Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2015, 7(3):2413-2417

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Research on humanoid robot vision system based on fuzzy image segmentation algorithm with color table

Zhong Qiu-bo[1,2], Zhao Jie[2] and Tong Chun-ya[1]

[1]*School of Electronic and Information Engineering, Ningbo University of Technology, China*
[2]*State Key laboratory of Robotics and System, Harbin Institute of Technology, Harbin, China*

ABSTRACT

According to the characteristic of humanoid robot soccer, the vision system embedded in robot is required to quickly and precisely recognize the target object, which facilitates a proper decision made by robot. Thereby, a useful approach which bases on HSI color space, uses the improved ambiguous color classes for color segmentation and applies the pyramid matching method to extract image eigenvalues is proposed in this paper. The end of this paper, a simulation experiment is done to prove validity of the proposed algorithm.

Key words: humanoid robot; vision; ambiguous color classes; pyramid matching method

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INTRODUCTION

The ultimate purpose of the research about humanoid robot is that, a high intelligence robot which has human characteristic like the ability of walking, feeling, thinking, judging etc., and can significantly substitute, server and be in harmony with human, have been manufactured[1]. It is can be imagine that, if the ultimate purpose have been achieved which will be an epoch making significance for human society just like industrial revolution.

As for research about humanoid robot, the foreign technological capability is obviously better than inland's. In humanoid robot soccer game, the robot called Nao from France as a standard platform for the game appears in the vision of people[2]. In the game, an ability of judgment given to robot is based on the fast and precise location of target object which is directly affected by the process of image, such as deposing, color segmentation and feature extraction[3].

There are a lot of researches about robot vision, Murch[4] etc use threshold method and edge detection to enhance precision of segmentation, however this approach is affected badly by illumination. Bandlow[5] etc. use morphological approach and 8-connected search to feature extraction. Seysener[6] etc adopt least square method and Levenberg Marquardt algorithm to fit and check the shape of clour block. Treptow[7] etc propose a grayscale-based segmentation and circle detection operator which ideas borrow from Adaboost algorithm for face recognition.

COLOR SPACE MODEL

Color space model is defined as a visual photon set in three dimensional space which includes the all color of a certain color gamut. There are some color space models useful like RGB, YUV, HSI, CMY and CIR Lab etc. Here, we choice HSI model as color space model.

HSI model is a approach that the color is defined by three basic attributes, hue, saturation and intensity. The reason why choice HSI model is that, HSI is more robust against the change of intensity than RGB, and correspondence to human perception which is more appropriate for the background about humanoid robot.

In HSI model, the H value means hue corresponding to light wavelength; the S value means saturation corresponding to the percent of white light; the I value means intensity corresponding to brightness of the color. Due to the fact that most humanoid robots use CMOS camera which output values of RGB, a formula about translation from RGB to HSI as follow.

$$I = r_1 R + r_2 G + r_3 B \tag{1}$$

Where I denotes intensity, $r_i \ (i = 1,2,3)$ represent the weight of brightness sensitivity of human eyes.

$$\begin{aligned} I &= \frac{1}{3}(R+B+G) \\ S &= 1 - \frac{3}{(R+B+G)}[\min(R,G,B)] \\ H &= \arccos\left\{ \frac{[(R-G)+(R-B)]/2}{[(R-G)^2+(R-B)(G-B)]^{\frac{1}{2}}} \right\} \end{aligned} \tag{2}$$

IMAGE SEGMENTATION

1.1 Image pretreatment

A 3*3 median filter is adopted to image deposing for a good image. The main idea of median filter is that a slide window containing points with an odd number, in which the assign point which typically is the central point of window will be substituted by the median value of the other points' gray value. When the number of points within the window is odd, the median value is defined as the median location of a value sequence which has been sorted by size; When the number of points within the window is even, the median value is defined as the average of two values in median location of the value sequence. Compared to gaussian weighting marks and mean filter, median filter performs best in deposing.

In order to prevent this from happening, in the original table lookup based on color, adding fuzzy color, fuzzy color means includes basic color more than one, for example, contains the fuzzy color orange is orange and red two base color, get a new with fuzzy color lookup table. Suppose there are three color area lookup table, algorithm flow chart shown in figure 1:

