APPLICATION OF HUE-SATURATION COLOUR MODEL TO THE REDUCTION OF VEHICLE'S TRACKING ERRORS

УПОТРЕБЛЕНИЕ ЦВЕТОВОЙ МОДЕЛИ ТОН-НАСЫЩЕННОСТЬ К УМЕНЬШЕНИЮ ОШИБОК СЛЕЖЕНИЯ АВТОМОБИЛЕЙ

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Abstract: *In the paper some possibilities of utilisation of reduced colour models for the improvement of the vehicles' tracking accuracy is discussed. Presented results are based on the HSV colour model limited to Hue-Saturation space by elimination of the value (V) channel. Presented approach is especially useful for tracking of vehicles with shining bonnets, particularly in the strong sunshine. Decreasing the colour variance of the vehicle's fragments on each video frame allows more precise estimation of the vehicle's location and its velocity.*

***KEYWORDS**: INTELLIGENT TRANSPORT SYSTEMS, IMAGE ANALYSIS*

1. Introduction

One of the most interesting aspects of contemporary road transport seems to be the application of Intelligent Transport Systems allowing not only the statistical traffic analysis but also more sophisticated automatic tracking and control. Application of such systems cannot be done without some image processing and analysis operations necessary for the proper work of the detection system.

One of the most advanced parts of the ITS is the video based automatic recognition and tracking system. In some applications it is reduced to simple recognition of the register plates' numbers often based on the analysis of the single image. Nevertheless, in most advanced applications the video part, allowing also tracking and estimation of some vehicle's motion parameters and also the geometrical ones, represents a serious fragment of the whole system.

Vision systems are usually sensitive on many factors related to weather conditions, lighting conditions, smog, fog, dust, noise, blinking street lamplights etc. That is why some errors may occur so the position and velocity estimation may not be perfect. The reduction of the influence of some disadvantageous effects, especially related to lighting conditions, seems to be one of the most relevant tasks for the image processing and analysis part of such systems.

2. Idea of the vehicle's detection and tracking

The algorithm used in the paper is based on the elimination of the background from each frame. Estimation of the background can be performed using various techniques described in our earlier paper [3]. After that, each difference frame is screened using the sliding window approach with the shape of the mask accordant to the shape of the sought vehicle. As the measure of similarity of each region with the specified pattern of the vehicle, we can use Euclidean distance in RGB colour space or apply the correlation coefficient. Euclidean distance is calculated as the following:

$$d = \sqrt{\left(R_{im} - R_{bg}\right)^2 + \left(G_{im} - G_{bg}\right)^2 + \left(B_{im} - B_{bg}\right)^2} \tag{1}$$

where R,G,B denote the red, green and blue channel's values respectively, 'im' stands for the analysed image and 'bg' for the estimated background.

However, obtained results are strongly dependent on the local changes of the vehicle's colour in each position caused by the changes of the local lighting conditions (visible shining areas with varying locations).

3. Proposed method

Taking into account the fact that observed changes of colour are mainly related to the intensity or luminance, it is possible to reduce such undesirable effects by elimination of the channel related to luminance data. It is impossible in the RGB colour space so the conversion into the HSV model is proposed.

Assuming the RGB values are normalised to the range <0 ; 1> the conversion can be performed using the following formulas:

$$H = \begin{cases} 0 & if \quad max = min \\ \left(60^0 \cdot \dfrac{G-B}{max-min}\right) \bmod 360^0 & if \quad max = R \\ 60^0 \cdot \dfrac{B-R}{max-min} + 120^0 & if \quad max = G \\ 60^0 \cdot \dfrac{R-G}{max-min} + 240^0 & if \quad max = B \end{cases} \tag{1}$$

$$S = \begin{cases} 0 & if \quad max = 0 \\ 1 - \dfrac{min}{max} & otherwise \end{cases} \tag{2}$$

$$V = max \tag{3}$$

where *max* and *min* are the greatest and the least values of R, G, and B channels respectively [6]. The dynamic range of S and V components is <0 ; 1> and for the hue it is from 0^0 to 360^0. The backward conversion from HSV to RGB can be performed as:

$$[R \quad G \quad B] = \begin{cases} [V \quad t \quad p] & if \quad \left(\dfrac{h}{60} \bmod 6\right) = 0 \\ [q \quad V \quad p] & if \quad \left(\dfrac{h}{60} \bmod 6\right) = 1 \\ [p \quad V \quad t] & if \quad \left(\dfrac{h}{60} \bmod 6\right) = 2 \\ [p \quad q \quad V] & if \quad \left(\dfrac{h}{60} \bmod 6\right) = 3 \\ [t \quad p \quad V] & if \quad \left(\dfrac{h}{60} \bmod 6\right) = 4 \\ [V \quad p \quad q] & if \quad \left(\dfrac{h}{60} \bmod 6\right) = 5 \end{cases} \tag{4}$$

where

$$\begin{bmatrix} p \\ q \\ t \end{bmatrix} = \begin{bmatrix} V \cdot (1 - S) \\ V \cdot \left(1 - S \cdot \left(\frac{H}{60} - \left\lfloor \frac{H}{60} \right\rfloor \right)\right) \\ V \cdot \left(1 - S \cdot \left(1 - \frac{H}{60} + \left\lfloor \frac{H}{60} \right\rfloor \right)\right) \end{bmatrix} \qquad (5)$$

In the case of elimination of V channel a constant value should be used (in our experiments V=0.5 has been chosen in order to ensure visual similarity of colours).

