# Ball identification in the RoboCup Middle Size League

João Silva, António J. R. Neves, Nuno Lau
ATRI/Instituto de Engenharia Electrónica e Telemática (IEETA)
University of Aveiro
{joao.m.silva,an,nunolau}@ua.pt

## Abstract

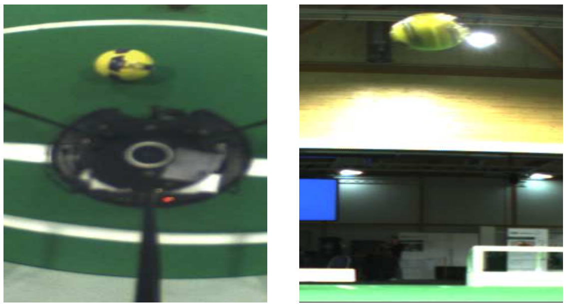
*In a soccer game, the ball is the most important element of the game, as it is the instrument used by the players to produce the results of the game. In robotic soccer, the robots need to know where it is to be able to play. When building the representation of the environment, the ball information tends to get some priority on its detection and validation. This paper briefly presents the visual detection and validation techniques used in the CAMBADA robotic soccer team, as well as higher level contextual validations during the information fusion process.*

## 1 Introduction

The RoboCup is an international joint project to promote robotics and artificial intelligence. It includes several leagues, several of them related to soccer. Within these leagues, the Middle Size League (MSL) is one of the most challenging, using real non-humanoid robot teams to play with an ordinary soccer ball.

CAMBADA, *Cooperative Autonomous Mobile roBots with Advanced Distributed Architecture*, is the Middle Size League Robotic Soccer team from the University of Aveiro. It is coordinated by the IEETA ATRI group and involves people working on several areas for building the mechanical structure of the robot, its hardware architecture and controllers and the software development in areas such as image analysis and processing, sensor and information fusion, reasoning and control.

In a soccer game, the ball is the main object that the players must consider. The knowledge about its position is what drives the game, since the objective is to take the ball and place it inside the opponent goal, while preventing it to enter the own goal. Some effort has been applied to the resolution of this problem and many solutions have been tested, with the objective of having a process which can recognize the real ball on the robot visual sensors. The detection must be reliable, but at the same time, all the process needs to be very fast, as it should not take longer than a few milliseconds so the robot can process and act following the camera framerate (for example at 30 fps).



**a)** **b)**

**Figure 1. Images of the ball: In a): image acquired from the robot omnidirectional camera; In b): image acquired from the robot perspective camera.**

## 2 Visual detection

The CAMBADA robots have cameras as main sensors. The perception of their surroundings comes mainly from data provided by the image analysis processes. Currently, all the robots are equipped with an omni directional camera and the goal keeper has an additional camera installed pointing forward, providing a perspective image (Fig. 1).

### 2.1 Omnidirectional camera

The omnidirectional camera is installed in such a way that the image plane is parallel to the ground plane [1] and, given the robots height, most of the image is the ground and only a small portion of the image includes points above the ground. For ball detection, it is currently assumed that it is on the ground. The detection of the ball is based on color segmentation and context analysis [3]. However, when the ball is kicked off the ground, there are still a few frames on which it remains detectable before going above the robots height. The estimation of the ball position for those cases degrade and aerial balls cannot be detected by the camera.

The omnidirectional vision system is a non-SVP hyperbolic catadioptric system. Through an inverse distance map calculation [1], the relation between the distances in the image and the distances in the real world is known. Using that relation, the ground position of the ball color blobs can be estimated and the distance to the robot calculated. Also using the distance relation and the fact that the ball size is well defined, we can roughly know the expected size of the blob and use it as validation. Also, since the ball is only considered on the ground, its neighboring area should have a given percentage of green color, which is known to be the ground color in this context. Blobs complying with these restrictions are considered candidates and are made available for the decision process.

### 2.2 Perspective camera

The perspective camera is installed in such a way that its focal axis is parallel to the ground. It is used to detect airborne balls, so the assumption of the ball blob being surrounded by green cannot be used as a validation. Thus, through the analysis of the ball blob size and position on the image, and based on the known characteristics of the camera and lens, we can estimate the ball position. The evaluation of the blobs is made according to their dimension and general shape, as the width and height of a ball on the image should obey some relations. With the analysis of the camera characteristics [2], one can evaluate the distance to the ball based on its size.

The algorithm to analyze the blobs uses horizontal scanlines and each time a ball color pixel is intersected the number of consecutive horizontal pixels of that color is counted. A vertical scanline is then created at the center of the horizontal segment and the number of vertical pixels is counted. The number of vertical pixels should be similar to the horizontal ones and both segments should be proportional in a cross like shape. Since it is an iterative process, we will obtain a set of cross points over the ball candidates which fulfill the criteria and thus, the center of mass of the set of points should approximate the ball candidates center [4].

## 3 Ball integration

After visually detecting the ball candidates, there is the need to decide which will be considered the ball and include its information on the worldstate [4]. This is done by the information fusion process after having information about the current pose of the robot. Some validations are performed to proceed with the selection. Candidates which do not comply with these validations should be discarded:

- One contextual validation performed both on the omnidirectional and perspective information, is whether the candidate is inside the field of play or not. Balls outside the field of play are discarded.

Since the perspective camera visual detection is less restrictive and less controlled, some additional validations are performed to try to reduce false positives to a minimum.

- To maintain coherence, ball candidates are tested, to see if they are in the angular vicinity of the omnidirectional ball position. This evaluation is performed on the first detections of a candidate, when the ball has supposedly just become not visible on the omnidirectional camera.
- After having the candidate on the first frames, the selection of the most probable candidate thereafter is based on the last ball visible on the perspective camera. This is done by choosing a candidate in the vicinity of the last perspective ball position.
- Finally, since during the games the ball is only off the ground for some moments when it is kicked, a filtering is made concerning the number of cycles on which the ball has been visible on the perspective camera. If it has been visible for too long, it will be discarded as a false positive, as a ball will not be on the air for long.

The information from both cameras is used to provide the agent with information of the detected ball, although this information is almost exclusive to one of the cameras at a time.

## References


[1] B. Cunha, J. Azevedo, N. Lau, and L. Almeida. Obtaining the inverse distance map from a non-svp hyperbolic catadioptric robotic vision system. In U. Visser, F. Ribeiro, T. Ohashi, and F. Dellaert, editors, *RoboCup 2007: Robot Soccer World Cup XI*, volume 5001 of *Lecture Notes in Artificial Intelligence*, pages 417–424. Springer, 2008.

[2] A. Neves, D. Martins, and A. Pinho. A hybrid vision system for soccer robots using radial search lines. In L. S. Lopes, F. Silva, and V. Santos, editors, *Proc. of the 8th Conference on Autonomous Robot Systems and Competitions, Portuguese Robotics Open - Robótica 2008*, pages 51–55, Aveiro, Portugal, April 2008.

[3] A. J. R. Neves, A. J. Pinho, D. A. Martins, and B. Cunha. An efficient omnidirectional vision system for soccer robots: from calibration to object detection. *Mechatronics*, 2010 (in press).

[4] J. Silva. Obstacle and airborne balls detection for cambada. Technical report, University of Aveiro, MAP-i Free Option work, 2010.