

Colmillos ITAM

RoboCup HSL 2026 Team Description*

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Abstract. This paper describes the Colmillos ITAM team formed to participate in the RoboCup Humanoid Soccer League as an evolution of the Aztlan team that participated in the SPL league.

1 Team Information

Team Leaders: Fernando Esponda, Marco Morales, Alberto Petrilli.

Our website and videos can be found at:

Web Site – <http://robotica.itam.mx/>

Qualification video – https://youtu.be/Oc4M_7h3Gxo

Robot Information. Our team currently has three H25 V5 Aldebaran robots. We plan to replace them for more advanced platforms this year.

Code Usage. Most of the code we use is ours. It was initially started by our team members when competing under our previous team names (Eagle Knights, Cuauhpiltin, and Aztlan) and we are still developing it now as Colmillos ITAM. We acknowledge that, so far, we have used the walk module of RunSwift from B-Human code.

2 Lessons learned from participation in previous RoboCup competitions

Our participations in the RoboCup started in 2005 (Eagle Knights). Later, after some initial collaborative efforts in 2012 (Cuauhpiltin), and 2014 (UTH-CAR), we created the team Aztlan in 2016 and we had encouraging results in the RoboCup SPL Drop-In competition. In 2017 we were chosen as an alternate team and we achieved good results in terms of team development and code integration. In 2018 we had a full qualification and we participated in the Challenge shield. This year, our team leaders are with the same institution and we are applying to the RoboCup as a single team again (Colmillos ITAM) with the goal of becoming regular participants in the future.

In Mexico, we have organized an SPL competition within the Mexican Robotics Tournament/RoboCup Mexican Open since 2011. We started with exhibitions from 2011 through 2014. In 2015, we held the first official competition with four teams in a round robin penalty shoot-out where two of our team members obtained first and second place. In 2016, the competition had four teams and full games in round robin format and was won by one of our team members (all games were ties 0-0 and resolved in shoot-outs). In both 2017 and 2018 one of our team members achieved second place. In 2019 two of our team members got first and second place again.

Here, we provide more details of our previous participations:

- **ITAM Eagle Knights** was created in 2003 and participated in the RoboCup SPL in 2005, 2006, 2007, 2008, and 2009. It gave exhibitions in the Mexican Robotics Tournament/RoboCup Mexican Open from 2011 through 2014 and in 2015, it won 2 shoot-outs and tied in 1 to obtain 7 points to advance to the final in shoot-outs against the Balam team achieving 1st place (score 1-0).
- **Cuauhpiltin** was created in 2012 by the ITAM Eagle Knights team and CIMAT, DEMAT-UG, and UNAM. This team participated in the RoboCup 2012 SPL.

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- **UTH-CAR** was formed in 2014 by UNACAR, UTH, and IPN. This team participated in the RoboCup 2014 SPL Drop-In competition.
- **Balam** was created in 2015 as an evolution of UTH-CAR by UNACAR and IPN. In the Mexican Robotics Tournament/RoboCup Mexican Open it won 2 shoot-outs to obtain 6 points to go to the final in shoot-outs against the Eagle Knights, achieving 2nd place. In 2016, it won 2 games (6 points, 6 goals scored and 2 goals against) and advanced to the final winning 1-0 (all the games were resolved in shoot-outs).
- **Aztlan** was created in 2016.
 - **RoboCup 2016** Participated in the SPL Drop-In competition earning the 2nd place in MVP Drop-in Individuals competition
 - **RoboCup 2017** Chosen as an alternate team and later qualified to participate. In the first round robin we were in Pool F, tying one game and losing the other one. In the second round robin we were in Pool H, again tying one game and losing the other one.
 - **RoboCup 2018** Participated in the SPL competition.

