KMUTT Kickers: Team Description Paper

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Abstract. This paper describes the design and development of our teen-sized Robocup Humanoid robot for the team KMUTT-Kickers. Our teen-sized robot team comprises of two robots: Ka-Ti(goalie) and Ka-Nok(kicker). The robot can walk and perform other motions such as falling to the side. The robot can autonomously locate the ball and walk toward the ball and the goal.

1 Introduction

Institute of Field Robotics(FIBO) at King Mongkut's University of Technology Thonburi (KMUTT) has developed the humanoid robots since 2002. Since 2005, 'Team KMUTT' has been the representative of our institute to participate in RoboCup humanoid kid-sized league. We have been competing in the kid-sized category in the last five years. After the RoboCup 2010 in Singapore, we started to develop the teen-sized humanoid robot and plan to participate in the RoboCup 2011 in Turkey. Details specification of the robot can be found at http://fibo.kmutt.ac.th

In this paper, we will describe our teen-sized humanoid robot systems that will be used in the competition. Section 2 describes the design of our two robots: Ka-Ti and Ka-Nok. Section 3 demonstrates our idea of vision based navigation and decisioning system. Section 4 concludes the paper.

2 Hardware Design

This section explains the mechanical and electrical system design of our two biped robots. Each robot is composed of mechanical hardware, sensors, and computing hardware.

2.1 Ka-Ti

Ka-Ti is designed to be the goalie robot. Since the goalie has to withstand damages from the fall, Ka-Ti is designed to be lightweight and compact. The structure of Ka-Ti is made from aluminum alloy sheet metal and tube. This robot use 12 RX-64 and 6 RX-28 Robotis motors. Ka-Ti is 1.025 meter tall and weighs 4.7 Kg.

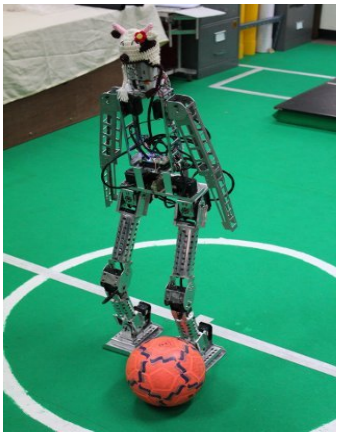

Fig. 1. *Ka-Ti* (Goalie)

Ka-Ti is installed with the 2-axis accelerometer [+/-2g], 3 rate gyros [+/-100 deg/sec]. The camera installed on the robot is a HaViMo camera which has the capture resolution is 640x480 pixels. The workspace of pan-tilt unit is -120 to 120 degrees in panning and 0 to -80 degrees in tilting. The accelerometer and gyros are used to computed for longitudinal and/or transversal tilt.

The locomotion is controlled by the ARM 7(60MHz RISC microprocessor) motor controller via RS485 port. The leg trajectory and balancing controlled is computed in the ARM 7 controller. The decision-making is also performed on this controller since we wants the goalie robot to be lightweight and simple as much as possible. The robot detects the position of the ball using the HaViMo camera and activates the falling motion according to the direction of the ball.

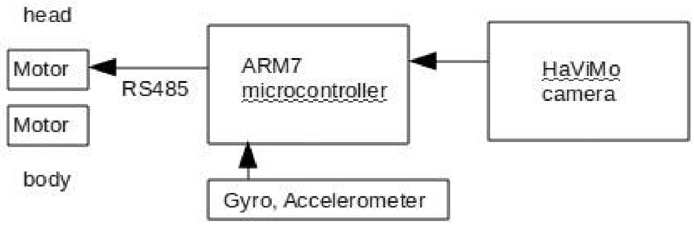

Fig. 2. System overview of the humanoid *Ka-Ti*

2.1 Ka-Nok

Ka-Nok is designed to be the striker robot. Ka-Nok is designed for dexterity of walking and kicking motion. The structure of Ka-Ti is made from Carbon Fiber tube for lightweight and high strength. This robot use 12 Ex-106 and 6 RX-28 Robotis motors. Ka-Nok's weight is 5.6 kg and the height is 1.1 meters. Fig.3 shows the humanoid robot Ka-Nok.

