Cuauhpipiltin 2012: Standard Platform League Team Description Paper

The Eagle Knights team participates this year under the original nahua *Cuauhpipiltin*

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1 Introduction

The Cuauhpipiltin[1] SPL team is a collaborative effort of four renowned mexican institutions: ITAM, CIMAT, UNAM, and DEMAT-UG, to participate in RoboCup 2012. The team consists of several undergraduate students from ITAM, UNAM and DEMAT-UG and master students from CIMAT as well as five researchers. The Cuauhpipiltin Team (previously Eagle Knights) was founded in ITAM in 2003, competing with the Aibo robots in RoboCup 2005, 2006, and 2007, and with the Nao Robots in RoboCup 2008, and 2009. Our website and videos can be found at:
Web Site – `http://robotica.itam.mx/spl`
You Tube Channel – `http://www.youtube.com/user/ROBOCUPITAMCIMATUG`
Classification video –`http://www.robotica.itam.mx/WebPage/video-spl-2012.html`

The current members of our team are (in alphabetical order) are:
Students: Fernando Aguilar Reyes (ITAM), Carlos Alegría Ramírez (ITAM), Oriol Castillo Gutiérrez (FI-UNAM), Diego de Jesús Caudillo (DEMAT-UG), Alan Córdova Posadas (ITAM), Mauricio Josafat García (CIMAT), Ricardo Leija (CIMAT), Lazaro Lesmes (CIMAT), Oscar Mar (CIMAT), Diana Martínez (DEMAT-UG), Moisés Melendez Reyes (FI-UNAM), Jonathan Patiño (DEMAT-UG), Karen Poblete Rodríguez (ITAM), Domingo Ivan Rodríguez (CIMAT), Hipólito Ruíz Galeana (ITAM) and Carlos Zubieta (CIMAT).
Faculty Advisors: Rubén Anaya (FI-UNAM), Claudia Esteves (DEMAT-UG), Jean-Bernard Hayet (CIMAT), Marco Morales (ITAM) and Jesús Savage (FI-UNAM).

2 Statement of Commitment

The Cuauhpipiltin Standard Platform Team is committed to participate in RoboCup 2012 in México City.

3 Research Interests and Planned Activities

Our main research interests include vision, localization and motion planning and control. Since the last participation of the Eagle Knights Team in RoboCup 2009, and with the inclusion of the other three aforementioned institutions, the architecture has been completely revamped and many functionalities, in particular related to vision and localization, have been re-done. In the coming months we plan to finish a multi-layered motion planning scheme and individual controllers as well as basic team coordination. The following sections provide more details of each area. Also, we currently have four Nao robots RoboCup edition version 3.2 ready for the competition.

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[1] From *cuauhtli*, eagle, and *pilli*, noble person, the cuauhpipiltin were the members of the cuacuauhtin (eagles). This was one of the two high ranking mexica militare orders

4 Software Architecture

The current Cuauhpipiltin-SPL Team's system architecture is shown in Fig. 1. The **Object Detection** module is in charge of taking visual information from the robot cameras and giving as output the detected object properties (e.g., position, orientation and size). Currently the detected objects are the ball, the goals, white-lines and in the near future other robots. Object properties are the input to the **Localization** module, which outputs an estimated absolute 2D position of the robot inside the field. The detected objects together with the estimated position and the **robot internal state** are compiled by the **World Representation** module and stored in the shared memory. The **Decision** module uses the **World Representation** and the **information from the Game Controller** in order to determine the best **Actions to be executed**.

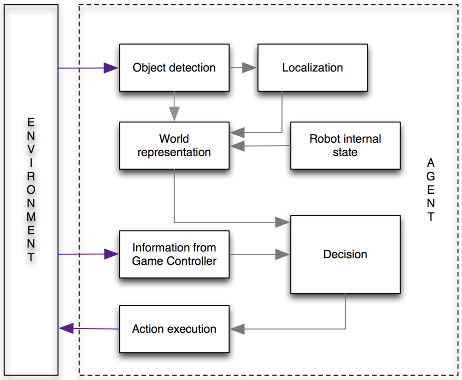

Figure 1: Cuauhpipiltin-SPL System Architecture. Information is distributed through the shared memory.

5 Current functionalities and planned developments

In the following paragraphs, the current state and future developments in our software are described:

5.1 Object Visual Detection

An Object Detection module has been implemented by Master students at CIMAT to identify the ball, the goals and the white lines within the environment. Our module efficiently segments these objects in the HSV space at QVGA resolution from any of the two cameras (which of the two being determined by the Decision module). As other teams do, 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, which alleviates the computational burden. We also heavily incorporate geometric knowledge that we gather from the robot joints: With the horizon line, we can restrict the segmentation to the lower part of the image, i.e. for objects on the field; With the image-to-field homography (that maps coordinates in the image to coordinates in the robot frame), we can filter out spurious object detections, e.g. detected balls with image radius not consistent with the homography and the real ball radius; With the joints information, we roughly define an image mask of the robot self image (which is particularly important when using the bottom camera). We are currently quite satisfied of the goal and ball detection system, and are improving the white line detection in order to be able to offer a wider range of observations to the localization module.

Another research line we are involved in is the use of fast machine learning algorithms based on boosting to detect other robots in the field. A few exploratory works in that sense are under way at CIMAT.

5.2 Localization

Particle filter localization. We have implemented a first functional absolute localization module based on a classical particle filtering strategy, i.e. that maintains a probabilistic, sample-based representation of the robot position and orientation. For the moment, it integrates only goal posts as observations, and works well with them. A very short-term goal is to add white lines as a second cue, in the form of quadrangles. In both cases, different strategies are being evaluated (1) to form the observation vector from image cues: point positions, distances along the horizon lines, angles to vanishing points. . . and (2) to propose well adapted noise probabilistic models for these observations.

