Applying Colour Image-Based Indicator for Object Tracking

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1 Introduction

This article will elaborate on the idea of object tracking. All discussion and solutions will draw from the field of knowledge which deals with colour images. Using colour images offers a large scale of possibilities; however, there are numerous problems which are not present in grey scale images.

The definition of each image point in colour images domain (e.g. RGB) provides much information about a real scene observed by a camera. At the same time, the 3D size of the space of colours results in complication of calculations and interpretations. The segmentation problem for the colour images will be the first discussed problem in this paper. In general, the idea of image segmentation is presented widely in the body of the literature. The first group of the papers, which we can distinguish, concerns colour space models and pattern recognition techniques [1–3]. Segmentation on the basis of colour vector patterns [4–9], constitutes the next group in the segmentation and recognition field. Yet another aspect of the pattern recognition on the basis of colour images is the recognition of the textures as discussed in [10–13]. The last problem which is presented in [14], concerns recognition of colour characters in scene images.

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In order to exploit information contained in colour images, the authors proposed the method based on clustering colours which appear in the image [16, 18]. The proposed method will operate on the space of an indicator calculated on the basis of the RGB colour definition. Therefore the proposed solution will support object recognition—object tracking [15, 17, 19] for the cases when we have efficient-enough quality colour images. The authors expect that using colour images may allow to define and analyse the properties of the tracked object with greater precision.

2 The Theoretical Basis for the Developed Method

This developed method is based on the analysis of the colour components of the RGB space. The ratios of the colour components r/g and r/b will be used to build a pattern vector which describes the features of the searched objects. The method proposed by the authors can be presented in the following steps.

I Creating the pattern vector for each of the searched objects.

(1) Let Object.jpg contain a colour image of the object defined in RGB space. We denote it as the variable $Object(i,j) \in RGB, i = 1, M_o; j = 1, N_o$; where M_o and N_o define the size of the object and, at the same time, the size of the aperture used for processing the terrain image.

For the searched object we calculate on the basis of the components (r, g, b) the representation of the object image in 2D space (L_1, L_2) where $L_1 = r/g$ and $L_2 = r/b$. In this way, we obtain a new image $NObject(i,j) \in (L_1, L_2)$.

(2) Next, we calculate for each point of the (L_1, L_2) space the number of the pixels in the object image which pixels have a pseudo-colour (L_1, L_2). The function $G_x(L_1, L_2) \in N, N$—natural numbers, defines for which L_1 and L_2 there are more or less pixels in the object image.

(3) Finally, we find three highest maxima G_x^{max} and we store their value and position on (L_1, L_2) plane—in the order from the highest to the lowest ones. In this way, we obtain the pattern vector W_{zob}, presented in (1), which defines the searched object features.

$$W_{zob} = \begin{bmatrix} G_x^{max1} & L_1^1 & L_2^1 \\ G_x^{max1} & L_1^1 & L_2^1 \\ G_x^{max1} & L_1^1 & L_2^1 \end{bmatrix} \quad (1)$$

II Calculating feature vector for all positions of the aperture in the terrain image where the object will be searched.

For each position of the aperture we follow the same as in point I. We assume that the size of the aperture is equal to the size of the object image. In this way, we obtain the feature vectors $W_z(i,j)$, presented in (2), for each position of the aperture in the terrain image with objects.

$$W_z(i,j) = \begin{bmatrix} G_x^{max1}(i,j)\ L_1^1(i,j)\ L_2^1(i,j) \\ G_x^{max1}(i,j)\ L_1^1(i,j)\ L_2^1(i,j) \\ G_x^{max1}(i,j)\ L_1^1(i,j)\ L_2^1(i,j) \end{bmatrix} \tag{2}$$

III Calculating the distance between the pattern vector and feature vector for each object in each aperture position.