3 Major challenges and plans for the RoboCup 2026

Our main challenge for the RoboCup 2026 is to upgrade our robots and code considering that we are planning to replace our Nao robot by a more modern platform. This implies a major restructuring of our software architecture that was based on NaoQi to a new one using ROS2. Nevertheless, we plan to keep similar modules with focus on our main research interests (vision, localization, motion planning and control). Our **Object Detection** module takes visual information from the cameras and outputs state estimates (pose, velocity) and other properties (e.g. size) of the detected objects (the ball, the goals, white-lines and other robots). The **Localization** module estimates the absolute position and orientation of the robot inside the field. The **Decision** module uses the **state estimates** and the **information from the Game Controller** in order to decide **Actions to be executed**. Below we provide more details on different problems addressed by our system.

3.1 Object Visual Detection

We are extending the experience we had with previous modules developed while we were a joint team, although we plan to develop them again from scratch with the new platforms we acquire.

Our module to identify the ball (originally developed at **CIMAT**) segments objects in the HSV space at QVGA resolution from any of the two cameras. We rely on scan-lines-based image processing algorithms for the color segmentation and we perform the object detection among the line segments found along these scan-lines. We also heavily incorporate geometric knowledge gathered from the robot joints to restrict the segmentation to the lower part of the image, filter out spurious object detections, and roughly define an image mask of the robot self image.

Our module to detect other robots and the goal (originally developed by one of our team leaders while at UNACAR) gets video in YUV model and efficiently applies color segmentation directly by using OpenCV. It binarizes the orange, white, green and yellow as shown in Fig. 1a. We already detect goals as shown in Figure 1b and robots as shown in Fig. 1c.

Our module to estimate the state (pose and velocity) of detected objects (developed by another of our team leaders at ITAM) applies an optical flow method based on [1] to estimate distance to objects and their velocity. This tracks a set of points from detected objects over time in order to estimate their relative motion or divergence and applies an Extended Kalman Filter to estimate distance and object speed.

3.2 Localization

Our localization modules exploit the Monte Carlo method and Kalman Filters and particle filters. We are working on integrating these two different techniques as well as on the evaluation of motion strategies based on stochastic optimal control, for implementing an active localization in a context of particle filtering, based on similar works in target tracking [2].

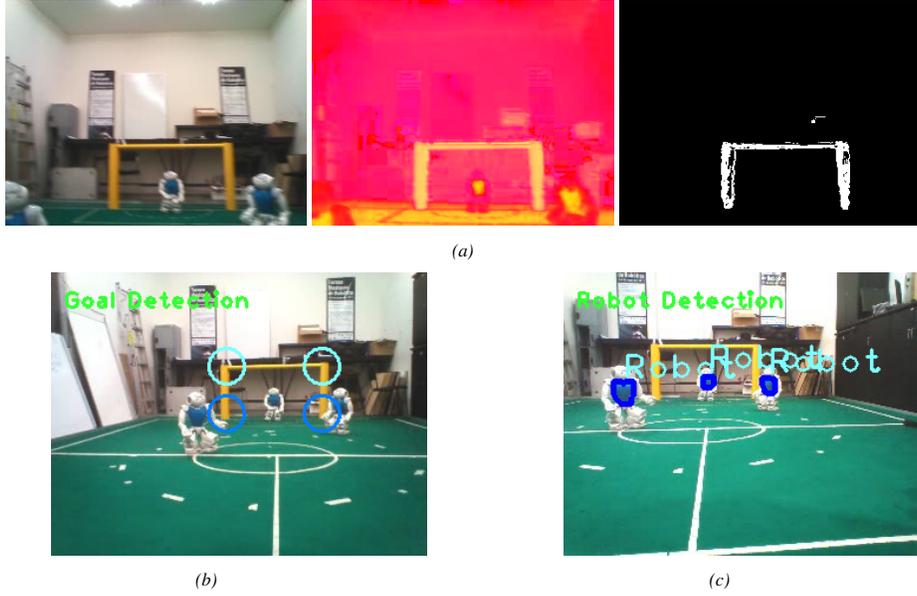


Fig. 1: (a) Color binarization. (b) Goal detection. (c) Robot detection

3.3 Decisions

Our robots make decisions based on a finite-state machine. Transitions between states are determined based on the position of the ball. We currently have the following states: (1) Track Ball (TB), (2) Localization of Ball Position (LBP), (3) Robot Turn (RT), (4) Robot Positioning at the Ball for Kicking (RPBK), (5) Robot Slide(RS), and (6) Kicking the Ball towards the Goal(KBG).

