Colour Tag Design of Robot Soccer Based on Computational Verb Theory

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Abstract*—The vision system is the key to the robot soccer competition process. While all the information related to the environment in the competition process is obtained through the vision system identification of the colour tag design .Therefore the colour tag design is essential in the robot soccer competition process.*

The computational verb theory is a new theory of artificial intelligence domain, it has not only made up for the insufficiency of the static image processing , but also lightened the image processing computation burden. To design an anti-jamming colour tag design according to the verb image processing characteristic and to recognize the colour tag design using the computational verb theory can not only enhance the recognition precision, but also simplify the algorithm, enhance the recognition speed, satisfies the real time of the competition .

Experiments show that the design has improved the stability and accuracy of vision system reduced, the preparation time for competition and achieved favorable effect in play . It has a bright future in application prospects.

***Keywords* —** *vision system; computational verb theory; colour tag design*

I. INTRODUCTION

Robot soccer match is a kind of high technology match which has arisen around the world in recent years.Now,in reference[1],robot soccer is divided in two kinds.The first one is MiroSot series and the second is RobCup series.Robot soccer,referring to the fields of robotics、intelligent control、data fusion、computer technology、wireless communication、image processing、mechanics and so on,is the outcome of all these scientific technology.It is also a typical nonlinear control object and is a good test bed for many kinds of control theory.

The Federation of International Robot-soccer Association (or FIRA, in short) was founded in June 1997 with a basic goal of taking the spirit of science and technology of robotics to the laymen and the younger generation through the game of robot soccer[2]. It offers a challenging arena to the young generation and researchers working with autonomous mobile robotic systems. It is hoped that the FIRA Cup will fuel scientific and engineering skills that ultimately develop into research outcomes to serve mankind in various ways.

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The research of this article based on the example of FIRA.Because Fira robot soccer itself does not contain any sensor and a colour tag is the only basis in the visual acquisition, thus the colour tag design, whether it is good or not, relates to the system identification precision, timeliness and the anti-jamming. The good algorithm of colour tag design should have the advantage of being simple, comparasively low identification algorithm and a higher identification precision[5],[7]. There are many traditional recognition algorithm, this article will design a colour tag of robot soccer according to the Computational verb theory.

II. A COLOUR TAG DESIGN OF ROBOT SOCCER

The vision system is the key to the robot soccer competition process[1]. While all the information related to the environment in the competition process is obtained through the vision system identification of the colour tag design . In robot soccer vision systems, colour tag design is an important factor, which is related to the target system identification accuracy, real-time and anti-jamming. The azimuth and the centre of robot soccer was got through the colour tag shape, size and other attributes.So the design is good or bad not only affect the accuracy of their identification, but also affect the identification algorithm design and its complexity.

At present, each participating team has many colour tag design proposal[, But no matter what kind of design proposal is, all should consider following several points:

⑴which can differentiate the main force and opposite arty team;

⑵which can differentiate each team member;

⑶algorithm of recognizes is simply, and complexity is relative lower. According to international stipulation，the team sign with yellow and blue , which the two tone are bright，so the first point is very easy to satisfy. In order to satisfy second point, We can take the following three options:

A. Distinguish Team Member According to Colour Shape

As shown in fig.1, middle-tag is team sign, Its center of gravity is the center of mass of the car, It can get car's center of mass through the center of gravity of team sign. Sideward colour next to the same colour, but shape different, On behalf of three members. colour can also be used to determine the direction.

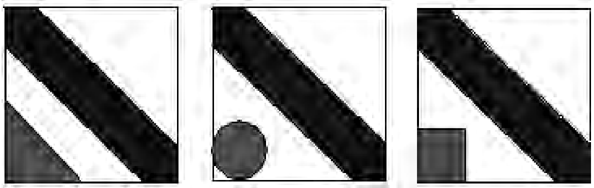

Fig.1 distinguish team member according to colour shape

B. Distinguish Team Member According to Colour

As shown in fig.2, car's team sign is front, the team members sign is back, the team sign has the same colour, the team member sign has the different colour, On behalf of three members. colour can also be used to determine the direction.

