Hanuman-KMUTT: Team Description Paper

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Abstract

This paper describes the design and development of the kid-sized humanoid robots of the Hanuman-KMUTT team for XXXXXXXXXXX. This paper will include system overview, vision module, game controller and decistion making. begingroup

1 Introduction

Institute of Field Robotics(FIBO) at King Mongkut's University of Technology Thonburi (KMUTT) has developed the humanoid robots to participate in RoboCup humanoid kid-sized league since 2005 under the name 'Team KMUTT' and later on 'Pheonix'. The successor, 'Hanuman-FC', won the Thailand Humanoid Soccer Robot Championship 2012 and participated in World-RoboCup 2013 (Eindhoven, Netherlands) under the name 'Hanuman-KMUTT'. In World-RoboCup 2013, our team passed into the quarter-final round. At the end of 2013, Our team won the Thailand Humanoid Soccer Robot Championship 2013. And then we joined the World-RoboCup 2014 (Joo Pessoa, Brazil) and passed into round robin 2. Because of limited funding and Thailand has no longer host the local competition in the country, our humanoid team development has been suspended. Last year, Robocup Asia-Pacific 2017 were host in Thailand, We participated after 3 years break with new undergraduate members. This year ...

In this paper, we will describe the recent development of our kid-sized humanoid robots. Section 2 gives an overview of the system design in our robots which consists of two strikers and one goalie. In section 3, the vision based navigation system of the robot will be explained. Section 4 discusses the game control and decision-making system. The last section concludes the paper.

2 System overview

Our team has 5 robots comprised of 2 sizes; 3 with 57 cm in height, and 2 with of 47 cm in height as shown in Fig 1. Each robot is composed of mechanical hardware, sensors, and computing hardware. The structure of all robots is made of aluminum alloy sheet. Each robot uses 20 servo-motors to control mechanical joints: 6 DOF in each leg, 3 DOF per arm and 2 DOF on head.Our team has 3 robots. Each robot is composed of mechanical hardware, sensors, and computing hardware. The structure of all robots is made of aluminum alloy sheet metal. Each robot uses 20 servo-motors (details are provided in the robot specification sheet).

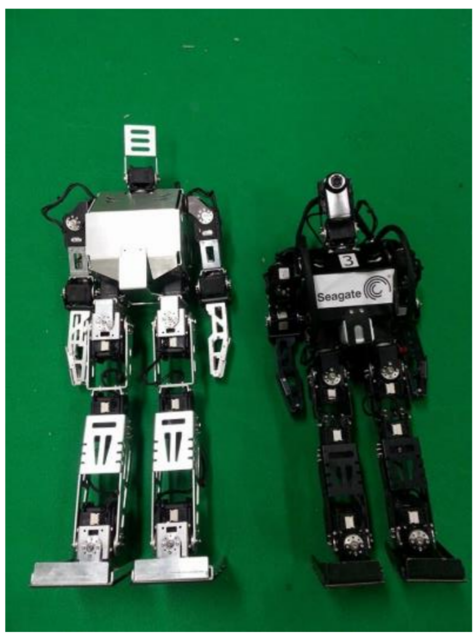

Figure 1: Robots of Hanuman-KMUTT Team

All robots use 6 DOF IMU sensor (MPU- 6500) which contains a 3-axis gyroscope to measure angular velocity and a 3-axis accelerometer to measure linear acceleration. The combination of IMU sensor used to adapt walking stability and detect falling state of robot. The Logitech camera installed on the robot head used to detect the ball and other features on the soccer field. The computing system separated into 2 computational level: high-level computation used ODROID-C1+ with ARM Cortex-A5 (1.5Ghz quad core CPUs) computer to receives pictures from camera and extract interesting features from picture. The vision based navigation system and robot decision-making system also installed on this level. Moreover, the computer can control servo-motors on robot head to pan-tilt the camera3 to find interesting features. The low-level computation used STM32F411RE micro-controller as main processor to operate locomotion system by receiving the locomotion command from high-level. The system diagram as shown in 2

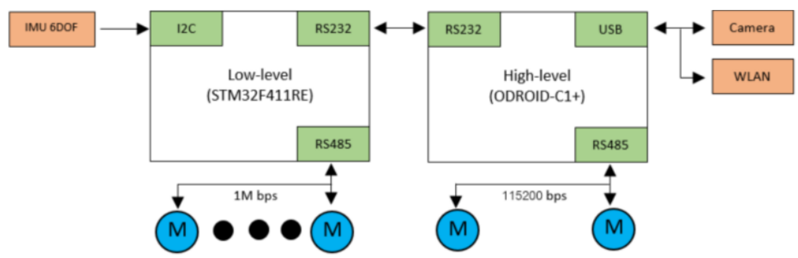

Figure 2: System diagram of Hanuman-KMUTT Team

The locomotion system on low-level receives locomotion command from high-level which consists of planar velocity (Vx, Vy) and angular velocity (). The command then map to walking gait parameters and generate trajectory for all servo-motors in each legs using 6DOF inverse kinematics combine with sensors information from IMU to improve walking stability.

