Colombian Robotic Soccer System

Daniel Eduardo Navas Barajas
Colombian Association of Robotics, Santander, Bucaramanga
dnavasbarajas@yahoo.com
secretariageneral@acrobotica.org

Abstract

This article treats about the complete design and construction of an autonomous robotic soccer system. This Work contain each of the stages of the physical construction of the control system, the treatment applied to the images used in the detection of forms inside the playground, The communications links used and the strategies of control to manage to play a football match, Lowering costs up to almost 50 % of the value of the market, to allow more people to work in this robotic field.

1 Introduction

The football of robots provides a field of test for systems of multiple robots that, across a common task as the game of football, stimulates the investigation of problems that involve robots moving rapidly and cooperating between to solve specific problems in dynamical environments and under adverse situations.

The purpose of a project of investigation of this caliber is to develop and to implement a team of robots that play football in a semiautonomous way, controlled by a computer that, receiving information from a camera, compare, decide and transmit the strategies of action that must take the mentioned robots.

One of the major challenges in the field of the artificial intelligence is the development of intelligent autonomous agents which performance approaches the behavior of the human beings.

It is not surprising that the importance robotic soccer in growing, since this problem imposes big requirements in diverse fields, such as robotics, mechanics, artificial intelligence, etc. Besides, these systems are implemented in a competitive environment that everyone can understand and enjoy.

For all these reasons the investigation always tries to reduce cost as much as it was possible.

2 Control System

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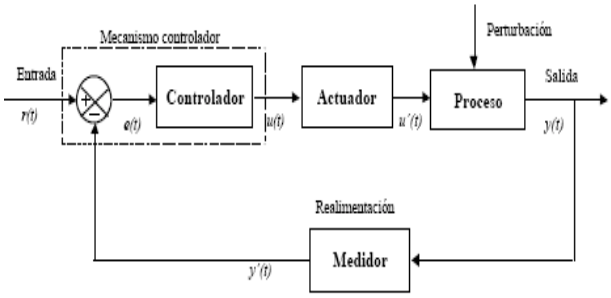


Figure 1: Closed Loop Control System

A Closed loop Control system works in such a way that the information that enters is tried by the controller and is sent to the actuador, and thanks to a stage of measurement, this response is re-fed in order that an alteration exists and this way it achieves that the functioning of the whole system is as ideal as possible in spite of the disturbances. Figure 1.

The autonomous system of robotic football is constituted by four principal blocks; comparator, control, actuador and of measurement [1].

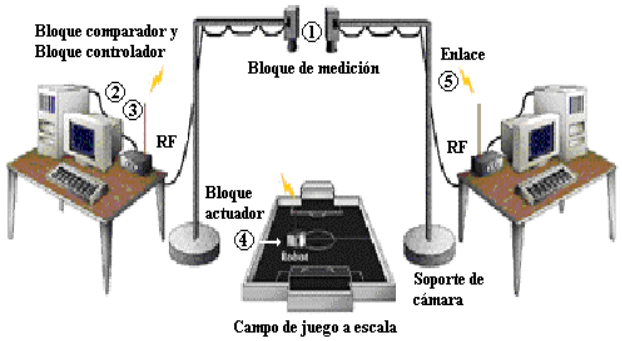


Figure 2: Autonomous System of Robotics Soccer

2.1 Measurement

The measurement block, is constituted by a camera connected to the comparator block, which takes images in real time of the current situation of the environment on the playground. (1 in Figure 2)

2.2 Comparator

In the comparator block, there are in use the images acquired by the measurement block, to try with software specialized in images treatment of the company Intel, with which the necessary parameters of comparison are obtained to be led to the control block. (2 in Figure 2)

2.3 Control

In the control block, we can finds the computer that process the information obtained from the comparator block and with base to this, takes the decision adapted by means of the different algorithms of strategy designed and implemented in (Visual C ++), applying this to the actuador block. (3 in Figure 2)

2.4 Actuador

The actuador block, it is shaped by the group of robots that constitute the soccer team, which receive the decisions coming from the control block, and by means of a microcontroller (control of under level), they acquire and execute the decision with base to the given information. (4 in Figure 2)

2.5 Communications (RF)

The link that is in use between the control block and the actuador block (computer - robots), consists in a serial communication of 8 bits that is sent by radio frequency, allowing the whole soccer robotic team to receive the information from the computer. (5 in Figure 2)

The decisions with base to the characteristics of the playground in a certain instant of time, are taken by means of the created algorithms applying the theory of control of discreet systems by events.
This is used because the robots do not remain in constant movement and the decision to act inside the playground, depends on the change on one or more parameters inside the same one.