As a distance function $D(i,j)$ we assume the difference between the positions of the following maxima according to (3).

$$D(i,j) = ||W_z - W_z(i,j)|| = \sum_{x=1}^{x=3} \sqrt{[L_1^x - L_1^x(i,j)]^2 + [L_2^x - L_2^x(i,j)]^2} \tag{3}$$

In this way, we obtain the distance function $D(i,j)$ between the feature vector $W_z(i,j)$ in a given position and pattern vector W_{zob}.

IV Calculating the position of the function *D(i, j)* minimum in the *(i, j)* plane.

The place where $D(i,j)$ assumes the minimum value we define as a place where the searched object is located. In order to present obtained results in the useful form, we define $D_1(i,j) = max(D_1(i,j)) - D_1(i,j)$. This function will be used to present obtained results. In this case the maximum of the function $D_1(i,j)$ corresponds to the place in the (i,j) plane where the object is located.

Fig. 1 The searched objects and their locations in the terrain

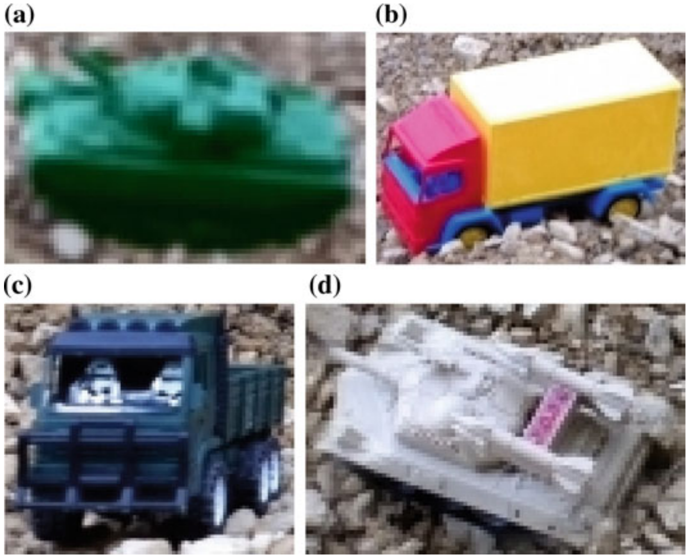

Fig. 2 The searched objects: **a** object 1, **b** object 2, **c** object 3, **d** object 4

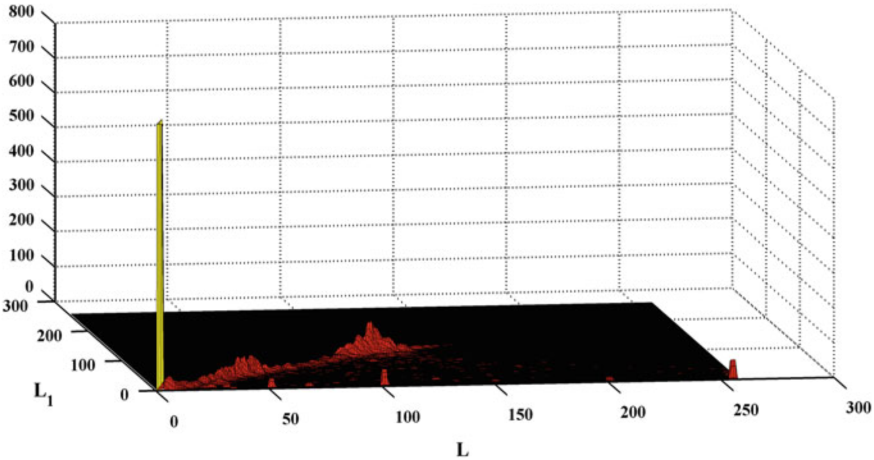

Fig. 3 Characteristics of the object 1 over the (L_1, L_2) plane

3 Examples

The functioning of the proposed method will be presented in the example of four different objects search. The objects and their locations in the terrain are presented in Fig. 1.

