the data provided by four cameras that are attached to a camera bar located 4 m above the playing surface. The vision system - called SSL-Vision - is an open-source project maintained by the league's community.

Off-field computers for each team are used for the processing required for coordination and control of the robots. Communications is wireless and uses dedicated commercial radio transmitter/receiver units.



- **Simulation League**

This is one of the oldest leagues in RoboCupSoccer. The Simulation League focus on artificial intelligence and team strategy. Independently moving software players (agents) play soccer on a virtual field inside a computer.
There are 2 subleagues: 2D and 3D

2D Simulation:

The RoboCup 2D Simulation Soccer League is the oldest of the RoboCup Soccer Simulation Leagues. It consists of a number of competitions with computer-simulated soccer matches as the main event. There are no physical robots in this league but spectators can watch the action on a large screen, which looks like a giant computer game. Each simulated robot player may have its own play strategy and characteristic and every simulated team actually consist of a collection of programs. Many computers are networked together in order for this competition to take place

.In the 2D Simulation League, two teams of eleven autonomous software programs (called agents) each play soccer in a two-dimensional virtual soccer stadium represented by a central server, called SoccerServer. This server knows everything about the game, i.e. the current position of all players and the ball, the physics, and so on.

The game further relies on the communication between the server and each agent. On the one hand, each player receives relative and noisy input of his virtual sensors (visual, acoustic, and physical) and may, on the other hand, perform some basic commands (like dashing, turning, or kicking) in order to influence its environment.

The big challenge in the Simulation League is to conclude from all possible world states (derived from the sensor input by calculating a sight on the world as absolute and noise-free as possible) to the best possible action to execute. As a game is divided into 6000 cycles this task has to be accomplished in time slots of 100 ms

3D Soccer Simulation League

The RoboCup 3D Simulated Soccer League allows software agents to control humanoid robots to compete against one another in a realistic simulation of the rules and physics of a game of soccer. The platform strives to reproduce the software programming challenges faced when building real physical robots for this purpose. In doing so, it helps research towards the RoboCup Federation's goal of developing a team of fully autonomous humanoid robots that can win against the human world soccer champion team in 2050.

The simulation is executed in the *RoboCup Simulated Soccer Server 3D* (rcssserver3d) which runs on Linux, Windows, and Mac OS X. The underlying simulation engine is SimSpark.

The Future

The goal of the international RoboCup initiative is to **develop a team of humanoid robots that is able to win against the official human World Soccer Champion team until 2050**. In some sense, the RoboCup challenge is the successor of the chess challenge for artificial intelligence (a computer beating the human World Chess Champion) that was solved in 1997 when Deep Blue won against Garry Kasparov. Currently, there exist a number of different RoboCup soccer leagues that focus on different aspects of this challenge. The Humanoid League is one of the most dynamically progressing leagues and the one closest to the 2050 goal.

- **Humanoid league**

In the Humanoid League, autonomous robots with a human-like body plan and human-like senses play soccer against each other. Unlike humanoid robots outside the Humanoid League, the task of perception and world modeling is not simplified by using non-human like range sensors. In addition to soccer competitions, technical challenges take place. Dynamic walking, running and kicking the ball while maintaining balance, visual perception of the ball, other players, and the field, self-localization, and team play are among the many research issues investigated in the Humanoid League. Several of the best autonomous humanoid robots in the world compete in the RoboCup Humanoid League.

Beneficial ByProducts

Technological Achievement

Since the premiere of the RoboCup Humanoid League in 2002, the pace of progress and the number of scientific and technological achievements through the participating teams have been remarkable. While in 2002 almost all robots struggled with basic locomotion capabilities like standing on one leg, walking and kicking, nowadays teams of robots in Kid and Teen Size perform fast and exciting soccer games autonomously with many goals. To properly assess these achievements it must be considered that the humanoid robots are fully autonomous and the only external sensors allowed are human-like (i.e. no active range sensors and vision is limited to a human-like field of view of 180 degrees). Also, the foot area size is quite limited with respect to the height of the center of mass.

Educational Achievement

The development of humanoid robots able to play soccer is a fundamental challenge problem for robotics and AI. Since the start of the humanoid league in 2002, there have been lots of improvements in humanoid soccer robot hardware and software. This is partially due to the introduction of standards and competitions for complex simulated robots (3D Simulation). In order to have a long term goal in the learning aspects of humanoid robotics, it has been started to organize International School on Humanoid Soccer Robots in different parts of the world. The objective of these schools is to give students deep insights into the current leading approaches in the field of humanoid soccer robots. By defining International School on Humanoid Soccer Robots, the humanoid league is planning to define a project to promote the RoboCup Community.