The detection of an event, that is to say, of the change of one or more of the characteristics or parameters of the environment it is a product of the constant apprehension of images realized by means of the camera to a rate of 30 frames per second, forming hereby a dynamical constant system.

The union of these two processes included inside the autonomous re-fed system forms what is known as a dynamical hybrid system, which is characterized by the interaction between constant and discreet dynamics.

These systems are usually applied in the control by computer of constant processes, in chemical processes and of manufacture, in the design of control supervisors for constant systems, in the operation of chemical plants (procedures of putting in march and stop, safeties mechanisms before failures, control during the regular operation by means of the commutation of different manners of operation, etc.), to coordinate robots of multiple interaction, for the process control of manufacture and to coordinate the operation of autonomous vehicles, etc.

Therefore there was constructed a system of control re-fed with great complexity, due to the great quantity of variables that are seen involved in the loop and to the functioning in real time.

3 Physic Design of the Control System

For the design of the system its necessary to focus in the minimal requirements to achieve that the robots play football, that is to say, the dimensions of the playground had to be known and how to construct it, the hardware of the robots, the type of lighting, among other things that will be explained later.

3.1 Playground

The playground is a field of football scaled, of 2.42 mts of length for 1.5 mts of width, constructed in wood of black dull color. (Figure 4)
It is limited by white lines of 1cm of width which define the areas of every side, the line of goal, the half of the field and the central bomb. (Figure 4)

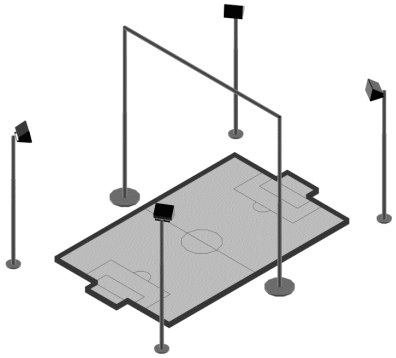


Figure 3: Playground in AUTOCAD

It is bordered by white walls of 5 cms of height that they avoid the loss of the ball.

Figure 4: Playground Real version

3.2 Lighting System

The system of lighting consists of four lamps Starlux located in the 4 corners of the playground in a metal support of 2 mts of high. These lamps have 300W of power and they handle 110 VAC. (Figure 5)

Figure 5: Lighting System on the Playground

One of the factors of major influence in the treatment of the images is the variation of the light, since the most minimal change of this is detected by the camera as an alteration of the factors and of the parameters of the playground, such as the colors of the robots, the lines of the field, the ball and the present noise.

For such a reason, the system of lighting described is used to try to keep constant the light conditions of the environment of game and hereby, to manage to minimize the mistakes that they can manage to present. The light conditions are the most complex factor and variant to the moment to connect the system of control to any condition in any place.

3.3 Vision System (camera)

The system of vision consists of an analogous camera (Safety and security) of 12 VDC to 110mh. A resolution of 380 has * 420 lines and a system NTSC of 60Hz. Besides there was acquired a lens of 2.8 mm to obtain the image of the whole playground, because with the original lens the image of the field that was obtained it was incomplete. The camera is located in a metallic structure 2 mts of the ground. (Figure 6)

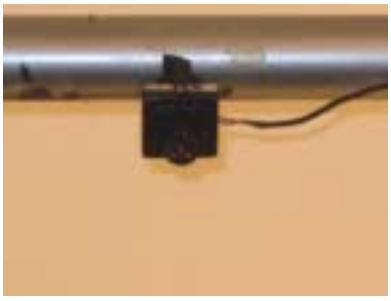


Figure 6: Camera for Vision System

For the digitalization there was in use a Grabber USB Capview of mark Lifeview that is a device Plug and Play that connects the analogical camera with the personal computer using the USB port. (Figure 7)
The unique algorithm of USB's compression CapView achieves a high speed of pictures of apprehension (30 frames per second) without losing the quality of the image and with a minimal use of the resources of the system.