Figure 2 presents objects' images for which we will calculate pattern vectors. As it was described in Sect. 2, the first stage will involve calculating for each object

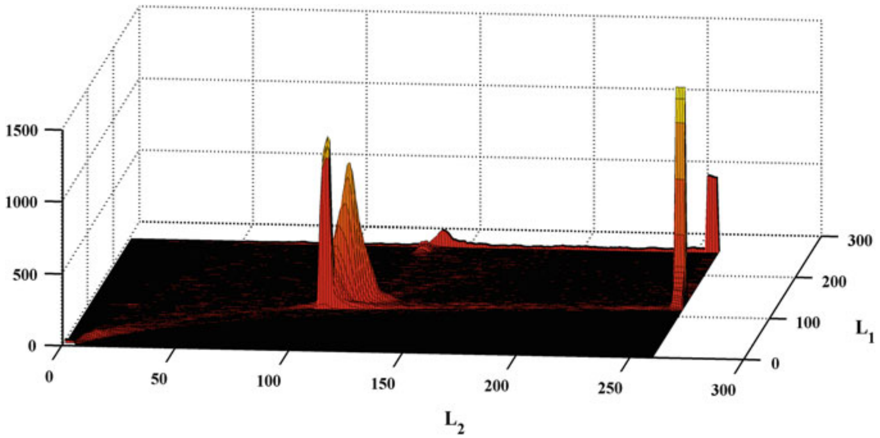

Fig. 4 Characteristics of the object 2 over the (L_1, L_2) plane

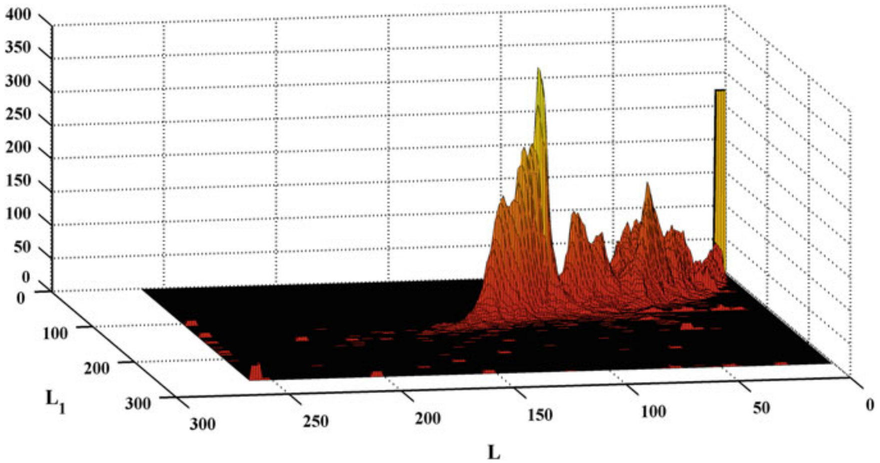

Fig. 5 Characteristics of the object 3 over the (L_1, L_2) plane

the pseudo-image $NObject(i, j)$ in which each pixel is defined by two elements $L_1(i, j) = r(i, j)/g(i, j)$ and $L_2(i, j) = r(i, j)/b(i, j)$. In this way, we obtain a new image $NObject(i, j) \in (L_1, L_2)$. Next, we calculate the function $G_x(L_1, L_2)$ for each object. These functions were presented in Figs. 3, 4, 5 and 6. We can see that for each object we have certain values (L_1, L_2) for which there are more pixels in the object image.

In the next step, we find the positions and values of these maxima. They were graphically represented in Fig. 7.