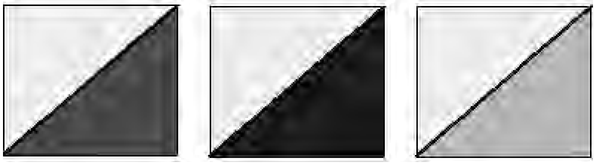

Fig.2 distinguish team member according to colour

C. Distinguish Team Member According to Position

As shown in fig.3, middle-tag has the same colour ,which is team sign. Sideward colour next to the same colour, but different positions, the distance of center of gravity between Sideward colour and the middle-tag for the distinction between and different players, but also can be used to determine the direction.

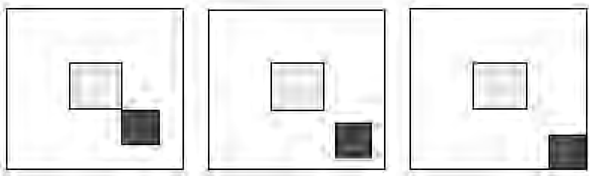

Fig.3 distinguish team member according to position

Several colour design above options for 3 to 3 game, but does not apply to 5 to 5 game, and reduce image processing burden through using the computational verb theory ,we take the following design proposal[6].

(a) (b) (c)

fig 4 Robot colour tag design proposal

In Fig.4 (a), all colours brightness value is 128. Blue colour marks for the team, the pink colour is direction marking, the green is team member marking, the gray scale image (in the fig.4 (b)) is consistent. Its edge two values image see Fig.4 (c). This plan merit is:

(1)The car center is located the team sign center, therefore the colour tag center is stable.

(2)Because the colour tag combines the gradation picture which is the rotational symmetry in the space coordinates, namely regardless of the robot direction , the gradation picture and the edge picture are all invariable, therefore we can decompose the spatial verb , separately decomposes it into the line function and a row function, then the match of picture and template turns into separately carries on the match to the line verb and a row verb.

If the template size is N*M, then by using this method the computation total quantity is N+M, but does not carry on the decomposition the computation total quantity is N*M. Thus, the system computation burden will reduce the several fold.

(3)There is a certain distance between the host and the vice-colour tag. the fuzzy of colour block boundary and the influence of proliferation is smaller, and the recognition precision is high, meanwhile, the host colour tag and the robot boundary also has the certain distance, therefore enormously reduces the occurrence of the adhesion phenomenon, and the anti-chirp ability is strong.

(4)This kind of design proposal can comprise 8 kind of situations, therefore, which not only is suitable for 5 versus 5, but also can apply to 7 versus 7 competitions, the serviceability is strong.

III. ALGORITHM RECOGNIZATION BASED ON THE COMPUTATIONAL VERB THEORY[3,4]

A. The Suggestion of the Computation Verb Theory

Computational verb theory (CV) was invented by Tao Yang in 1997 in the Department of Electrical Engineering and Computer Sciences, University of California at Berkeley. Since then, CV has been growing up into a multidisciplinary scientific field attracting attentions of researchers from information sciences, linguistics, biology, psychology, physics and computer sciences. Pushed far beyond fuzzy theory, CV is the first step towards building a complete artificial language into machines. The ultimate goal of CV is to build dynamic irrational intelligence into machines. CV also bridges the gap between physics and linguistics to give birth to a measurable linguistics; namely, physical linguistics. In physical linguistics, many classical linguistic problems such as verb classification and telicity in verbs were studied from an entirely new standpoint. Surprisingly, the bifurcation theory of dynamic systems leads to solid and precise solutions to many linguistic problems such as verb categorizing tests and verb ambiguity. CV also provides a platform of solving engineering problems based on dynamic experiences in the form of verb if-then rules. Such engineering applications include verb controllers, verb prediction and verb image processing. Written by the founding father of CV, this is a lucid, solid and timely monograph for professionals, scientists, academic researchers and students in information sciences, linguistics, fuzzy logic, computer sciences and control engineering.

