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IDENTIFICATION OF FOOTBALL PLAYERS BASED ON GENERIC FOURIER DESCRIPTOR APPLIED FOR THE RECOGNITION OF NUMBERS

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Abstract. There are various possible approaches to the task of automatic identification of football players on video sequences. In the paper the numbers on jerseys are analysed and investigated. Firstly, the algorithm for the localisation of sport shirts and consecutively numbers is described. Secondly, the method for the recognition of the extracted numbers is proposed and experimentally investigated. The approach analysed in the paper applies the Generic Fourier Descriptor for the representation of extracted binary shapes of numbers.

Key words. football players identification, sport television broadcast, shape recognition, Generic Fourier Descriptor.

1 Introduction

Football is a very popular sport discipline, especially in South America and Europe, but it becomes more popular in new regions, e.g. in Asia and Africa. The automatic or semi–automatic analysis of the sport television broadcast is nowadays becoming more and more popular and concerns various aspects. The identification of players is one of them. However, several other problems are also taken into consideration when the broadcast is automatically analysed. For example in [1] the Support Vector Machines were applied for the ball detection. In [7] some special events were recognized using the selected properties of the MPEG format. In [8] the scene changes were found based on the so–called close–up detection in order to emphasize the parts of the broadcast with important events. The recognition of trademarks visible on banners next to the play field can be also an interesting goal for the analysis. For this purpose the shape descriptors can be applied, e.g. in [5] the UNL, UNL–Fourier, Point Distance Histogram, and Contour Sequence Moments were investigated.

As mentioned, the detection and identification of football players is one of the most widely analysed problem when considering the automatic analysis of sport TV broadcast. In [11] the player movement is recognized by means of the enhanced entropy. For the extraction of players the mosaic images can be applied [15]. The detection of players can also be based on their position according to the model of the playing field [13] or algorithms typical for video surveillance systems [10]. Another method proposed for this task is the usage of the finite state machines, template matching and play field zones definitions [3]. In [9] the dominant colour for background and the Haar-like features were utilized for the same goal. The colour features were also used in [14]. Usually, the player identification is a consecutive problem investigated by researchers. In order to solve it various algorithms can be utilized. For example, in [2] the watershed and region adjacency graph were used for the analysis of numbers on the shirts and shorts. The same goal was reached using the ranges in various colour models [4]. The recognition of numbers placed on jerseys was also performed in [12], where the HSV colour space and Internal Contours were applied. For the identification of football players their faces can also be used [6]. The mentioned approach starts with the scene change and close–up detection, later YCbCr and HSV spaces are applied for the face localisation; finally, the Discrete Fourier Transform and PCA+LDA are utilized for the face identification.

The paper is devoted to the automatic identification of football players using the numbers placed on players' kits. The second section describes the method for the localisation of the numbers. The third one describes the method for the recognition of extracted numbers. The fourth section describes obtained results of the experiments. The fifth section gives some conclusions the paper and suggests some plans for future works.

2 The Algorithm for the Localisation and Extraction of the Numbers

For the needs of the developed algorithm the approach proposed in [4] was applied for the localisation and extraction of the numbers visible on football players' kits.

Tab. 1: The ranges in colour models applied in localisation of jerseys

	Y	Cb	Cr	H	S	V
white	>90	120-150	—	—	—	—
red	—	90-130	>145	—	—	—
yellow	—	30-80	130-170	—	—	—
white-red	<85 or >140	90-150	<125 or >160	—	—	—
white-blue	—	120-145	110-135	—	—	—
orange	—	—	—	0.045-0.1	>0.7	—
green	—	95-120	100-122	—	—	—
blue	—	135-190	95-125	—	—	—
maroon	<85	115-135	135-165	—	—	—
navy-blue	—	—	—	0.4-0.7	0.22-0.8	

It starts with the search for the pixels within a frame that belong to a football player. For this purpose the colour features are applied. It is pre–assumed that particular colours are associated with particular football teams. In the described approach firstly a shirt is localised and afterwards numbers placed on it. Experimentally obtained values in colour spaces are applied here. The performed experiments evaluated ranges in HSV, RGB, CIE L*a*b and YCbCr models. Usage of HSV and YCbCr gave the best results. The obtained ranges for the localisation of football players' shirts for particular colours and colour models are given in Tab. 1 [4]. In order to reject objects other than a shirt, the length of an extracted object boundary has to be higher than 200 pixels. Fig. 1 presents a result of the shirt localisation.

The above–described method gave the localised and extracted shirt. The next step was the localisation of a num-

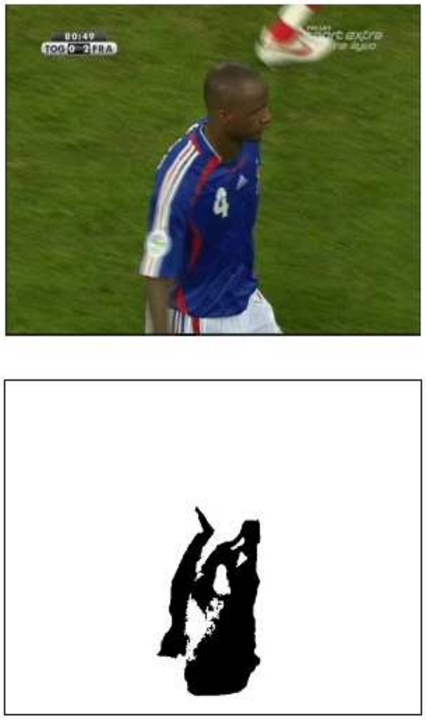

Fig. 1: An exemplary result of the shirt localisation

Tab. 2: The values for colour spaces applied in localisation of numbers inside earlier extracted shirts

	Y	Cb	Cr	H	S	V
white (red)	>110	125-155	—	—	—	—
white (blue)	>130	125-160	—	—	—	—
white (green)	>95	115-145	—	—	—	—
yellow	—	65-105	135-155	—	—	—
black (blue-white)	45-130	120-140	—	—	—	—
black (orange)	105-130	125-175	—	—	—	—
green	—	60-95	110-140	—	—	—
blue (white-blue)	—	—	—	0.45-0.6	—	0.19-0.6
blue (white)	—	—	—	0.3-0.8	0.22-0.57	0.3-0.75

ber placed on it using new ranges in colour spaces — see details in Tab. 2 [4].