Fig. 3. *Ka-Nok* (Striker)

Ka-Nok is installed with 9DOF Razor IMU unit (3-axis accelerometer [+/-2g], 3 rate gyros [+/-100 deg/sec] and 3 magnetometer) from Sparkfun electronics. The camera installed on the robot is a single lens USB webcam (Logitech Quickcam C905) which has the horizontal field of view at 60 degrees. The capture resolution is 320x240 pixels. The workspace of pan-tilt unit is -120 to 120 degrees in panning and 0 to -80 degrees in tilting. The accelerometer tells the robot if there is any longitudinal and/or transversal tilt. The three rate gyros measure angular velocity in three axes of rotation. Kalman filter is used to estimate the body angle from gyro and accelerometer information. The angular position and velocity information will be used to adapt the attitude of the body during walking. The camera is used to track the ball and other objects of interest, which is crucial for navigation decision-making software.

The main computer for the robot is PICOITX (PICO820) SBC with ultra low power Intel AtomTM processor Z500 (1.6GHz CPU) . The PICO820 board computer receives information from the CCD camera via the USB port. The computer computes the walking path and sends locomotion command to the ARM 7 (60MHz RISC microprocessor) motor controller via RS485 port. Two sets of Lithium Polymer batteries are used to power the motors and the computer separately.

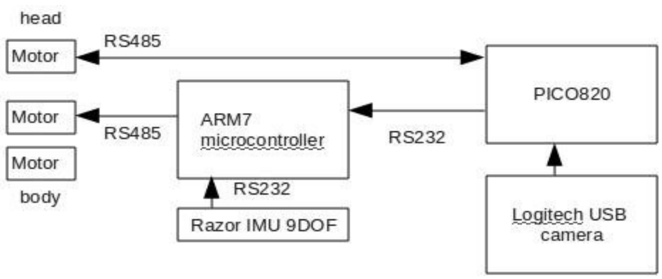

Fig. 4. System overview of the humanoid *Ka-Nok*

The position, velocity, load , voltage and temperature of all motors will constantly be read back to the PC via the ARM-7 that acts like a smart router. The accelerometer and gyro sensor readings also automatically report to the PC via the smart router. This allow us to gather all information of the robot in real-time into the PC. With this system, the locomotion module was moved to the PC. The locomotion code is written in Python, which allow us to adjust the locomotion and display all sensor feedback during the development phase.

We also add the Kalman filter into the sensor fusion module, therefore, the body angle around X and Z axis of the robot can be more accurately estimated. This ability allow us to experiment with new algorithm of balancing on the robot, where not only angular velocity is concerned but also the body angles.

3 Vision based navigation system

The vision system on Ka-Nok is based on the vision system that we used in Team KMUTT's KM-series robot. The vision computation in this robot is performed by the PICO820 on-board computer. To obtain objects information associated to the game play, the robots must have abilities to identify and distinguish each object in the field including the abilities of locating the objects and their movement. These can be solved by implementing vision-based navigation system which consist of two major parts, the object recognition and objects observation. The output from the object observation process is the input for the decisioning system. After the objects information is known, the robot plays the game by using the finite-state decision-making system described in section 4.

3.1 Object Recognition

Each object type in the field is clearly assigned a specific color, so the recognition can be done by focusing on the color feature of each type. To do this, a color segmentation technique, called color scoring, which based on fuzzy concept are implemented. Instead of using hard threshold on every pixel value of an image in a traditional color space, such as RGB or HSV, the image scoring approach uses the relation among each color channel value and the fuzzy concept to assign a score for each pixel as shown in the Fig 5.

