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DAFTAR ISI

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FAST BALL DETECTION AND TRACKING FOR HUMANOID SOCCER ROBOT USING SIFT KEYPOINT DETECTOR

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Abstract

The main feature for Humanoid Soccer Robots is the ability to vastly detect and tracking the ball in uncontrolled environment. This paper proposes a high speed ball detection and tracking method using SIFT(Scale Invariant Features Transform) *Keypoint detector and PID controller for Humanoid Soccer, because the ability to accurately track a ball is important especially for processing high-definition image. We use pan tilt camera system to track and find the position of the ball. The proposed method is able to detect a ball based on its keypoint in 10 ms, determine the position of a ball and kick the ball correctly greater than 80%.*

Keywords: *ball detection, sift, tracking, flann*

1. INTRODUCTION

The humanoid soccer robots is popular today for the contest such as RoboCup Humanoid League and entertainment. The important features of humanoid soccer are accurate, robust and efficient determination and tracking of ball size and location, has proven to be a challenging subset of this task and the focus of much research. With the evolution of robotics hardware and subsequent advances in processor performance in recent years, the temporal and spatial complexity of feature extraction algorithms to solve this task has grown accordingly [1].

In the case of Humanoid soccer, vision systems are one of the main sources for environment interpretation. At the same time many other topics like human-machine interaction, robot cooperation, mission and behavior control give to humanoid robot soccer a higher level of complexity like no any other robots [2]. So the high speed processor with efficient algorithms needed in this issue.

One of the performance factor of a humanoid soccer is highly dependent on its tracking ball and motion ability. The vision module collects information that will be the input for the reasoning module that involves the development of behavior control. Complexity of humanoid soccer makes necessary playing with the development of complex behaviors, for example situations of coordination or differ rent role assignment during the match. There are many types of behavior control, everyone with advantages and disadvantages: reactive control is the simplest way to make the robot playing, but do not permit more elaborated strategies as explained for example in [3]. On the other side behavior-based control, are more complex but more difficult to implement, and enables in general the possibility high-level behavior control, useful for showing very good performances [4]. In this paper we propose the robust system to detect a ball using SIFT keypoint detector and FLANN(Fast Library for Approximate Nearest Neighbour) based matcher, tracking using PID cntroller then kick the ball after getting the nearest position of the robot with the ball.

2. PROPOSED METHOD

Humanoid soccer robot design based on the vision involves the need to obtain a mechanical structure with a human appearance, in order to operate into a human real world. We propose an embedded system that able to handle high speed image processing, so we use main controller based on the ARM Processor. Webcam and servo controller used to track a ball, and the output of the main controller will communicate with the CM510 controller to control the actuators and sensors of the robot as shown in fig. 1.

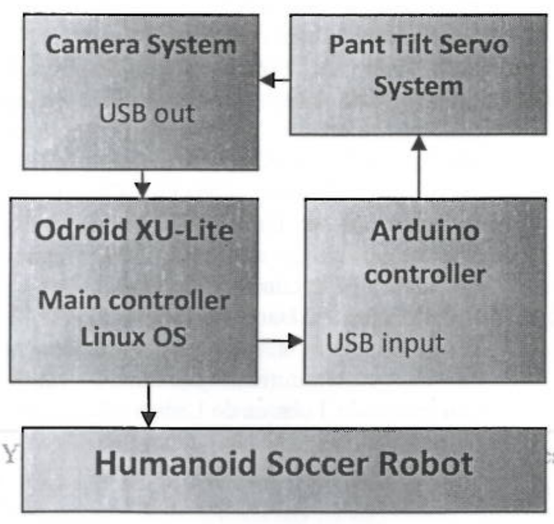

Fig.1. Architecture of our humanoid soccer robot for ball detection and tracking.

The main controlier using Odroid that consist of Exynos5 Octa Cortex™-A15 1.6Ghz quad core and Cortex™-A7 quad core CPUs and sufficient memory and ports to be connected with other devices as shown in fig. 2

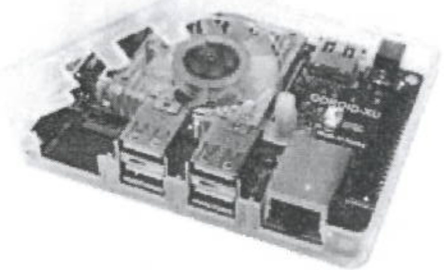

Fig.2. Odroid XU-Lite for processing the images from webcam[a]

The ODROID-XU Lite provides the processor running at 1.6GHz. Features of the board include:

