

Vision Based Self Localization for Humanoid Robot Soccer

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Abstrak

Sistem lokalisasi robot sepakbola berbasis mesin visi, bertujuan untuk membuat rancang bangun sistem lokalisasi robot sepakbola. Upaya untuk mewujudkan gagasan ini dilatarbelakangi perlunya sistem lokalisasi pada robot sepakbola agar dapat bermain bola dengan efektif dan efisien. Hasil penelitian yang diharapkan adalah adanya sistem lokalisasi robot sepakbola berbasis kamera dan kompas elektronik. Dengan demikian akan dapat dikembangkan robot sepakbola yang memiliki kemampuan bermain yang lebih baik, karena dengan adanya sistem lokalisasi ini, robot akan dapat menentukan perilaku yang lebih tepat pada kondisi dan lokasi tertentu, misalnya: ketika menemukan bola di daerah sendiri maupun menemukan bola di daerah lawan. Metode penelitian disusun berdasar rancangan sistem yang terdiri dari bagian-bagian utama yaitu: pengambilan gambar/citra lapangan, pemrosesan informasi citra menjadi informasi tentang lokasi robot pada saat itu. Hasil penelitian menunjukkan bahwa sistem lokalisasi pada penelitian ini telah mampu melakukan perkiraan lokasi robot terhadap gawang.

Kata kunci: lokalisasi, mesin visi, pengolahan citra, filter HSL

Abstract

Vision based robot soccer localization system, aiming to create a robot soccer localization system. The implementation of this idea is motivated by the need of the localization system for the robot soccer to play the ball effectively and efficiently. The expected result of this research is to develop the localization system for the robot soccer based on camera vision. Thus the developed robot will be able to play football better. It is because of the localization system that can make the robot able to behave more precisely on certain condition and location. For example, the robot should be able to find the ball in its own area or in the opponent's. Research conducted on several major parts, consisting: image capture, processing image information and directions to the information about the location of the robot at the time. The experimental results indicate that the localization system in this research work has the ability to perform an approximation of the robot location with respect to the goal.

Keywords: computer vision, HSL filter, image processing, localization

1. Introduction

Humanoid robots have become an interesting research theme for the last two decades. The main reason for this is that these robots are theoretically capable of performing the same tasks and operate in the same environment with humans. On the other hand, there are also tasks that are too complex to be done by a simple robot and too dangerous for humans to live. Therefore humanoid robot providing a common platform for researching and developing technologies in various fields. Some examples are walking on two legs (bipedal), stereo vision systems, self localization and human interaction with robots. Although research on the development of humanoid robots has been a long time, there are still significant shortcomings in the aspects of functionality and performance, compared to an actual human being [1].

RoboCup, an organization that spearheaded the existence of a form of activity for the various types of robot competitions, one of which is the RoboCup Soccer, which uses the principles of the game of football. RoboCup Soccer in this case has declared that the main objective in 2050 has created a robot soccer team capable of competing with humans. Through this event is expected to attempt to achieve a level of functionality and performance robots closer to humans can be accommodated well [2]. A class or division in organizing the

RoboCup held in 2011 are divided into several classes, which are grouped into four main categories. Class divisions in the RoboCup can be seen in the following table

Tabel 1. Robocup categories

Category	Class division
RoboCup Soccer	Simulation League Small-Size League Middle-Size League Standard Platform League Humanoid League
RoboCup Rescue	Rescue Simulation League Rescue Robot League
RoboCup Junior	RoboCup Junior Soccer RoboCup Junior Rescue RoboCup Junior Dance
RoboCup@Home	

Locomotion, which can be either walking or running, self localization ability, the ability to find the ball and the goal, and the ability to manipulate the ball (kick, lead, and catches the ball for a robot that serves as a goalkeeper) are some of the fundamental ability of a humanoid robot soccer league in the category.