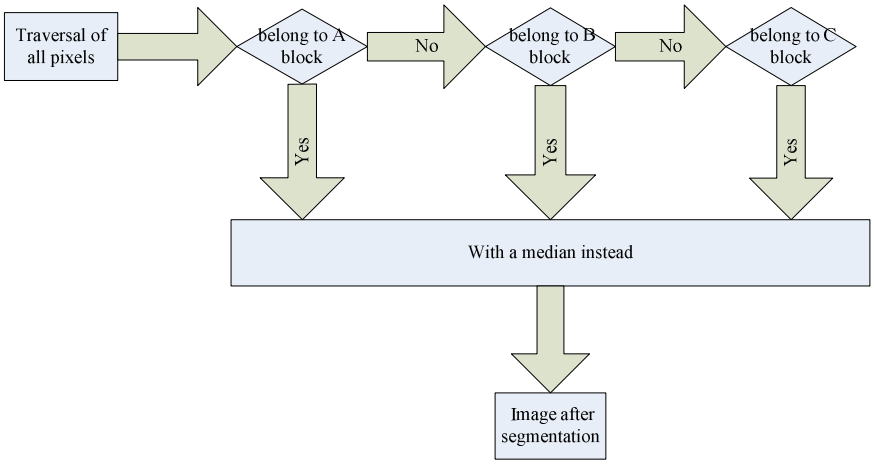
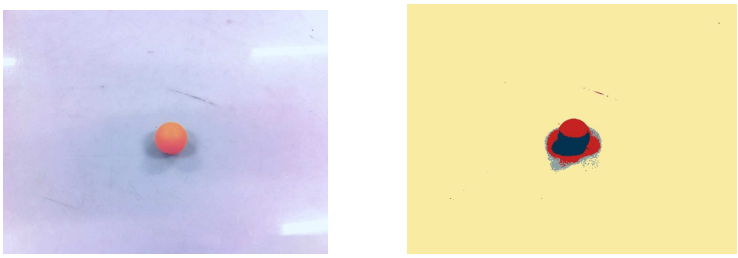


Fig. 1 Flow chart of fuzzy color table method

The result of image segmentation as shown in figure 2:



(a) original image **(b) processed image**

Fig. 2 Using fuzzy color table method processing effect chart

1.2 Ambiguous Color Classes

The main idea of color classes is that: a lookup table is defined before as a three dimension array for storing several color sets which actually is a range of values of HSI, i.e. Color classes. Next the all pixels within the image should be traversal and computation to a value, which values are used to compare to the color classes and replaced by the median value of a fitness color classes.

The color classes within color table are obtained manually. During the cognition, a repeat color region must be occurred, i.e. A certain pixel may belong to both A color classes and B color classes which will lead to the connection between target color and other color; On the other hand, the pixel may neither belong to A color classes nor belong to B color classes which will cause image fuzzy.

In order to compensate this problem, we add an ambiguous color classes to the lookup table. The ambiguous color classes inherit from at least two color classes. E.g. Orange-red is an ambiguous color which contain orange and red. The more ambiguous classes contain a lookup table, the more precise is image segmentation.

FEATURE EXTRACTION

Template matching algorithm considered as a common and effective feature extraction method, of which the main ideas is that, the await-matching map of a M*M size compared to the searching map of a N*N size, of which part covered by the searching map is called as subgraph S(i,j),the value i and j:1<i, j<M-N+1. The subgraph S(i,j) is compared with the target template T, if the contrast result is true, namely the difference of T and S(i,j) is zero, that means the target has been found. D(i,j) is used to indicate the difference:

$$D(i,j)=\sum_{m-1}^{M}\sum_{n-1}^{M}[S^{i.j}(m,n)-T(m,n)]^2 \tag{3}$$

Of course the difference couldn't be zero, so the status mostly nearing zero is taken. Besides it is obvious that template matching method have a big calculated amount due to the scanning and computation about the whole image, which is not beneficial to the robot game. The pyramid matching method is used in this paper.

The pyramid matching method is an improvement based on the template matching method which compensates the shortcoming, a big calculated amount. The fundamental as follow:

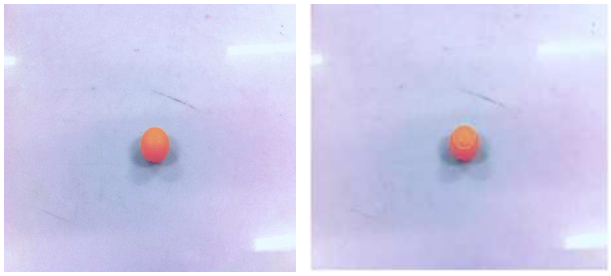
Step 1. The slice process is applied to the await-matching image. Every 2*2 dimension adjacent region of original image is processed with the average process one by one, in order to get a less resolution and smaller dimensions image, in that way, a sequence of the processed images which is sorted by resolution from high to low and dimension from big to small.

Step 2. The slice process is applied to reference image and real-time image, and then two sequences of the processed images can be got. The image sequence of M*M dimensions reference image and N*N dimensions real-time image can be presented as follow:

Step 3. The relation searching begins from the image with minimum resolution to find match point. Due to slice process, the low resolution image will lose some high-frequency information. In order to avoid losing match points, it is necessary to add some test positions around the rough matching position.

EXPERIMENTAL SECTION

A simulation test has been done in two different light intensities to test the robustness for the change of intensity. The results in brighter condition after feature extraction is shown in figure 3:



(a) original image (b) processed image

Fig. 3: the result chart in brighter condition after feature extraction.