- Exynos5 Octa Cortex™-A15 1.6Ghz quad core and Cortex™-A7 quad core CPUs
- PowerVR SGX544MP3 GPU (OpenGL ES 2.0, OpenGL ES 1.1 and OpenCL 1.1 EP)
- 2GB LPDDR3 RAM
- USB 3.0 Host x 1, USB 3.0 OTG x 1, USB 2.0 Host x 4
- Micro HDMI 1.4a output Type-D connector

The architecture of Odroid shown in fig. 3 that very powerful to be used for the next generation of humanoid robot soccer comparing with other very expensive humanoid robots. OpenCV with Machine Learning class for SIFT and FLANN methods run very well in this board.

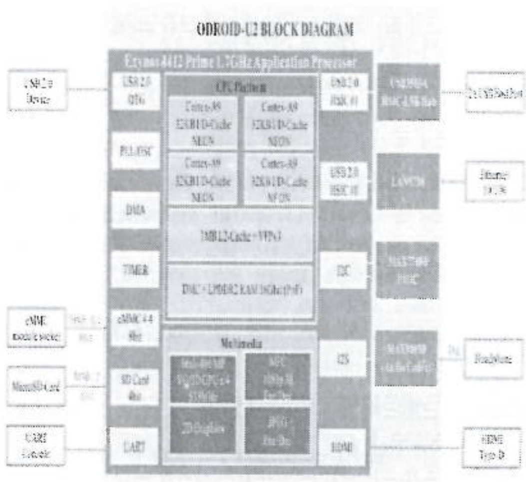

Fig.3. The architecture of the Odroid [a]

Ball Detection using SIFT Keypoint Detector. Computer vision is one of the most challenging applications in sensor systems since the signal is complex from spatial and logical point of view. An active camera tracking system for humanoid robot soccer tracks an object of interest (ball) automatically with a pan-tilt camera. At previous work, we detect ball based on color (color-based object detector) which is not robust[11]. An object detection system based on SIFT Keypoint detection is based on Machine Learning. The features are invariant to image scaling, translation, and rotation, and partially in-variant to illumination changes and affine or 3D projection.

Features are efficiently detected through a staged filtering approach that identifies stable points in scale space. The first stage of keypoint detection is to identify locations and scales that can be repeatedly assigned under differing views of the same object. Detecting locations that are invariant to scale change of the image can be accomplished by searching for stable features across all possible scales, using a continuous function of scale known as scale space. The scale space of an image is defined as a function, $L(x, y, \sigma)$, that is produced from the convolution of a variable-scale Gaussian, $G(x, y, \sigma)$, with an input image, $I(x, y)$ "

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y) \quad (1)$$

Where*is the convolution operation in $x$and y, and:

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$$G(x, y, \sigma) = (1/2\pi\sigma^2)e^{-(x^2+y^2)/2\sigma^2}$$

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To efficiently detect stable keypoint locations in scale space, David G. Low proposed using scale-space extrema in the difference-of-Gaussian function convolved with the image

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$$D(x, y, \sigma) = [G(x, y, k\sigma) - G(x, y, \sigma)] * I(x, y)$$
$$= L(x, y, k\sigma) - L((x, y, \sigma))$$

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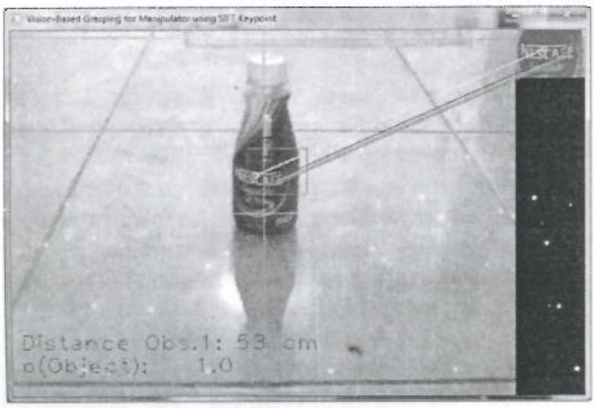

Fig.4. Example of object detection using SIFT Keypoint detector and FLANN based matcher.

To have a good estimation, the object must be in the centre of the image, i.e. it must be tracked. Once there, the distance and orientation are calculated, according to the neck's origin position, the current neck's servomotors position and the position of the camera respect to the origin resulting of the design [7]. The ball will be track based on the color and webcam will track to adjust the position of the ball to the center of the screen based on the Algorithm 1.