The principal characteristics of this device are:

- integrated Income of video S (S-VHS) and composed, which allows to connect PC's cameras, recording cameras, discs laser, video cassette player and other devices of TV's visualization and video to a personal computer by the interface USB.
- Compatible with the specifications Plug and Play USB's active, which means that can connect USB CapView without any problem and in any moment, without mattering if the computer is ignited or switched off.
- It allows the apprehension of video up to 30 frames per second with resolution of format CIF.
- A resolution supports up to 640 x 480 pixels.
- The size of the window of video is completely scalable of a resolution of 80 x 60 up to 640 x 480 pixels.
- It is fed by the port USB of the computer, which causes that is not needed an adapter of energy.

· It does not need a device or a card for apprehension of additional video.

Figure 7: Grabber Capview Lifeview

3.4 Robots Hardware

For the implementation of the system of traction used in the robots two existing systems were had in bill; linear system and omni directional system. The linear system can be used with rims or with caterpillars and works locating two engines in an angle of 180 º, allowing a movement towards ahead or backward of each of the rims. (Figure 8)

In the system omni directional three separated engines are located 120 º one of other one, allowing a movement towards any direction without mattering which is the front of the robot. (Figure 9)

Figure 8: Linear System

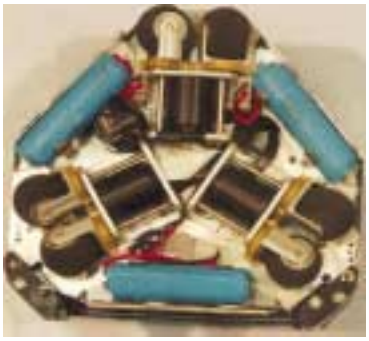


Figure 9: Omni Directional System

For the robots players the linear system was implemented, and there were in use rims of skate covered by rubber of tire, which allows a better grasp on the surface of game and the robot prevents from slipping.

Locomotion System

The system of locomotion consists of two servomotors Hobbico CS-60 modified to turn freely. (Figure 10) These engines were in use because they have several advantages with regard to the engines ordinary DC:

· They Offer major facility of control, because it can be applied a PWM to them (Width Pulse Modulation), it is possible to fit exactly the time of ignition and the time of extinguished that needs every engine to realize a specific movement.

· They have very much more torque thanks to the train of gears and the system of reduction that have.

· They have less inertia by what more exact movements can be obtained.

Figure 10: Servomotors Hobbico CS-60

Chassis

The chassis is the external structure of the robots and is the manager of protecting them and of giving them form. The most common materials with which the chassis is constructed are a balsa-wood, metal and acrylic.

For this case the balco-wood was in use, since it is the sufficiently strong and robust for the wished applications, besides its price is very much a comfortable than the other materials.

The top of the chassis is covered with two circles of colors, which allow to locate the position of each one of the robots inside the playground. One of these circles is the badge of the team, that is to say, the yellow team has

a yellow circle in the front and the blue team has a blue circle in the front. (Figure 11)

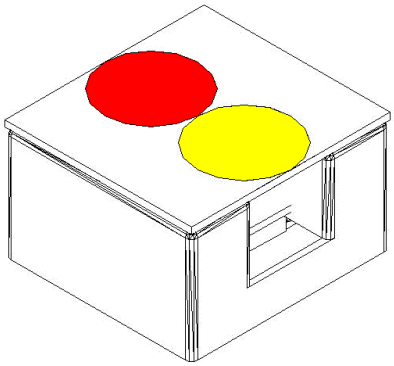


Figure 11: Top of the chassis

The internal part of the chassis constitutes a base in the shape of H allowing that the rims should be within of the external framework. On this base there are leaned the engines assured a few supports of pine by means of a few anti vibrators that avoid any type of movement.
(Figure 12)