The problem in this study emphasized the need for self localization ability in robot soccer. Some of the problems encountered in this study can be expressed through the following questions:

1. whether the data that can be collected by the robot and the environment itself can be used to perform self-localization?
2. how does the data processing is to be used by the robot for localization process itself?
3. how the techniques to analyze the data obtained to be able to localize the robot itself, so that the robot can distinguish one location to another?

With the above three questions, problems encountered in this study can be formulated and also can be used as a boundary problem. This research aimed at the RoboCup Soccer Humanoid League, where a number of humanoid robot (like humans) playing soccer on a field that is generally the same as a football field in general, namely: having a goal and lines on the field, the difference contained on the size and the presence of some additional field, for example: blue and yellow goal, there is a marker rod in the right and left field, as well as a number of special line pattern on the ground.

Knowledge of the position of the robot (localization) in robot soccer is one of the skills a robot needed to be capable of playing well. Various approaches for doing this has been done, including in other kind of mobile robot. The most popular approach in the mobile robot localization and navigation generally based on the information about the distance of an object to the use of proximity sensors [3], mobile robot with infrared sensor or ultrasonic sensor is an example of this approach. Other approaches based on images obtained from an omnidirectional camera [4] [5]. However, these approaches can not be used in the RoboCup Soccer Humanoid League class, because one of the main rules in this category is that the robot must have a certain level of compatibility with people, one of them on a system of sensors used. In short it can be said that any kind of active sensors that are emit a energy or signal and receiving back the reflections are not allowed in the Humanoid League. Using the camera as a sensor to be the most likely alternative to the Humanoid League, but it should be noted that the camera used is limited point of view, maximum 180°. To measure the internal state of the robot, the use of accelerometer, gyroscope and compass are allowed [6].

As mentioned earlier, the robot soccer field used resemble football field in general, but with differences in the size and color, as well as a number of special markers. Pitch arrangement and size can be seen in Figure 1 and Table 2.

From Figure 1, it appears that in the field there are a number colored objects, lines and circles, which are the limiting / marker of the parts of the field. These field features could be used to determine the location of the field. Hundelshausen F.V. et al, use the lines as a basis for the localization of the robot soccer midsize cameras [4]. The use of these lines for robot localization, especially humanoid robots have also been made by H. Schulz et al [7]. To be able

to perform localization based on the lines of the field, it needs a vision system that is able to find the lines.

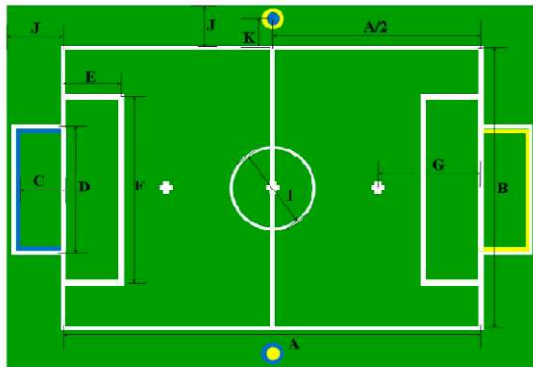


Figure 1. Humanoid robot soccer field (KidSize)

Tabel 2. Humanoid robot soccer field dimension (KidSize)

Label	Name	Dimension (mm)
A	Field length	600
B	Field width	400
C	Goal depth	50
D	Goal width	150
E	Goal area length	60
F	Goal area width	300
G	Penalty mark distance	180
I	Center circle diameter	120
J	Border strip width (min.)	70
K	Distance of pole to field	40

This paper proposed a localization using colored object and heading in the humanoid robot soccer's field. It based on assumption that the main interest of the soccer play, e.g. the goals, in the humanoid robot soccer field have a distinct color. One is colored blue and the other colored yellow. Information about a goal post could be used to infer an approximation about where the robot is, and furthermore it could be use to infer what action the robot must take if the robot encounter a ball at that location, whether to kick the ball toward the goal or turn the ball away to protect the goal if the goal detected is the robot's team own goal. This approach only, however has a drawback, because the Robocup comittee is trying to make the Robocup game much and much closer to a real soccer match, there are trends in rule evolution from year to year in the Robocup, one of them is to replace specifically colored goal to non colored goal. Based on this trend it would be a must to have a robot that could distinct its own goal and the opponent goal based on non color information, such as heading, due to the fact that goals in soccer play are placed in opposite side. This paper combined color based information (e.g. the goals) and heading for localization process.