Three peak figures of HSI in brighter condition are shown in figure 4:

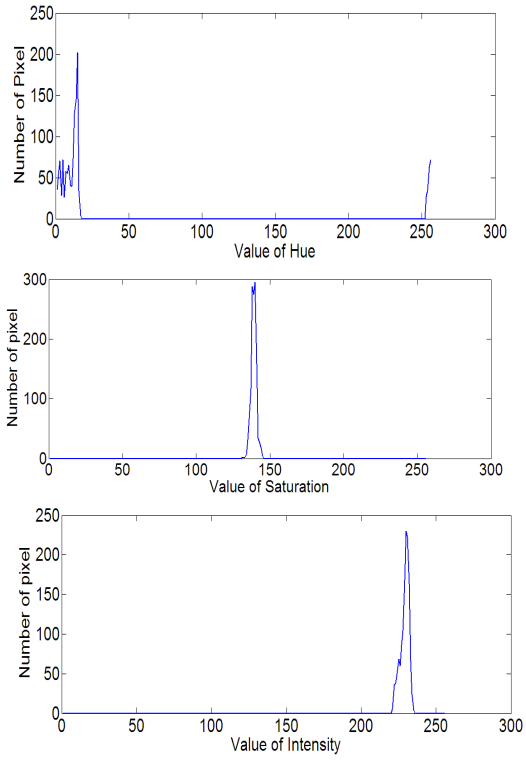
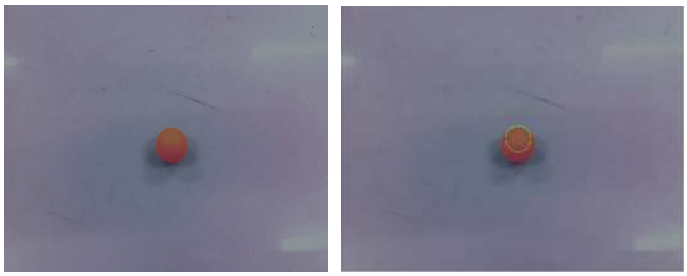


Fig. 4 The peak figure of HSI in brighter condition

The figure indicates the value of hue, saturation and intensity respectively and the ordinates indicates the number of pixel.

The results chart in darker condition after feature extraction is shown in figure 5:



(a) Original image (b) processed image

Fig. 5 The result chart in darker condition after feature extraction.

Three peak figures of HSI in darker condition are shown in figure 6:

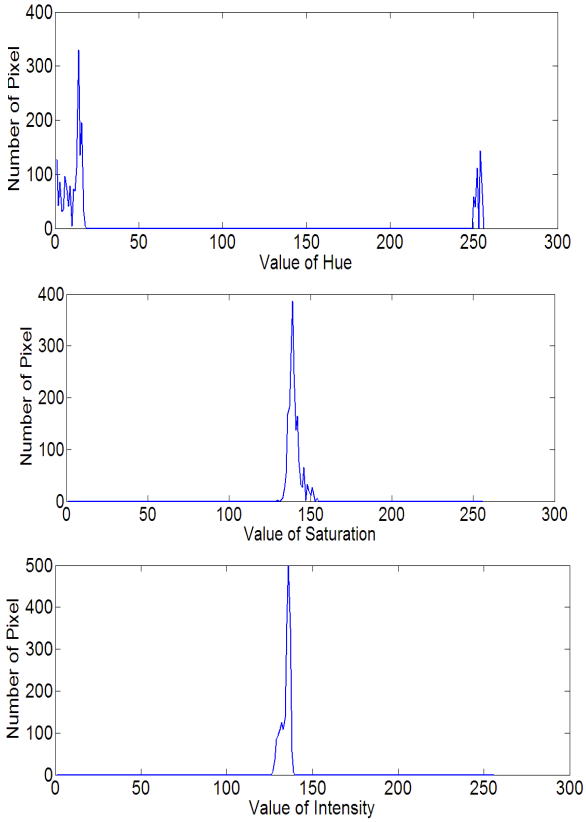


Fig. 6 The peak figure of HSI in brighter condition

CONCLUSION

This paper propose an approach based on HSI model, in which ambiguous color classes for color segmentation and pyramid matching method for feature extraction. As known from the result of simulation test, the vision system have has the ability to recognized target object. Via the comparison between the results of simulation test in two different light intensity conditions, the proposed vision system is proved to the robustness for the change of light intensity.

Acknowledgements
This material is based upon work funded by Natural Science Foundation of China under Grant No.61203360, Zhejiang Provincial Natural Science Foundation of China under Grant No.LQ12F03001, LQ12D01001, LY12F01002, Ningbo City Natural Science Foundation of China under Grant No.2012A610009, 2012A610043, State Key Laboratory of Robotics and System (HIT)Foundation of China under Grant No.SKLRS-2012-MS-06, China Postdoctoral Science Foundation under Grant No.2013M531022

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