3 Vision based navigation system

To interact with objects in the soccer field, the robot shall be able to distinguish and identify many types of objects in the playing environment. Currently the ball and field lines can be detected, other useful information associated with the objects such as position and speed shall be determined. Once the information is determined, the robot can compute an appropriate action for the soccer game. Following subsections describe how the robot recognizes objects in the field and compute the position of objects. Moreover, information outside the soccer field can be useful since there is no landmark for robot to recognize which side is friendly territory. We found a method which have a potential to detect some objects outside the field.

3.1 Position Determination

Three dimensional position of an object can be estimated when the object is identified in an image. The necessary information consists of a selected pixel on image coordinate (u, v) that belong to the object, forward kinematic from a robot base to a camera and camera's properties. Coordinate of interested pixels will be projected to a plane (floor) using perspective transform then three dimensional position which respect to robot base will be calculated using forward kinematic.

3.2 Color Segmentation

Each pixels in an image will be classified into eight colors (green, black, orange, blue, yellow, magenta, cyan and white) base on their pixel value. Then, apply watershed segmentation to get a better result on color segmentation.

We used HSV color system for classify a color of each pixels.The white color pixels would classified when the value of Saturation (S) is lower than the threshold, while the Value (V) is higher than the threshold. Black color pixels can also be classified when both Saturation (S) and Value (V) is lower than each threshold. For other colors, their Hue (H), Saturation (S) (and also Value (V)) on the appropriate certain ranges could be used for classification.

3.3 Field Boundary Detection

An information about field boundary is importance for our soccer robot. This information can be used later on other image processing algorithm. We detect a field boundary by scanning an image from top to bottom and find a first green pixel for each columns of an image. Convex hull from those points we get by scanning an image will be our field boundary.

3.4 Ball Detection

From the competition in Robocup asia pacific 2017 [2] we have tried to used HAAR feature for ball detection. A lot of false positive detections have been occurred, so we have to remove out the un-related background by ignore every object outside a field boundary. The approach for ball detection has been slightly changed as followed.

1. As the ball contains white component mostly, the white color segmentation from 3.2 has been used. RamerDouglasPeucker algorithm [3] was used to classify how well the circle shape the object is. And then the region of the interests (ROI) of the detected objects would be used for consideration.

2. The ROI(s) from previous step were checked with well-trained HAAR cascade classifier (using adaboost) [4][2]. Because we have limited the ROI(s), the scanning is faster than before.

3.5 Line Detection

Line information should bee useful for localization in future work. To detecting a line, we scan an image inside a field boundary from top to bottom every 8 image columns and find points where color is change from white to green. Three dimensional coordinate of those point can be obtained as we mention in 3.1. Those points on a field line can be treat like a point cloud from laser scanner and be used by particle filter.

3.6 Landmark Detection

detect landmark

detect landmark deep learning Fully-convolution Siamese network **??** track (arbitrary object tracking) track exemplar image Search image initial score map Search image

exemplar image landmark Search image score map exemplar image score map threshold filter landmark detect goal goal

4 Game Control and Decision-making

4.1 Game Controller

To control the operation during the game, all robots continuously receive the message from the referees game controller. When the received message indicates the change of the game state, the current operation is terminated. Then the robot loads the new operation which associated with that state.

4.2 Decision Making System

The decision making system of all striker robots can be described by the finite state machine illustrated in figure below. The conditions for state changes of each state are determined based on the observation data from the vision system and internal sensor reading of the robot. In addition, the robot shares this information among the teammates by broadcasting mechanism via WLAN network. Therefore, the robot can cooperate to score the game as a team. The goalie decision can be described in a simpler state machine. The goalie is looking for the ball, if the ball heads toward the goalie on either direction (left/right). The goalie will fall in that direction in order to block the ball.

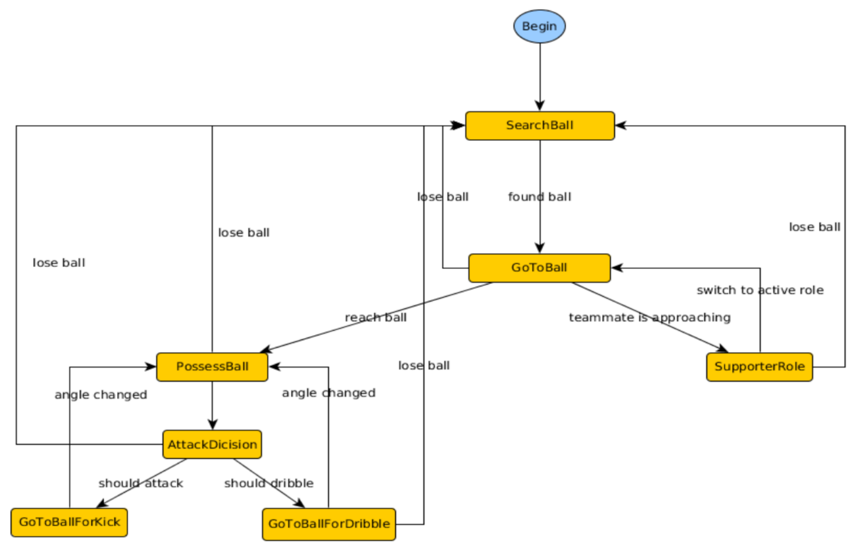

Figure 3: The state diagram shows the decision making system for a striker.