2. Research Method

2.1 Digital Image

A digital image is a numeric representation (normally binary) of a two-dimensional image. Depending on whether the image resolution is fixed, it may be of vector or raster type. Without qualifications, the term "digital image" usually refers to raster images also called bitmap images.

Raster images have a finite set of digital values, called picture elements or pixels. The digital image contains a fixed number of rows and columns of pixels. Pixels are the smallest individual element in an image, holding quantized values that represent the brightness of a given color at any specific point.

Typically, the pixels are stored in computer memory as a raster image or raster map, a two-dimensional array of small integers. These values are often transmitted or stored in a compressed form.

Raster images can be created by a variety of input devices and techniques, such as digital cameras, scanners, coordinate-measuring machines, seismographic profiling, airborne radar, and more. They can also be synthesized from arbitrary non-image data, such as mathematical functions or three-dimensional geometric models; the latter being a major sub-area of computer graphics. The field of digital image processing is the study of algorithms for their transformation.

2.2 Computer Vision

Computer vision is the transformation of data from a still or video camera into either a decision or a new representation. All such transformations are done for achieving some particular goal or purpose. Computer Vision is an important tool for robotics systems since it mimics the human sense of vision and allows for non-contact measurement of the environment [8]. In this work, the computer vision mainly used to detect special object in the robot soccer field in order to infer its locations and the robot location. The computer vision comprised a webcam, for imaging process and an embedded computer at the back of the robot for the image processing process.

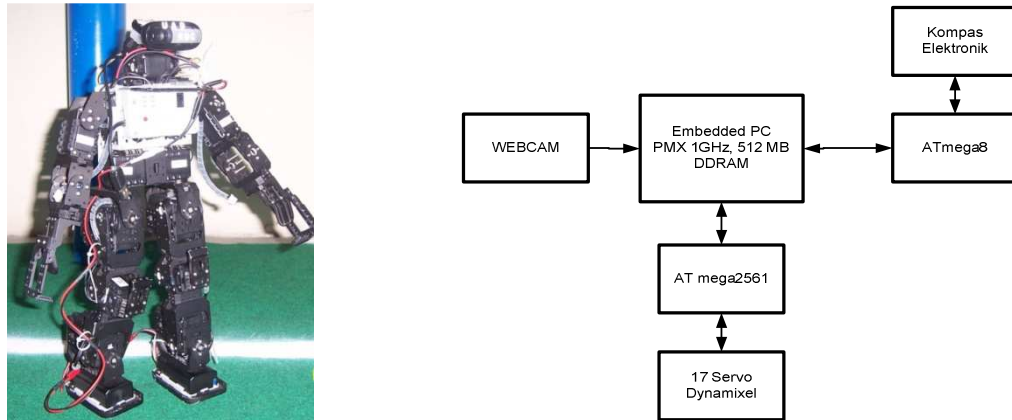


Figure 2. Humanoid robot soccer and block diagram of the humanoid robot soccer

2.3 Goal detection

Detection based on HSL filtering to select the object with specified color, blue for instance, prior to HSL filtering the original image was posterized. Color conversion from RGB to HSL steps are as follows [9] : r, g, b values are first obtained by normalizing each pixel such that:

$$r = \frac{R}{R+G+B}, g = \frac{G}{R+G+B}, b = \frac{B}{R+G+B} \quad (1)$$

Accordingly, the H , S , and L values can be computed as

$$V = \max(r, g, b) \quad (2)$$

$$S = \begin{cases} 0 & \text{if } V = 0 \\ V - \frac{\min(r, g, b)}{V} & \text{if } V > 0 \end{cases} \quad (3)$$