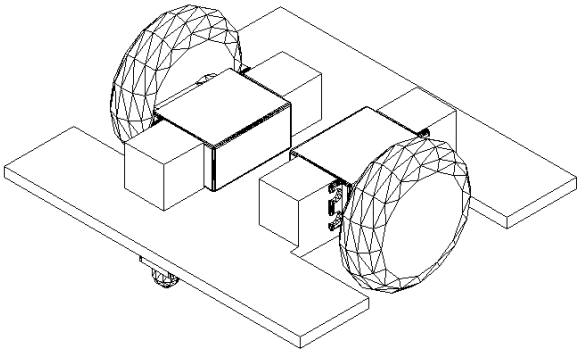


Figure 12: Internal Chassis Shape of H

On the top of the engines a cover is located in the shape of T that separates the engines of other electrical components of the robot. On this cover there are located the control circuit, Reception device and the batteries. (Figure 13)

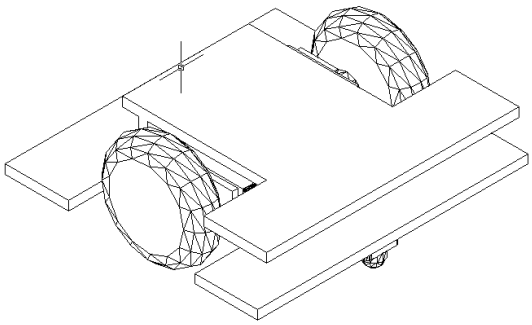


Figure 13: Top cover of the engines

To each of the robots it was added in the front a couple of fins designed in balco-wood so they can take and to control the ball inside the playground. (Figure 14)

Figure 14: Soccer Robot

3.5 Principal Control Station (PC)

Figure 15: Principal Control Station

For the control of the actions of game of the robots inside the field, according to the information got for the camera, a portable computer was in use with specifications according to the Figure 16.

Figure 16: Specifications Principal Control Station

4 Physic Design of Communication Link

To realize the suitable construction of this link the following devices were used:

- MAX232: It is an integrated circuit recipient multichannel, which particularly is used in conversions of protocol RS-232 to TTL, designed to be applied in interfaces of communication.

- Transmitter TLP 434A: Transmitter of radio frequency that uses modulation ASK to 433.92 MHz, that manages to send a serial asynchronous communication up to 4800 bauds.

- Recipient RLP 434A: Recipient of radio frequency that uses modulation ASK to 433.92 MHz, that manages to receive a codification of information up to a rate of 4800 bauds.

- Microcontroller PIC16F873: They are in use in applications where there exist external events that they need of the detection and control of digital signs or analogous, having also applications on the serial communications with different devices, by means of the Universal module of Transmission Receipt Asynchronous Synchronously (USART), or also known like interface of serial communications of the Microcontroller.[5]

Figure 17: Recipient RLP 434A Circuit Card

5 Images Treatment

The principal aim of the images treatment in the soccer robots systems is to realize a suitable detection of colors to obtain the exact location of the robots and of the ball inside the playground. As result of different proves and investigations it was possible to find several methods that allowed to detect these colors in spite of the disturbances that they present for the variations of the light.

These methods were based on the fundamental characteristics of the colors, the morphology applied to the images and the different technologies of improvement of images.

5.1 Color

In 1666, Isaac Newton discovered that when a beam of solar light is reflected on a prism of crystal, the light that goes out is not white, but it is formed by a constant spectrum of colors that go from violet to the red one. It might be said that the spectrum can be divided in six wide regions: violet, blue, green, yellow, orange and red.

The characteristics that usually are used to differentiate a color of another are: sheen, shade or tone and saturation.

The sheen takes partner the concept of intensity. The shade is an attribute associated with the length of domineering wave in the mixtures of the luminous waves. The saturation refers to the quantity of white light mixed with the shade.

Color model:

The intention of a model of color is to facilitate the specification of colors in some standard format. At present it exits a great quantity of color models that have been developed for specific applications.

For the treatment of images implemented in this investigation, there were in use the RGB model and the HSV model.

RGB

In the RGB model every color appears in the primary spectral components red, green and blue. The model is based on a Cartesian system of coordinates. The subspace of interest is the bucket that shows itself in the figure 18.