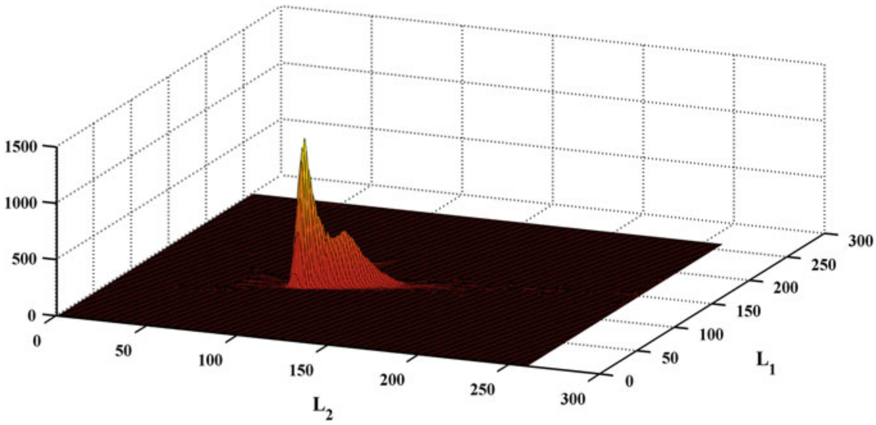

Fig. 6 Characteristics of the object 4 over the (L_1, L_2) plane

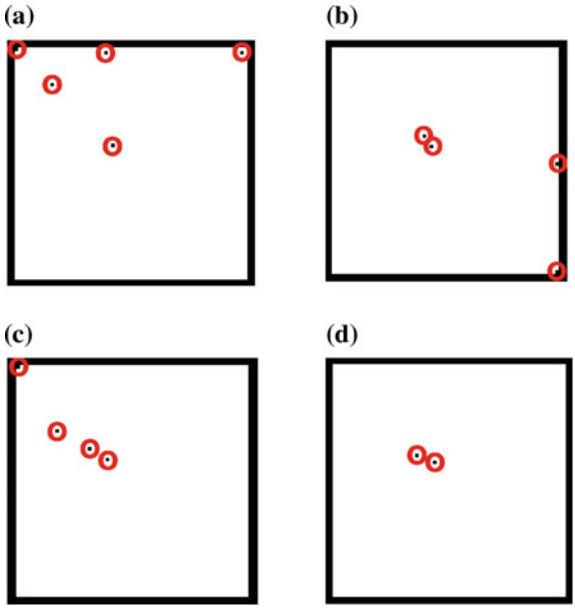

Fig. 7 The position of the highest maxima of the function $G_x(L_1, L_2)$ for the objects 1, 2, 3 and 4

Table 1 shows numerical values of the pattern vectors for each object.

Then we calculate the distance function $D_1(i, j)$ for each object. They were presented in Figs. 8, 9, 10 and 11. We can see that there are certain maxima which define the location of the searched objects.

Table 1 The model vectors characterising 4 examined objects

Object 1	Object 2
$W_{zob} = \begin{bmatrix} 795 & 4 & 4 \\ 121 & 112 & 112 \\ 69 & 44 & 48 \end{bmatrix}$	$W_{zob} = \begin{bmatrix} 797 & 136 & 260 \\ 520 & 104 & 108 \\ 462 & 116 & 116 \end{bmatrix}$
Object 3	**Object 4**
$W_{zob} = \begin{bmatrix} 228 & 4 & 4 \\ 194 & 108 & 104 \\ 87 & 76 & 48 \end{bmatrix}$	$W_{zob} = \begin{bmatrix} 771 & 104 & 96 \\ 232 & 112 & 116 \\ 0 & 0 & 0 \end{bmatrix}$