For the applications of computational verbs to image processing, a credit card counting system with vision sensor, called YangSky-MAGIC, had been developed[2]. During the R&D of this product, he realized that verb image processing has a much stronger ability than he originally thought. This is the reason that he want to probe this direction more.

Based on this theory，image processing is to describe the object development change process characteristic from the thing dynamic characteristic description, computation obtaining accurately and completely, will make the accurate forecast to the object future trend of development. Under this theory frame, the tradition describes ，which based on the static characteristic object, will be a spot or an exceptional case of its describes process, similarly enables the static characteristic of the logic operation to develop into the dynamic characteristic logic operation, which brought the unprecedented development opportunity for the information science.

The evolving function of a spatial verb v for image processing purpose is defined as follows.

$$\varepsilon_v: \quad \Omega_S \to \Omega_B \qquad (1)$$

where $\Omega_S \subset Z \times Z$ denotes the support for a two-dimensional image（Each element of Ω_S is called a pixel for the purpose of digital image processing.） and $\Omega_B \subset R$ denotes the range of the brightness or the gray value of each pixel. For simplicity and without loss of generality, here we assume that $\Omega_B = [0,1]$.

B. Constructing Spatial Computational Verbs

The evolving function of a spatial verb denotes the changes of gray-values along spatial coordinates. Therefore, two factors contribute to the forms of the evolving functions of spatial verbs; namely, the spatial configurations and the changes of brightness. However, the couplings between the spatial and the brightness facets of spatial verbs sometimes make the forms of evolving functions too complicated to deal with. On the other hand, it will be very helpful to construct canonica forms of spatial verbs for different situations. To construct the canonical forms of spatial computational verbs, it is convenient to decouple evolving functions of spatial verbs into two functions: one handles the brightness information and the other deals with the spatial configuration.

To construct canonical spatial computation verbs we use a brightness profile function $f_p: \quad Z \to [0,1]$ and a shape outline function $f_0: \quad Z \times Z \to [0,1]$ The evolving function ε_v can be expressed by

$$\varepsilon_v(i,j) = \bigoplus_{k=-\infty}^{\infty} \bigoplus_{l=-\infty}^{\infty} f_o(k,l) \otimes f_p(i-k, j-l) \qquad (2)$$

where $i,j,k,l \in Z$, and $\oplus$ denote an s-norm and a t-norm, respectively. Since the method in (2) is a composition of functions f_p and f_o , we called it a composition method(composition, for short) for constructing spatial verbs. To reduce the computational complexity of (2), in practice ，As robots color combination of gray images and the Edge binary image are rotation symmetry in space coordinates , that is, no matter how the robot's direction, the gray image and edge image are unchanged. Therefore, its brightness profile function and edge function can be decomposed of the Row-wise Composition and Column-wise Composition, and Row-wise Composition and Column-wise Composition are the same.we choose either row-wise or column-wise compositions to construct the canonical forms of a computational verb v .

1) Row-wise Composition.

$$\varepsilon_v(i,j) = \bigoplus_{l=-w_d}^{w_d} f_p(l) \otimes f_o(i, j-l) \qquad (3)$$

Comparing (2) and (3) one can see that in (2) the composition of f_o and f_p is performed along a 2D plane while in (3) the composition is performed along a 1D line.

2) Column-wise Composition.

$$\varepsilon_v(i,j) = \bigoplus_{k=-w_d}^{w_d} f_p(k) f_o(i-k, j) \qquad (4)$$

According to Fig.4(a) , the map fig.4 (b) the information line and the gray out of the points after seeking means to receive the following profile brightness function (Row-wise and Column-wise):

$$f_p(i) = \begin{cases} 1 & i \in [-15,-12] \cup [12,15] \\ 1 - \dfrac{\sqrt{144-i^2}}{60} & i \in (-12,-8] \cup [8,12) \\ 13/15 & i \in (-8,-4] \cup [4,8) \\ \dfrac{13 - \dfrac{\sqrt{16-i^2}}{2}}{15} & i \in (-4,4) \end{cases} \qquad (5)$$

Window size is 31 × 31 pixels, the origin marking for the center.