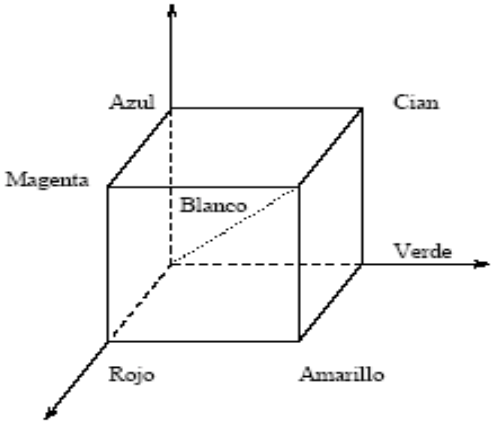


Figure 18: RGB Cartesian System

HSV

The system of color HSV combines gradually the properties of the colors to create new colors moving in coordinates across the cone that it is possible to observe in figure 19.

-Hue: Tone or shade and it correspond to the type of color. It is measured by the angle about the vertical axis.

-Saturation: it refers to the quantity of target in a color (Hue).

-Value: It is component of sheen or luminosity, that is to say, is the degree of auto-luminosity of a color (quantity of light that it emits).[2]

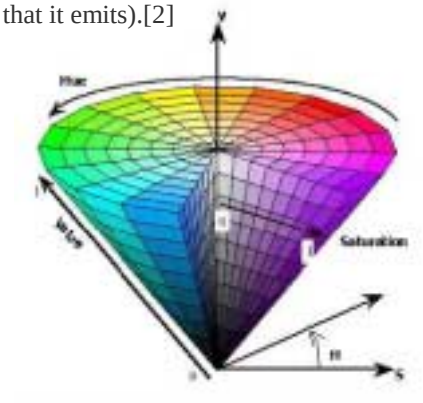
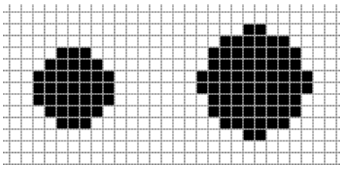


Figure 19: HSV Cone

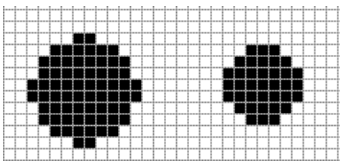
5.2 Morphology

Nowadays the scope of the morphologic processing is so wide as it is the images processing. It can be found applications such as segmentation, restoration, detection of edges, increase of contrast, analysis of textures, compression, etc. But for this application specifically four processing we worked:

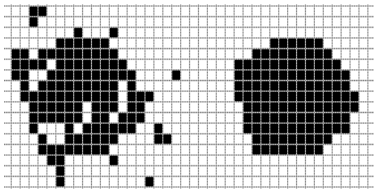
· Dilatation:



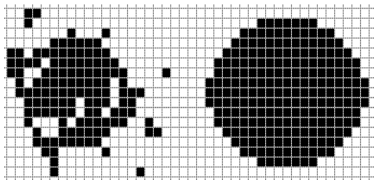
· Erosion:



· Opening:



· Closing:



For the detection of the colors of the robots (Yellow, Red, Green and Blue) and of the ball (Magenta) was employed Microsoft Visual C++6.0 and two specializing libraries in images treatment were acquired. With the acquisition of these two libraries the work was facilitated, because these were possessing functions related to the properties of the color, morphology and improvement of images. The realized software was constituted by several stages.
The first stage was the manager of acquiring the images in real time. For this there was done an infinite loop that was guarding the images to be tried. [3][4]

Once the images were captured, a filter Gaussian was applied to each image. This filter was smoothing the image and the noise was minimizing.

The following step was consisting of taking this filtered image and each of the colors were found independently. For the colors Blue, Red, Green and Magenta was in use a technology based on the model of color HSV. In this technology a specific range of Shade was applied. For the Yellow one a technology based in RGB model of color was in use whose procedure was similar to that of the renowned technology previously. A range was applied of red, green and blue to the taken image, with alone which there was allowed the step of the yellow colors.

Once every color was identified, each image was transformed to binary, that is to say, was assigning a vale of zero to each of the black pixels and a value of one to every white pixel. To the image in binary a sweep carries out in where it wonders for the coordinate of every white pixel (of value one) inside the Cartesian plane (field).