Algorithm 1: Ball Detection, Tracking and Kick the ball

```
Get input image from the camera
Detect ball using SIFT Keypoint detector
If detected then
  Get the center position of the ball
  Centering the position of the ball
  Move robot to the ball
  If ball at the nearest position with the robot then
    Kick the ball
  endif
endif
```

PID Controller for Ball Tracking. We use a PID controller for servo to calculates an error value as the difference between a measured [Input] and a desired setpoint. The controller attempts to minimize the error by adjusting [an Output]. The model of PID Controller shown in fig. 4 :

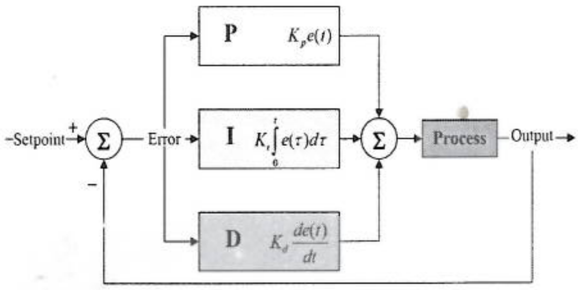

Fig.5. General PID Controller [8]

The output of a PID controller, equal to the control input to the system, in the time-domain is as follows :

$$u(t) = K_p e(t) + K_i \int e(t)dt + K_d \frac{de}{dt} \qquad (4)$$

3. EXPERIMENTAL RESULTS

The approach proposed in this paper was implemented and tested on a humanoid Robot named Humanoid Robot Soccer Ver 3.0 based on Bioloid Premium Robot and OpenCV 2.4.9.

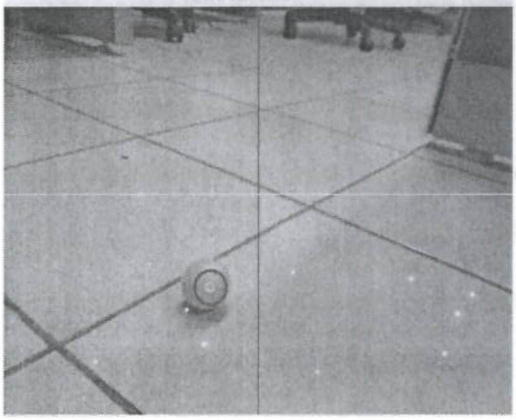

Fig. 6. The ball detected by our vision-based system for humanoid soccer robot.

When a ball in front of the robot and detected, the robot try to track the ball, and if the ball at the nearest position with the robot, robot will kick it as shown in fig. 7.

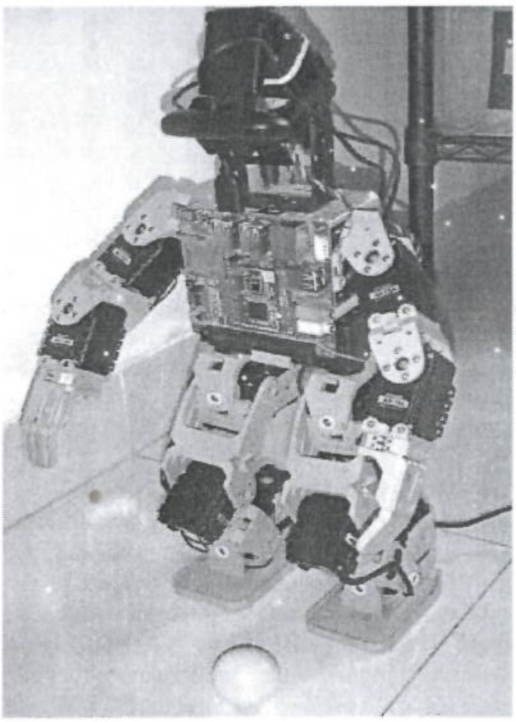

Fig. 7. The robot tracks and kicks a ball when at the correct position.

The overall result of our system shown in table 1 below:

Table 1. Detection and tracking status

Parameter	status
Detect a ball	10ms
Tracking object without error	90%
Kick a ball	> 80%

4. CONCLUSION

In this paper, we introduced the hardware architecture implemented on our humanoid robot soccer. They are based on Odroid XU-Lite that have powerful ability for high speed image processing. We propose robust system using SIFT keypoint detector to detect and track a ball, then kick the ball after getting the nearest position of the robot with the ball. The FLANN based matcher suitable to be used for real situation. For future work, we want impro the ability of robot to battle with the opponent.

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Website

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