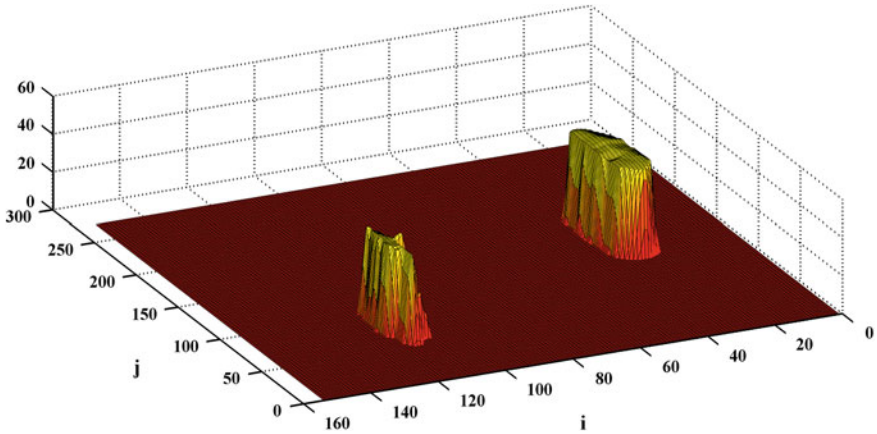

Fig. 8 Distance $D_1(i,j)$ for the object 1

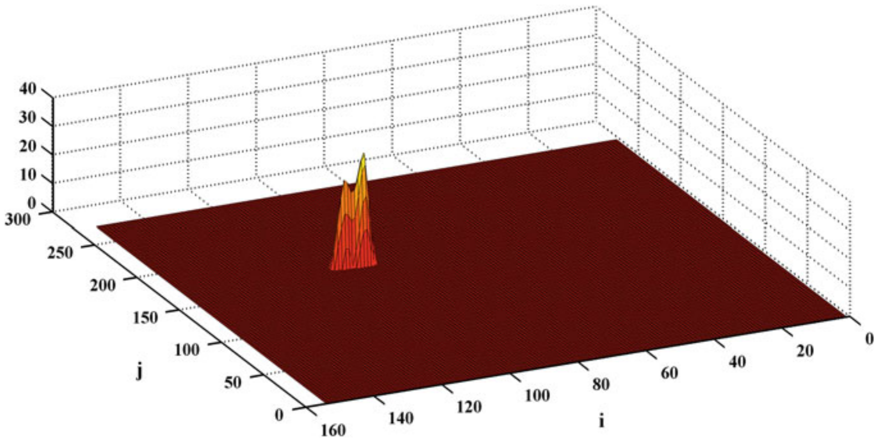

Fig. 9 Distance $D_1(i,j)$ for the object 2

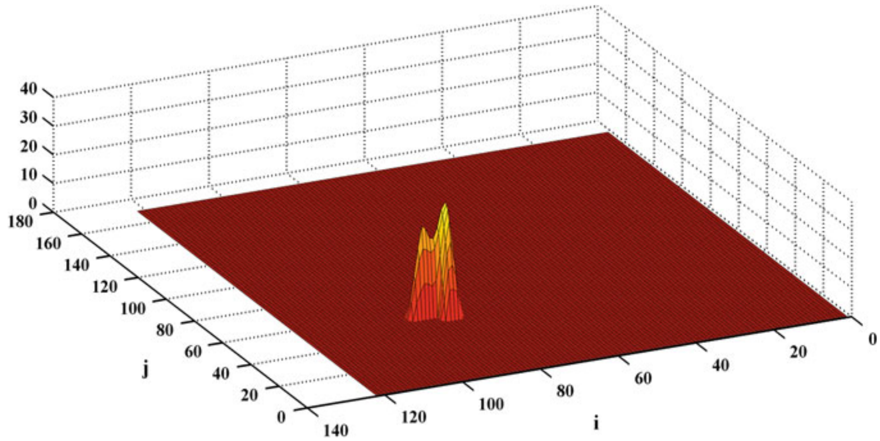

Fig. 10 Distance $D_1(i,j)$ for the object 3

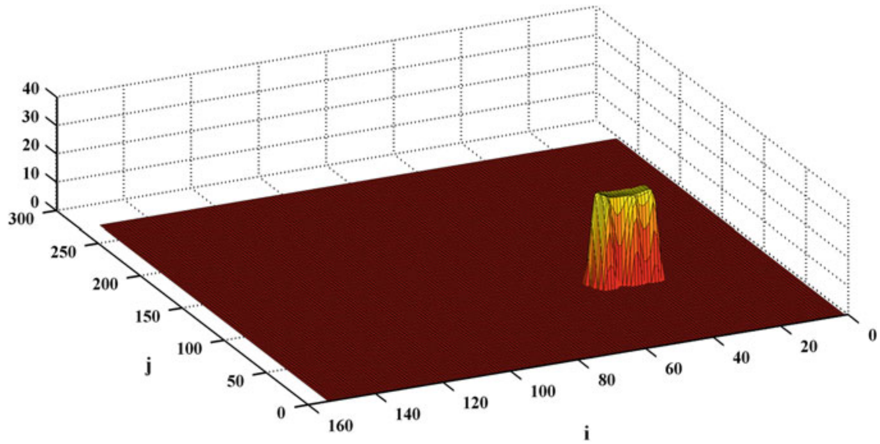

Fig. 11 Distance $D_1(i,j)$ for the object 4

The found locations of the objects are presented in Fig. 12. The contour lines, which were marked by appropriate colours, correspond to the minimal values of the distances between the pattern vector for a given object and the pattern vector for the current location of the aperture.

As we can see, the object 2 has been found correctly as well as object 3 and 4. Whereas the object's 1 location is indicated in two places. One of these places is

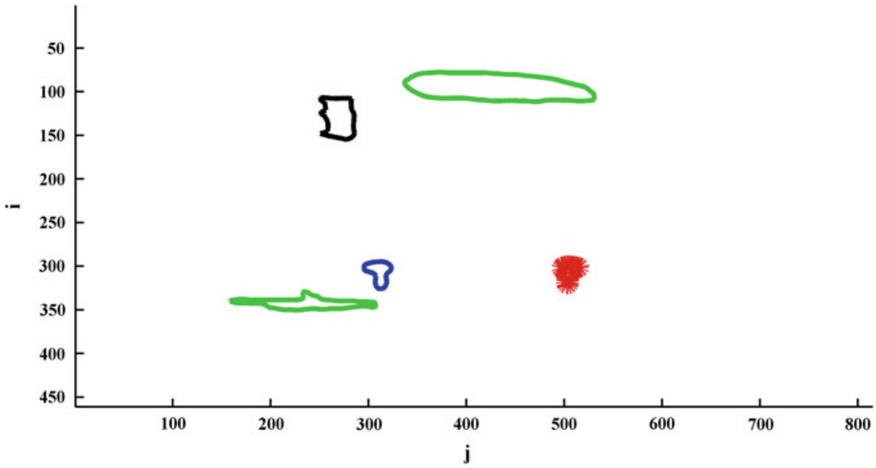

Fig. 12 The location of the searched objects. *Green*—ob.1, *Red*—ob.2, *Blue*—ob.3, *Black*—ob.4

correct. It results from the fact that the dominating colours in the object 1 are similar to the colours in the object 3. Nonetheless, the presented examples illustrate the correct functioning of the devised method in the cases when the objects has different colours.

4 Conclusion

The devised method combines both: easy calculation and the possibility of using information contained in colour images. The proposed solution was based on the calculation of an indicator which described the colour features of the object. The authors assumed that the role of this indicator would be realised by the ratio between the red and green components as well as the ratio between red and blue components. The abovementioned ratios were used to create the pattern vector. Such a defined pattern vector was used to calculate the error function and the minimum of this function indicated the object location.

The proposed approach turned out to be particularly useful in the cases when the object and terrain colours were significantly different.

This paper presented the examples of object tracking for both: the different object colour from the terrain colour and the similar object colour to the terrain colour. As expected, in the case of an object with the colour which blurs in with the background colour, the object recognition may be difficult when we base only on the object colour. However, it seems to be beneficial to use the developed method in order to enlarge features space used for the analysis of grey scale images. In this way, we may significantly enlarge the correctness of pattern recognition and object tracking.

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