$$H = \begin{cases} 0 & \text{if } S = 0 \\ \frac{60 * (g - b)}{S * V} & \text{if } V = r \\ 60 * \left[2 + \frac{(b - r)}{S * V} \right] & \text{if } V = g \\ 60 * \left[4 + \frac{(r - g)}{S * V} \right] & \text{if } V = b \end{cases} \quad (4)$$

$$H = H + 360 \text{ if } H < 0 \quad (5)$$

In HSL Color filtering, pixels with value are in the specified range value of each H, S and L component, pixels value will not change. Therefore, after filtering, pixels with HSL values in the range specified by value of input parameters will still appear as the original color, while the outside of the range will be replaced with black or with a value of 0. HSL filtering can be expressed as Equation (6)

$$F_{HSL}(p_i) = \begin{cases} p_i & \min_H \leq H(p_i) \leq \max_H, \min_S \leq S(p_i) \leq \max_S, \min_L \leq L(p_i) \leq \max_L \\ 0, & \end{cases} \quad (6)$$

If HSL value of pixel p_i is between minimum values for each HSL component \min_H, \min_S, \min_L and maximum values \max_H, \max_S, \max_L , value of p_i still remain, otherwise p_i is set to value 0 or black.

After HSL filtering, we use a method to check the shape of the remaining object (blue colored object), we assume that for being a goal an object must have for corner (quadrilateral). Using Blob filter and a Quadrilateral checker, we select and process every blue colored object, and if an object is a quadrilateral we draw a red polygon (rectangle) on it for further processing.

