Efficient Object Recognition of Humanoid Robot

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Abstract. This document can be explained as follows. First, we briefly introduce our group, KOBOT (Kookmin Robot), about its past and current activities, including competitions we participated, and budgets we acquired for the past few years. And we describe what we have studied to build our system, and what we have achieved throughout the past years, such as, image processing algorithms, path planning algorithms, and robot control mechanisms. Some of our work has been published as conference papers in the domestic conferences. Finally, we will describe our approach to build an efficient movement for humanoid robot, to participate Marathon competition of FIRA. We used various image processing algorithms to recognize objects, and have tested them on several experiments, such as, sprint, penalty kick, lift and carry, marathon, and so on. We mainly focused on accuracy and speed for recognizing objects, and the experiments showed some reasonable results. We will continue on this approach to enhance the performance for the competition. For the experiment, we used MF-RAPI robot, Respbian linux Os and OpenCV library.

Keywords: Humanoid Robot, Intelligent Robot, Image Processing, Embedded Software.

1 Team Information

KOBOT is a study group, whose members are the undergraduates of Kookmin University, to study intelligent humanoid robots. The members are mostly 2nd and 3rd year undergraduate computer science major, and equipment and space is supported by the department. The main focus of our study is the intelligent algorithms for building intelligent robot system, but also we are interested in building software for embedded platforms.

Our team challenges mainly humanoid robot related contests every year, and made outstanding results for the last 5 years (1st and 2nd prize in FIRA marathon 2013, 2012; 3rd place in HuroCup marathon 2014; grand prize in 11th and 12th embedded software competitions; and 3rd in SOC contest 2016). Also our team was supported by our university, Samsung Electronics, and our government (Ministry of Science, ICT and Future Planning) due to our impressive performances. Every year, we participated in various engineering festivals, and some of our study results were published in the domestic conference proceedings [1][2][3][4]. This year, we are continue studying about humanoid robot system with various intelligent algorithms.

2 Our basic Approaches

When we receive images from the camera, we first convert the RGB model as HSV image since the RGB model gets impacts from the inter-relations, and removed the noises by Gaussian filtering. Also we could extract more precise color by image reflection based on the critical value. It finally recognizes the object by HSV value, and tracks balls, avoids the obstacles by calculating distance and angle of the objects and robot.

In this section, we describe our basic approaches to process images for our experimentations

2.1 Gaussian Filtering

In order to get some precise result, we need to remove noise in the image. Among the many different noise filtering algorithms, we used Gaussian filtering [5] for this experiment. We described the Gaussian mask for the image can be in Figure 1. We can also use the Gaussian equation to get the value of Gaussian mask element, but instead we used the cySmooth function form OpenCV[6] library.

1/16	1/8	1/16
1/8	1/4	1/8
1/16	1/8	1/16

$\frac{1}{273}$

1	4	7	4	1
4	16	26	16	4
7	26	41	26	7
4	16	26	16	4
1	4	7	4	1

Fig. 1. Gaussian Mask

2.2 Save as HSV image

We used the RGB to HSV conversion equation. The Hue color represents the color spectrum, saturation represents the purity of color, and Intensity represents the lightness of the color. Our experimentation result is in the Figure 2.

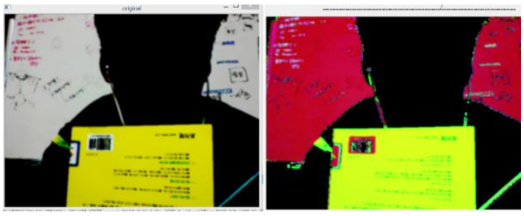

Fig. 2. RGB to HSV output

2.3 Finding Object

We can find the ball by using HSV value; it first find the pixel and find coordinate value in the center by calculating the average value of the pixel. We need to control the value by avoiding lights from the environment. The robot can track the object when we provide the precise HSV value.

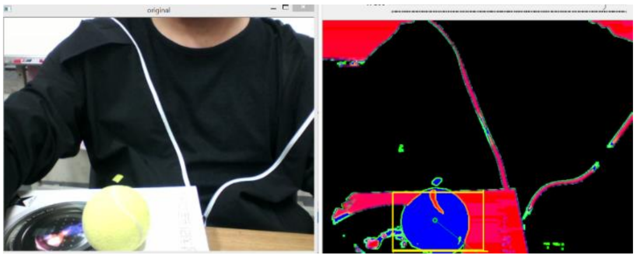

Fig. 3. Output image of finding object

2.4 Finding distance between Robot and Object

If we can get coordinates of an object by recognition, then we can get twisted angle of robot and object as in the figure 4.