Visual SLAM. Given the important rules changes in the 2012 edition (*both* goal posts will be yellow), we aim at incorporating basic visual SLAM capabilities in our NAOs. As the goal posts will be undistinguishable, we are planning to search for more visual beacons (from the environment structure, advertisement panels. . .) and use them to augment the map in a stochastic way. Several team members have visual SLAM and landmark-based robot navigation as one of their main research interests [6, 13] and several involved students are pursuing their thesis in this area. Typically, we would limit ourselves to very few, stable landmarks, given the robot limited computational capacities. These landmarks can be multiple-scale interest points, for which recent detectors have proven great efficiency [11] or geometric structures such as quadrangles [6]. Maintaining this augmented map among the team could also be a very interesting problem in terms of multiple robot collaborative map estimation (see also: Team Coordination).

Active localization. As the theme of one of the team members Master thesis, we are currently evaluating motion strategies based on stochastic optimal control, for implementing the idea of active localization in a context of particle filtering, based on similar works in target tracking [12]. The idea would be not only to control the robot head for improving the localization, as other teams do, but also to give speed controls for moving on the field.

5.3 Motion Planning and Control

Motion Planning is the main research field of some of the authors of this proposal and as such they have contributed with planners for humanoid robots and with adaptive sampling-based planning [5, 8, 14, 16]. In this regard, the first priority for a motion planning strategy for the team is to implement a local motion planner, the Nearness Diagram (ND) [7] to avoid other robots in the field and navigate through them toward the ball or the goal. Our plan is to also 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. For example, one of the roles could be to intercept the ball, the function uses the estimation of the position of the ball and self-localization to determine a desired position for the robot. In addition, following ideas in [2] we can arbitrate among the available roles.

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* [4] planner to simulate a few steps ahead in order to choose an appropriate sequence of decisions. In our current agenda we will explore techniques similar to those in [15] 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. This collection of motion primitives is vast enough to allow the robot to perform all the roles it can be assigned in the game. We follow the ideas in [2] to arbitrate among the available controllers.

Individual controllers. We are developing all the controllers to cover the needs of the robot, we provide more details below.

Locomotion. We currently use the locomotion controller from Aldebaran Robotics [3].

Kinematics. A generalized inverse kinematics algorithm [1, 10] has been implemented to generate whole-body motions for the Nao. This implementation was done to have additional and lower level control than the whole-body control provided by Aldebaran. The implemented algorithm gives a numerical solution to various input tasks, each of them with a different order of priority. Such a prioritized strategy works by projecting the tasks with less priority on the null-space of the Jacobian matrix of the tasks with higher priority. Currently supported tasks are: (1) to reach a position/orientation in 3D space with an end-effector (hands or foot) (2) to direct the gaze of the robot to a desired location in 3D space and (3) to keep the center of mass (CoM) inside the support polygon of the robot.

Adaptive kicking. A strategy very similar to [9] is being implemented to produce a kicking motion that adapts to the current ball position and the direction to the goal. The position of the ball is extracted from the recognition module and the localization module provides the orientation or the robot relative 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.

5.4 Team Coordination

Our plan for a team play and coordination strategy consists in using the goalkeeper to centralize the information computed by all other modules in a 2D stochastic map. It will 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, players will be able to send messages to their partners to query for information that is either unavailable to them or which has low reliability.

6 Utilities

A **visualization interface** (Fig.2.) has been developed in Qt and C++. It allows us to connect to a robot and have a synthetic view on the current robot state, to evaluate the performance of the visual detection and localization modules, to interact with them for tuning and calibrating parameters.

7 Conclusion

In this document we presented the Cuauhpipiltin Standard Platform team. We want to stress (1) that our team results from the collaboration between four prestigious educative and research institutions of Mexico, (2) that our joint project is on track to have a competitive by the time of RoboCup, and (3) that it has already generated and will generate in the next months a lot of enthusiasm among students and researchers, translating into challenging Robocup-related projects in courses such as Advanced Programming, Probabilistic Robotics, Computer Vision, Computer Graphics, and Research Seminar.

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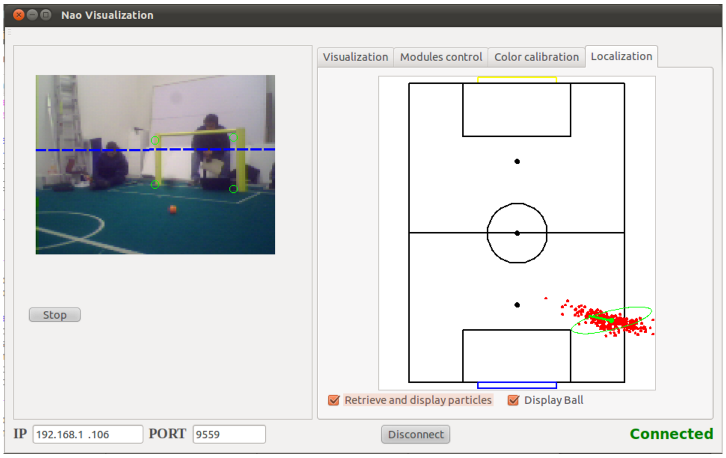

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☑ Retrieve and display particles ☑ Display Ball

Connected

Figure 2: Visualization and module control interface. On the left side the image seen by the robot camera is displayed. The average goal observation among particles is shown in green and the horizon line in blue. On the right side the particle distribution of the Localization module is shown in red and the estimation position and orientation of the robot is depicted in green.

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