By using either row-wise or column-wise composition, the computational burden of implementing verb image processing task can be reduced dramatically.

C.Images and Template Matching

The basic principles of verb image processing are to find the relation between an image and a template spatial verb. The process of the verb matches is the process of the solution similar. Without losing of generality, let us suppose that the first verb $v_1(i,j)$ is constructed by a row-wise composition, of which the profile function $f_p(\cdot)$ has a limited support $[-w_d, w_d]$, and the shape outline function is a curve $f_o(\cdot,\cdot)$ .There is no constraint to the shape of the second spatial verb v_2 .Let us assume that the supports of both verbs are the same, then the similarity between both spatial verbs are given by the following steps：

(1)Let us first calculate the verb similarity between the profile function $f_p(\cdot)$ and each row of the evolving function of v_1 , the results stored in a function $h(j)$.

$$h(j) = 1 - \frac{\sum_{i=-w_d}^{w_d} \left| v_1(i,j) - f_p(i) \right|}{\sum_{i=-w_d}^{w_d} v_1(i,j) + f_p(i)}, \quad \forall j \in \Omega_J \quad (6)$$

Where we assume $\sum_{i=-w_d}^{w_d} f_p(i) \neq 0$, Ω_J is the set of all column indexes for the support of the verbs.

(2)Calculate the verb simulation between the profile function $f_p(\cdot)$ and each of the evolving function of v_2 , the results stored in a function $g(j)$.

$$g(j) = 1 - \frac{\sum_{i=-w_d}^{w_d} \left| v_2(i,j) - f_p(i) \right|}{\sum_{i=-w_d}^{w_d} v_2(i,j) + f_p(i)}, \quad \forall j \in \Omega_J \quad (7)$$

Where we assume $\sum_{i=-w_d}^{w_d} f_p(i) \neq 0$ 。

(3)Finally，two kinds of verb similarities between v_1 and v_2 can be calculated as follows：

$$S(v_1, v_2) = 1 - \frac{\sum_{j \in \Omega_J} \left| h(j) - g(j) \right|}{\sum_{j \in \Omega_J} h(j) + g(j)} \quad (8)$$

Here we assume that $S \in [0,1]$, Ω_J is the window size. The similarly goes past high then is more possibly the goal. Obviously, if two verbs based on identical image, then the similarity is one . After separately carries on the row-wise and the column-wise verb matches to the entire image. The place highest similar five are our five robots positions .

When spatial verbs are used in image processing, we usually choose a standard spatial verb which called template verb to play the role of templates as those used in cellular image processing, or the role of convolution kernels as those used in digital image processing. Here, the spatial verb v_1 plays the role of template verb. In practical applications, the function $h(\cdot)$ can be calculated off-line and stored as a set of standard parameters. Whenever an image operation needs to use the template verb V1, as the corresponding function $h(\cdot)$ doesn't need to be calculated again. Therefore, we call $h(\cdot)$ the template function.

I. CONCLUSIONS

The robot soccer competition is a extremely high timely project, according to the visual system, its processing speed and the complex degree of processing method is a pair of contradictory, how to coordinates the two relations, is one of core contents, which is studied at present. This article focuses on the robot soccer vision system timely request, designs one kind of simple and practical colour tag. And aimed at this colour tag to propose the corresponding quick algorithm. Thus enabled the robot soccer vision system recognition algorithm to obtain the simplification, Simultaneously distinguished the speed to obtain the corresponding enhancement, which has built the foundation for the entire robot soccer assembly system performance optimization.

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