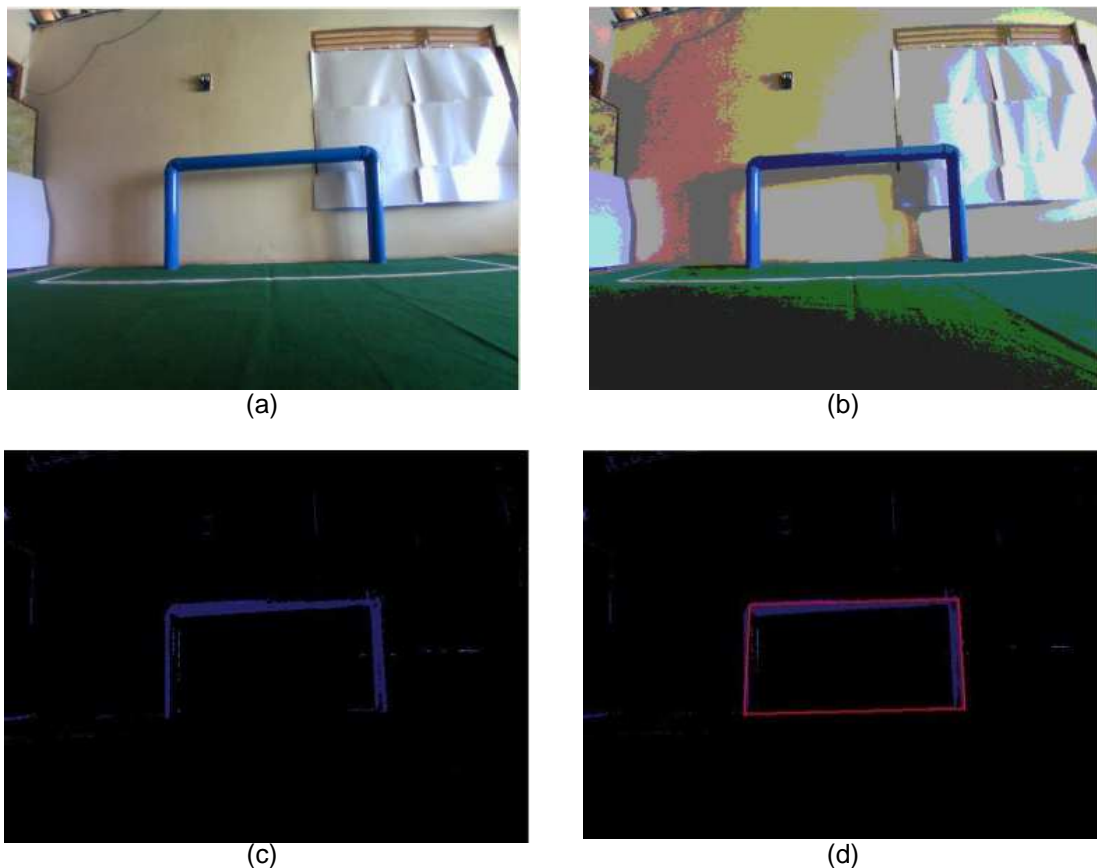


Figure 3. Process for detecting (a) goal image capture, (b) posterization, (c) HSL filtering, and (d) quadrilateral check

2.3 Robot's location approximation

Based on the result of goal detection process, e.g. the red rectangle on a goal, we infer an approximation using the location of the goal's center point and the distance between the posts from a detected goal. The process explained briefly here, to simplify the localization

process, the robot only captures the field image when the robot is standing perpendicular to the goal line. Information from the electronics compass is used to achieve this method. Prior entering the field the robot initialize its heading database, so when the robot is in play it could detect whether it standing perpendicular to a goal line or not. When the robot is not standing perpendicular to a goal line, the controller send a command to change the robot heading until its heading is approximately perpendicular to a goal line. Because image taken only when the robot is perpendicular to a goal line, a simple camera projection could be used to infer important information about the robot location with respect to the goal. The goal center point offset to the center of the image is used to determine whether the robot is standing right in front the center of the goal or not. The goal post length on the image could be used to infer the distance between the robot and the goal.

Figure 4 shows a diagram of the camera projection in one dimension.

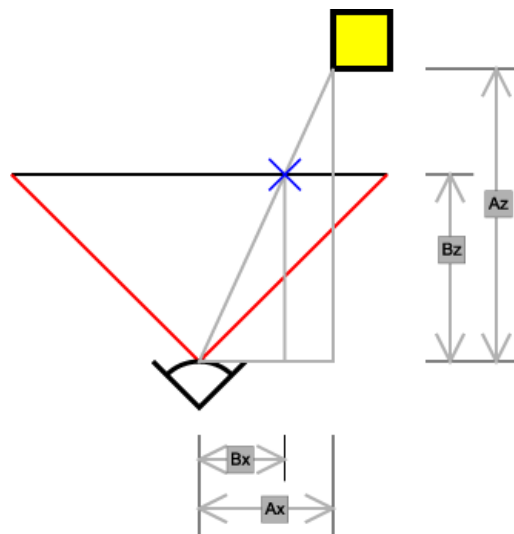


Figure 4. Camera Projection Diagram

To determine which screen x-coordinate corresponds to a point at A_x, A_z multiply the point coordinates by:

$$B_x = A_x \frac{B_z}{A_z} \quad (7)$$

where

B_x is the screen x coordinate

A_x is the model x coordinate

B_z is the focal length—the axial distance from the camera center to the image plane

A_z is the subject distance

3. Results and Analysis

Several experiments have been carried out to validate our algorithm. Some of them are presented here.

3.1. Goal detection and approximate robot location

Figure 5 depicted the process for detecting goal and robot location when the robot standing slightly left off the field center (from robot's point of view). Goal marked by a red rectangle, when the size and the center of rectangle is found, we could infer an approximation about the robot locations from the goal. Figure 6 depicted the process for detecting goal and

robot location when the robot standing slightly right off the field center (from robot's point of view). Goal marked by a red rectangle, when the size and the center of rectangle is found, we could infer an approximation about the robot locations from the goal.