3.4 Motion Planning and Control

Our plan is to develop a multi-layered motion planning and control as follows:

Role selection. We define a set of roles that the players can achieve during the game, each role is assigned a function to dynamically compute a set of candidate goals for state and environment variables relevant to achieve it.

Sequence planner. In order to achieve the state and environment variables for the selected role, a sequence of actions to achieve them is planned. General states observed in the games are associated a small set of typical actions. Our initial approach is to use an A* [3] planner to simulate a few steps ahead in order to choose an appropriate sequence of decisions. We will explore techniques similar to those in [4] that apply demonstration-guided learning and sampling-based motion planning to train controllers that are robust to the presence of obstacles.

Composition of controllers. There is a set of available controllers that implement the most basic skills of the robot. We follow the ideas in [5] to arbitrate among the available controllers.

Individual controllers. We are developing all the controllers to cover the needs of the robot.

Locomotion. In the past we have used the locomotion controller from Aldebaran Robotics [6] and we plan to transition to the one in the platforms we acquire.

Kinematics. In the past we used a generalized inverse kinematics algorithm [7,8] to generate whole-body motions.

Adaptive kicking. We use a strategy very similar to [9] to produce a kicking motion that adapts to the current ball position and the direction to the goal. Before kicking, the robot makes sure that the ball lies within the reachable space of its feet. If the ball is not inside the reachable space, the robot has first to approach to it. Depending on the position of the ball and goal relative to the robot, the left or right foot is chosen to perform the kick using the kinematics controller.

Adaptive goalie. As in adaptive kicking, a goalie is implemented to adapt to the ball position/direction.

3.5 Team Coordination

We are working on the development of algorithms of cooperation between agents. We are using a centralized control where the goalkeeper gathers information computed by all other modules in a 2D stochastic map. The goal is to maintain at least the position of its teammates in the field, the position of the other team robots and the position of the ball, by fusing the related metric information coming from all the robots and from its own sensors. Every time a teammate needs information to decide its next action, it will ask the goalkeeper. Also, messages will be sent to the appropriate players to query for information that is either unavailable or which has low reliability.

4 Impact

Our collaborative efforts to create the Colmillos ITAM team has had a very positive impact in our institutions as well as on the development of the Standard Platform League in Mexico.

In our institutions, different aspects of this project have been the subject of the thesis work of several students. Also, some of our students are already pursuing more advanced degrees to do research in autonomous robotics. Moreover, our team performance has increased our institutions visibility and prestige since it helps us to better communicate with the public about the quality of our programs and of our students. In addition, the problems we are studying in the Robocup competition are closely connected to the team leaders' research and teaching areas. Consequently, we have used the challenges in the RoboCup SPL as examples or projects in our courses on Advanced Programming, Autonomous Robots, Probabilistic Robotics, Computer Vision, Computer Graphics, and Research Seminar.

Regarding the development of the Standard Platform League in Mexico, the impact has been through the organization of this competition within the Mexican Robotics Tournament/RoboCup Mexican Open, where we have helped other teams to get started and we have noticed that the interest in this league in Mexico is increasing.

5 Our contributions to the RoboCup Humanoid Soccer League or humanoid robotics research in general

Our medium term goals include publishing the advances we made in our team in relation with multi-agent planning and control. We already explore related problems in multi-agent motion planning and control [10,11,12].

6 Conclusion

Here, we presented the Colmillos ITAM Standard Platform team. Although our team is still building infrastructure in order to be competitive, we already have had encouraging participations in local competitions and in the RoboCup SPL 2016, 2017 and 2018. As a collaborative effort, we have had a broad impact in our institution and in the SPL in Mexico with a lot of enthusiasm from our team members for competitions. We develop our own code with functional modules for object detection, and robot localization. We plan to have a competitive team in the next years.

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