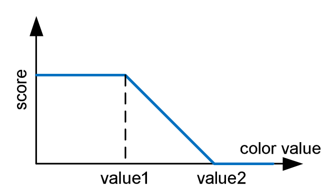

Fig5a: Color segmentation using image scoring with low brightness of high values

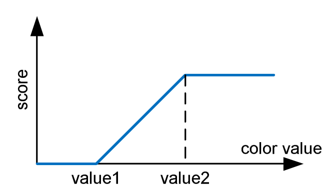

Fig5b: Color segmentation using image scoring with high brightness of high values

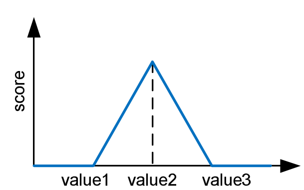

Fig5c: Color segmentation using image scoring with high value of medium brightness

The scores of each color channel are defined between 0 and 1. The score to the color class of each pixel are the product of score of its channels. After testing both segmentation schemes, the image scoring is more efficient than HSV transform because the image scoring method adds up brightness values of each pixel to the values between 0 and 1. Therefore, it is more robust to the changing lighting conditions than the hard thresholding method.

3.2 Object Observation

After recognizing every object in the scene, the objects position referenced to the robot are determined. This process assumes the camera is well calibrated, so the intrinsic and extrinsic parameters of the camera installed on the head pan-tilt is obtained and the robot knows the head pan and tilt angle of each scene.

To compute the angle to the object from robot reference, the horizontal pixel position of the object centroid in the scene is converted to the angle deviation from the center of the scene. Then, this value is combined with the head pan angle to obtain the object angular position referenced to the robot reference. For the distance to an object, the head tilt angle associated with the known height of the robot is used to compute the distance. This is shown in the Fig 6.

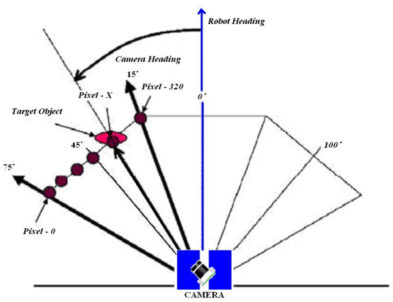

Fig. 6. Determination of robot heading toward the targeted object (Top View)

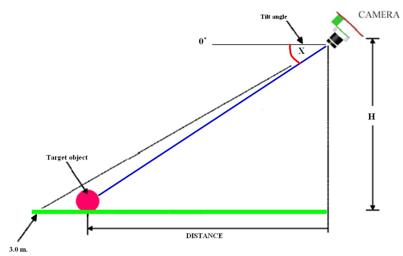

Fig. 7. Determination of the distance from the robot to the target object (Side View)

4. Decision-making process

In Ka-Nok, the game play decisioning is performed on PICO820 SBC. After the robot detects the ball and landmarks such as the yellow and blue goals, the localization process based on the estimated location of the goal is performed. The decisioning procedure in the robot is based on finite state machine. Each state is defined as the brain state which depends on the result of object observation process. The robot implements a visual servo algorithm for walking toward the ball. The goal scoring operation of Ka-Nok can be shown by the following state diagram in Fig 8.

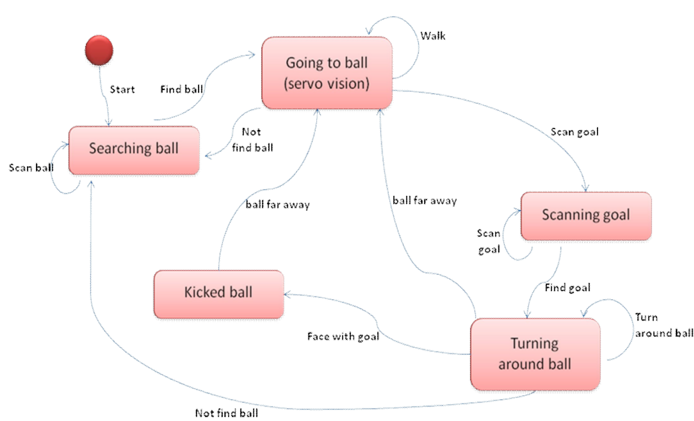

Fig 8. State diagram of goal scoring brain

5 Conclusions

Two teen-sized humanoid robots have been developed for participating in the Humanoid soccer league for RoboCup 2011. These robots has been based on the kid-sized humanoid robot system of TeamKMUTT. This year we are focusing on designing and building larger humanoid robots that are lightweight and robust. These robots can perform different motions such as walking, turning, getting up and blocking the ball. These robots can also autonomously navigate the game field and score the goal in a 2-2 soccer game.

Acknowledgements

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References

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