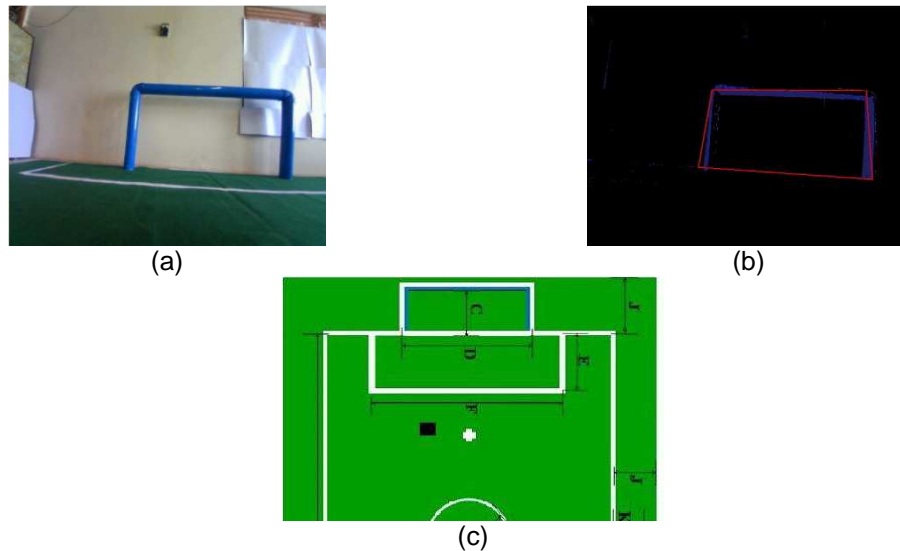


Figure 5. (a) Image capture, (b) goal detection, and (c) Robot's approximate locations (black rectangle)

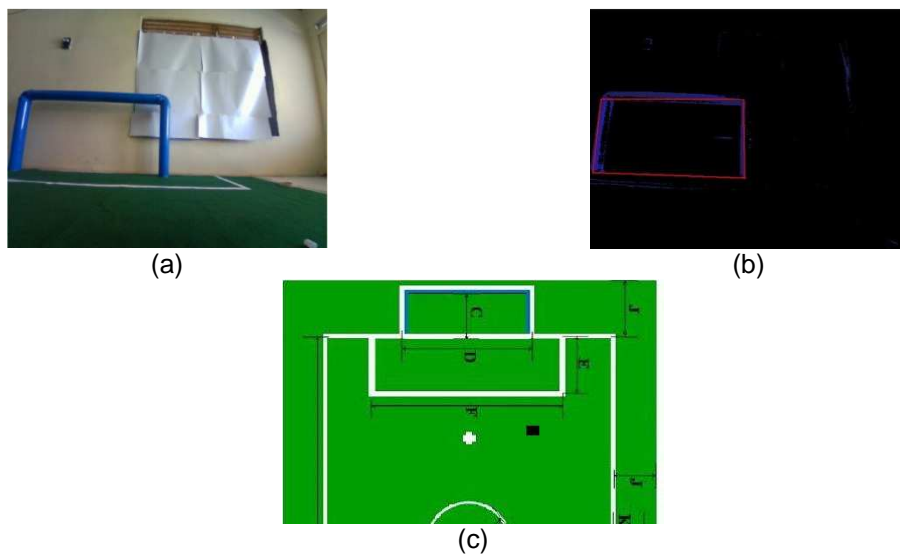


Figure 6. (a) Image capture, (b) goal detection, and (c) robot's approximate locations (black rectangle)

4. Conclusion

Vision is the most important sensor of the robot in Robocup, especially Humanoid Robot soccer. The robot must able to detect different kind of object to have a competitive play, furthermore from these informations robot must know what action to take. Location is a crucial factor for the decision taken. This paper proposed a methode utilizing goal detection and heading to infer an approximation about the robot locations. The experimental results indicate

that the localization system in this research work has the ability to perform an approximation of the robot location with respect to the goal.

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