Some results of the above–described approach are given in Fig. 2.

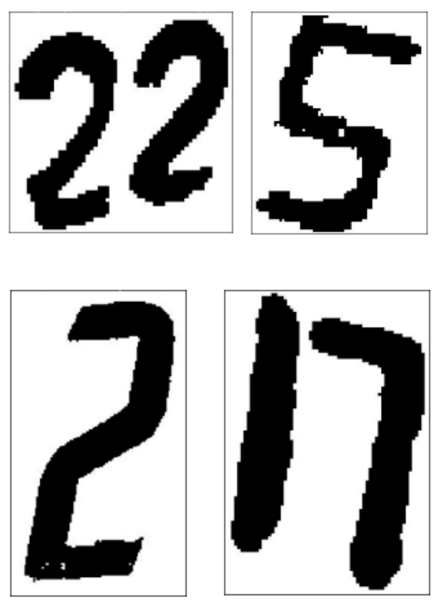

Fig. 2: Examples of extracted numbers

3 The Algorithm Applied for the Representation and Recognition of the Extracted Numbers

The shape representation algorithm (Generic Fourier Descriptor) applied for the experiments described in the next section was introduced by Zhang D. and Lu G. in [16]. The coordinates of pixels belonging to a region shape image are transformed into polar co-ordinates and put into a rectangular Cartesian image. Later $2D$ Fourier transform is used.

The approach firstly applies the above–mentioned image transformation. For obtained image the $2D$ discrete

Fourier Transform in Cartesian co–ordinates is applied, using the following formula [16]:

$$PF(\rho,\phi)=\sum_r\sum_i f(r,\theta_i)exp[j2\pi(\frac{r}{R}\rho+\frac{2\pi i}{T}\phi)], \quad (1)$$

where:
$0 \le r = [(x-x_c)^2+(y-y_c)^2]^{1/2} < R$,
$\theta_i = i(2\pi lT), (0 \le i < T)$,
$0 \le \rho R, 0 \le \phi < T$,
$f(x,y)$ — the shape image,
(x_0,y_0) — the centre of gravity,
R and T — radial and angular resolutions, with ρth radial and θth angular frequency.

The last step is the derivation of GFD [16]:

$$GFD=\{\frac{PF(0,0)}{area},\frac{PF(0,1)}{PF(0,0)},\ldots,\frac{PF(0,u)}{PF(0,0)}, \frac{PF(m,u)}{PF(0,0)},\ldots,\frac{PF(m,n)}{PF(0,0)}\}, \quad (2)$$

where:
$area$ — the area of the bounding circle,
m — the maximum number of selected radial frequencies,
n — the maximum number of selected angular frequencies.

4 Methodology and Experimental Results

The GFD shape was utilized for the representation of the extracted shape numbers in a form of the feature vectors. For the derivation of the dissimilarity between represented objects the Euclidean distance was used. The dissimilarity value was calculated between the tested extracted numbers and the templates. The template base covered the original undistorted numbers, limited only to the players that currently were visible on the play field.

In the experiments twenty video sequences, lasting between two and three minutes, were used. For each sequence particular frames were extracted. Only frames with visible players were taken for further processing. The algorithm for the localisation of a shirt and number placed on it, described in the second section, was applied and then the above-mentioned procedure for the number recognition was used. The obtained results are given in Tab. 3. For 173 frames that were containing numbers the extracted shapes were recognized using the Generic Fourier Descriptor and for them the result was correct 125 times. It gives the average recognition rate equal to 72%. It seems that the obtained efficiency is not ideal. However, one have to take into account various problems that occur during the sport broadcast and significantly hamper the recognition efficiency. Some examples are given in Fig. 3. As we can see, the number not always is clearly visible, sometimes it is strongly deformed or only partially visible.

Tab. 3: Experimental results for the recognition of numbers placed on shirts according to particular classes of shirt colours

Class	No. of frames with numbers	No. of correct results	Recognition rate [%]
1.	25	21	84
2.	15	10	67
3.	14	10	71
4.	15	9	60
5.	14	10	71
6.	17	11	65
7.	19	9	47
8.	18	15	83
9.	20	18	90
10.	16	12	75

5 Conclusions

In the paper the application of Generic Fourier Descriptor for the recognition of numbers on jerseys during sport video broadcast were described and analysed. The

Fig. 3: Examples of problematic frames leading to the extraction of numbers of poor quality

Generic Fourier Descriptor is based on the transformation of the image coordinate system. Before the shape descriptor was applied, the numbers were localised on the frames by means of the appropriate ranges in colour spaces. The obtained efficiency was above 70% and was strongly hampered by various factors, e.g. occlusion, poor quality, blur, etc. The resultant recognition rate enforces the necessity of future works on the problem. Above all, other shape description algorithms would be investigated. Also some pre–processing techniques would be used for the improvement of the quality of extracted frames and give better results of shape localisation.

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