6 Strategies

The strategies of control in a system of Robotic soccer are the procedures that are in use in order that each of the members of a team expires with the principal aim; to manage to annotate the major number of goals in the arch rival and to prevent them from annotating goals in the own arch. It is necessary have in bill that these strategies apply to themselves after have rivals, the ball and the own robots located inside the own playground, of knowing the position of these robots with regard to the ball and of obtaining the distances and the angles of the robots to the ball, that is to say, after realizing the treatment of images. Also it is necessary have in bill that these strategies of control were implemented in a team of robotic soccer of two members.

Offensive

This strategy was implemented to facilitate the process of doing goals and for stop doing own goals, since with the simple follow-up of the ball it is very difficult to control this.
This strategy consists of determining if the ball is beyond of the opposite arch that the robot and if it is like that, one proceeds to locate the robot exactly aside of the ball (taking in bill that this point is inside the playground) and then the robot proceeds to realize a draft towards the ball so that the ball stays between the robot and the opposite arch and that the front of the robot make his position towards this arch. (Figure 20)

Figure 20: Offensive Strategy

Restrictions

To prevent them from existing stagnation between the robots and with the walls of the playground, it was designed and implemented a routine that does verify if the robot that must be in movement is or not. If it they are not, they are sent by the order of which they move back to go out of the stagnation. With this the robots are prevented from being damaged. (Figure 21)

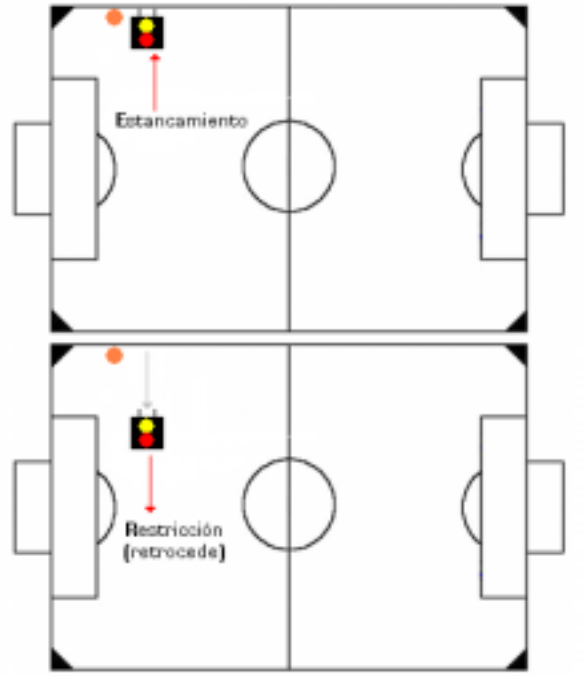


Figure 21: restrictions

7 Conclusions

There was designed a team of mobile semiautonomous robots with characteristics similar to the offers by the different categories of robot soccer existing worldwide, with components of easy acquisition, based on the utilization of materials of under cost with the same functionality.

Thanks to the realized proves along the project of investigation, it is possible to affirm that the variation of light on the field of action of the robots is the mainspring mistake during the process of detection of colors inside the treatment of images. To stabilize the conditions of light on the playground, a system of invariant lighting was in use.

There was realized a serial asynchronous communication that was receiving to 19200 bauds the information coming from the principal controller and in turn this information was sending to a rate of 1200 bauds to the robots that they find in the playground, this in order to improve the speed of processing in the principal controller of the autonomous system robotic soccer, and to mate to a module of radio frequency which has a speed of transmission of 1200 bauds.

It is possible to affirm that the images treatment is the initial stage of the Robotic soccer, which is necessary for the detection of colors and necessary to find the exact location of the robots and the ball inside the playground. Besides it has to be rapid and effective, that is to say, of high processing in little time and capably of pushing back the mistakes produced by the variations of the light.

The strategies of control are fundamental to achieve that a team of robots play football, expiring with the aim to annotate goals in the opposite arch and to prevent them from annotating goals in their own arch.

For the first time in Colombia there was created a category of robotic Soccer, which was implemented in Expoelectrónica 2006, fair of technology organized by the University Pontificia Bolivariana designing a special regulation to realize a competition of this type in the country and in ROBOGAMES 2006. The previous thing in order to stimulate groups of investigation to start being employed at new fields of the robotics, fields like Robotic Soccer.

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