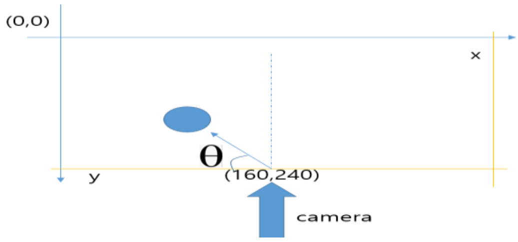

Fig. 4. Coordinate of image

From the figure 4, if we guess the angle using Tangent function, the 240-Y value becomes the height of the triangle, and 160-X value becomes the base. Then (240-Y)/(160-X) value becomes tangent value, and we can get other side of angle, which allow us to track the object by controlling the robot.

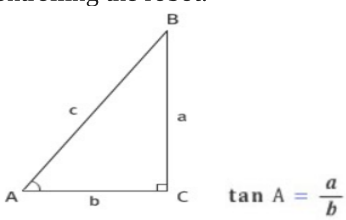

Fig. 5. Calculation of twisted angle

Finally, since we do not know the Z-coordinate value, we can't find the exact distance. But if we treat the Z value as parameters and consider the value as estimated one, then we can estimate the distance as following equation.

$$\text{Distance*Distance} = x*x + y*y + (y\text{-}120\text{-Pixel})*(y\text{-}120\text{-Pixel}) \quad (1)$$

3 Experiments

In this section, we describe our approaches for 5 different experimentations, including Penalty Kick, with their processing steps and the immediate results.

3.1 Penalty Kick

The processing steps for Penalty Kick is as follows. It first, receives images from the camera. Second, image is inverted based on our own critical value. Third, the images are filtered by using the Gaussian filtering algorithm. Fourth, save the result as HSV image. Finally, ball tracking and obstacle is recognized as HSV value.

We have done 5 experiments including 'Penalty Kick', 'Marathon', 'Sprint', 'Object Movement', and 'Obstacle run'. Most of them are done with similar image processing procedures as in Penalty Kick, but the distance calculation needs to consider more isolated ideas.

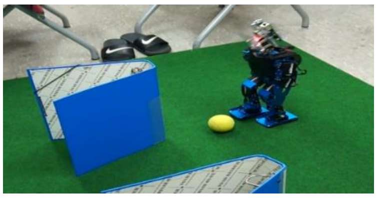

Fig. 6. Penalty Kick experiment

For the 'Marathon', we can think of effective method of 'Line-tracing' that can reduce line recognition time as follows. Since if we search the entire pixel, then the search time gets longer and it is inefficient. If we find the font path of the robot foot, then we can estimate the correct direction. Therefore, if we divide the image by 5x5 (25 spaces), then we only need to search the bottom 5 spaces as in the Figure 7, and we can finish the marathon with increased search speed.

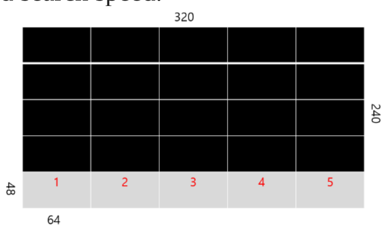

Fig. 7. Image division as 25 spaces

Also, if we calculate the number of pixels among the bottom 5 spaces, we can estimate a space with the most number of pixel has a correct path. This allows us to control the robot to find correct path (Figure 8).

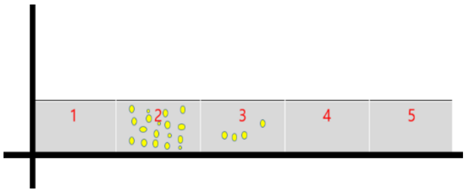

Fig. 8. Distribution of pixel

4 Conclusion

In this paper, we described our experimentation of humanoid robot movement using various image processing algorithm and distance estimation equations. The importance of our approach is as follows. First, we used image processing algorithm on five different experimentation, which gave us successful results. Second, we tried to optimize the speed of image processing. If we can speed up the image processing time, then we can efficiently perform the movement of the robot, and also increase the recognition of the object. To do this, we increased to processing time by searching only the partial portion of the image. Third, we could get some successful result on finding distance between robot and object by using our own distance calculation algorithm by try and error.

Our future research will continue on elaborate these algorithms and also will find more interesting experimentation.

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