Real-time image processing in robot soccer

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ABSTRACT

This paper deals with design of fast image processing necessary for robot soccer system of MIROSOT category. The robots are small cubes with color patches on their top. A color camera situated over the playground captures the image of the playground. The purpose of image processing is to acquire the position and orientation of the robots in appropriately short time (the frame rate is 50 fps) from the image. In this paper we present our approach to this problem. Our techniques of image segmentation, objects classification and scene understanding are optimized for speed and robustness. We also present various types of the patches and methods for their recognition.

Keywords

Real-time, image processing, robot-soccer, MIROSOT, camera

1. INTRODUCTION

MIROSOT is one of the robot soccer categories of FIRA [FIRA04]. The robots play with the orange golf ball on the black playground (Fig. 1). Robot team patches (blue and yellow, of the minimal size 3.5 cm x 3.5 cm) are used for vision system to determine which robot belongs to which team. Possible additional color patches have to be of different color from ball and opposite team. The number of robots depends on the played league and varies from 5 to 11 robots of one team. A camera over the playground with a digitizer is a feedback of this system. We use an analog camera (with resolution 760 x 285 pixels) and a frame grabber with A/D conversion. The image from this system has more noise and distortion compared to a digital camera. Hence our approach is also robustness oriented. The robots can move up to 4 $m.s^{-1}$, therefore, the control loop should have a high-speed sampling rate with as minimal transport delay as possible. Sampling rate (50 fps) is, in our case, produced by used camera. Transport delay (35 ms) is mainly caused by mentioned feedback.

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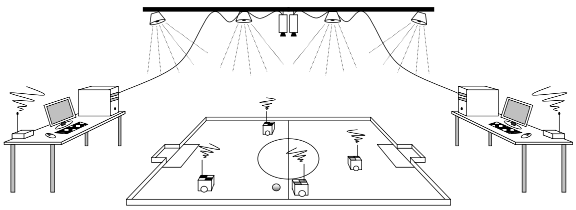

Figure 1. Overall system

2. IMAGE SEGMENTATION

We chose the color segmentation to reduce amount of data as the best way of image segmentation, because the color patches on the robots are used. We use 24-bit RGB model because of its hardware support and easy way of working with the color components. In the RGB color space every color patch is pictured as an object with irregular shape. To classify these objects in the RGB color space, we created six ranges for each class. Three ranges limit R, G and B values. Another three ranges limit ratios R/G, R/B and G/B. These six ranges are enough for fast and suitable classification.

3. OBJECT CLASSIFICATION

In this part we need to put together pixels of the same class, which belong to one patch and merge the patches to determine robot position. In the first step every fourth pixel is taken in horizontal and vertical direction to speed up computation and skip most of the noise. If this pixel has assigned any class (it is not the background), algorithm will check if the sum of neighboring pixels of the same class in horizontal and vertical direction from this pixel is more than a chosen threshold. Then the object will be “filled” from the found pixel to find out its area. If the area and the horizontal and vertical sizes are in the chosen limits, the object is stored in the Table.

The merging process, in case of using standard identification recommended by FIRA, is always searching for two objects, which identify a robot. We must consider the distance between the objects and between old and possible new position of the robot.

4. TYPES OF THE PATCHES

It is only on our imagination, limited by the rules, to create a new identification of the robots. We could define three main types of identification of patches.

Differentiation using only colors

This is widely used identification of robots. The number of color patches on one robot varies from two (recommended by FIRA) to four and depends on team’s preference. Merging these patches into the robot is similar to the algorithm described in section 2. We must only check more possible combinations.

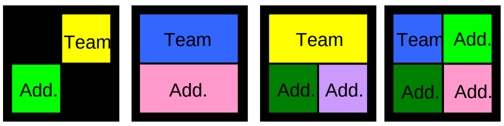

Figure 2. Types of the patches for identification by color

Differentiation using only shapes

Used shapes should fulfill several conditions: incommutability, irregularity, simple identification, noise immunity and limited minimal area. We created irregular n-angle shapes, which fulfill mentioned conditions (Fig. 3). Our shapes are identifiable by sequence of vertex angles.

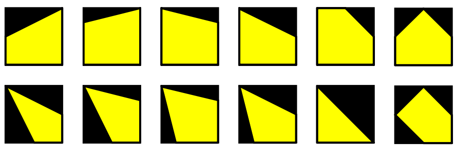

Figure 3. Possible types of the patches for identification by shape

To identify the shapes we used algorithm [Lak04a], which cyclically reduce number of the points of the shape edge. Vertex points of the shape are result of this algorithm. It is simple to get vertex angles from these points. This algorithm is suitably fast for our application, but not always reliable.

Differentiation using shapes and colors

The third type of the patches combines features of previous two types. We may create lots of unique combinations using only a few colors and a few shapes for the patches. We designed 3 shapes: a square, rectangle and L-shape. Every patch has a complement in other patch with other shape (with other color) and together they constitute the square (Fig. 4). This ordination is very robust because of redundancy of the information.

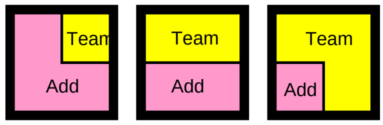

Figure 4. Identification by shapes and colors

The shapes could be differentiated by each of this parameter: area, circumference and sum of sizes in vertical and horizontal direction. The most probable shape class is determined with a nearest-neighbor method in the space of these parameters. Merging objects together is similar to the first mentioned type. Only one new condition (two objects should create a square) was added. We have very good results with this marking. Object searching is both fast and robust.

5. CONCLUSIONS AND RESULTS

This paper has presented a design of the fast image processing in the robot soccer system. We showed the methods how to locate the positions of the robots in the image. We also presented the main types of identification for the robots and outlined the methods for finding positions of the robots with these patches. Now we are using the third described type and we are able to find position of 14 robots in the image in 10 ms. The method was tested on the large playground, using a computer with P4 at 2.4 GHz and RDRAM 1066.

6. ACKNOWLEDGMENTS

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7. REFERENCES

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