Another possibility is using H2SV colour model, which can be also used for tracking purposes [7]. Nevertheless, such approach, based mainly on the conversion of hue from radial to Cartesian coordinates, is not necessary in our algorithm. In our approach the main elements of the conversion are elimination of the V channel and backward conversion from H-S to RGB colour space. Further analysis is performed in RGB colour space with the use of Euclidean distance. The main elements of the algorithm are illustrated in Fig. 1

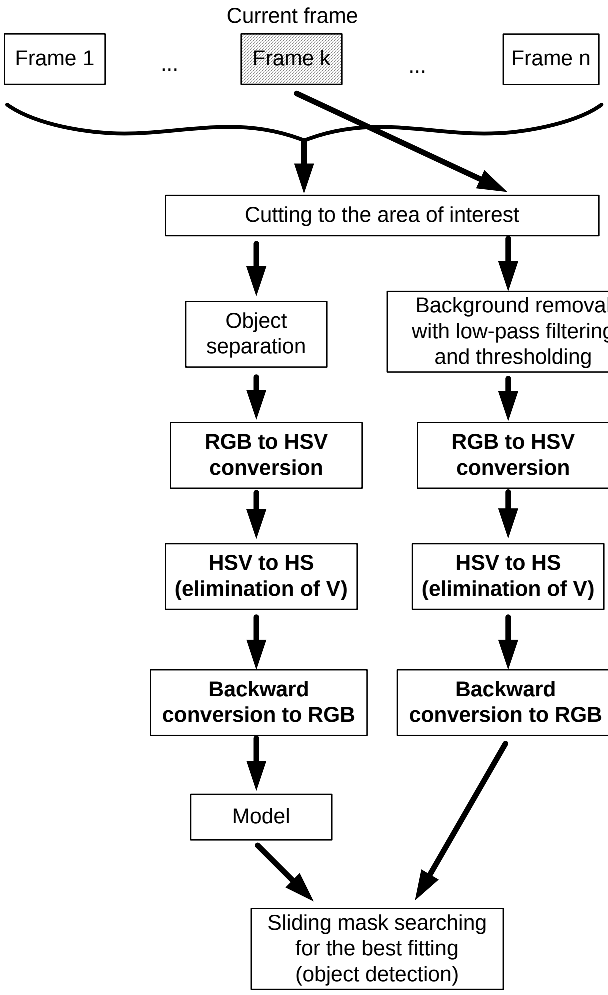

Fig.1 The idea of the detection algorithm

4. *Results*

Results obtained using RGB and H-S approach are presented in Table 1. As we can easily notice some results achieved using H-S approach are inappropriate (they are marked with asterisk in the Table 1). Because of the side-view localisation of the camera only the horizontal positions of the vehicles have been analysed. The images taken from the camera used in our experiments are presented in Fig. 3 while Fig. 4 and 5 illustrate the visualisation of obtained results – dark areas indicate lower values of Euclidean distance.

Fig.2 Example frame with the vehicle's model (pattern) marked as the black shape

Table 1. Results obtained using RGB and H-S colour spaces (outliers marked with asterisk).

No. of model [no. of image]	**Location in pixels (horizontal coordinate)**		
	proper	estimated using RGB model	estimated using proposed H-S approach
1 [1]	639	639	639
1 [2]	448	446	**631 ***
1 [3]	254	249	**508 ***
1 [4]	99	92	**404 ***
2 [1]	641	641	645
2 [2]	450	448	453
2 [3]	210	204	211
2 [4]	75	67	76
3 [1]	618	618	618
3 [2]	454	451	452
3 [3]	269	265	266
3 [4]	111	104	105
4 [1]	583	584	**493 ***
4 [2]	438	435	493
4 [3]	354	350	**494 ***
4 [4]	215	209	**494 ***
5 [1]	607	608	608
5 [2]	447	444	446
5 [3]	276	273	273
5 [4]	85	78	80
6 [1]	621	621	**8 ***
6 [2]	564	564	**8 ***
6 [3]	380	379	**8 ***
6 [4]	137	135	**33 ***
7 [1]	413	414	414
7 [2]	308	305	304
7 [3]	219	215	214
7 [4]	110	104	105
8 [1]	416	416	416
8 [2]	333	334	332
8 [3]	226	223	232
8 [4]	87	82	87
9 [1]	631	632	**3 ***
9 [2]	492	492	**291 ***
9 [3]	292	287	277
9 [4]	153	147	152
10 [1]	623	623	623
10 [2]	473	471	473
10 [3]	330	326	329
10 [4]	138	130	132

Fig.3 Images corresponding to the results presented in Table 1
(cut to the area of interest)

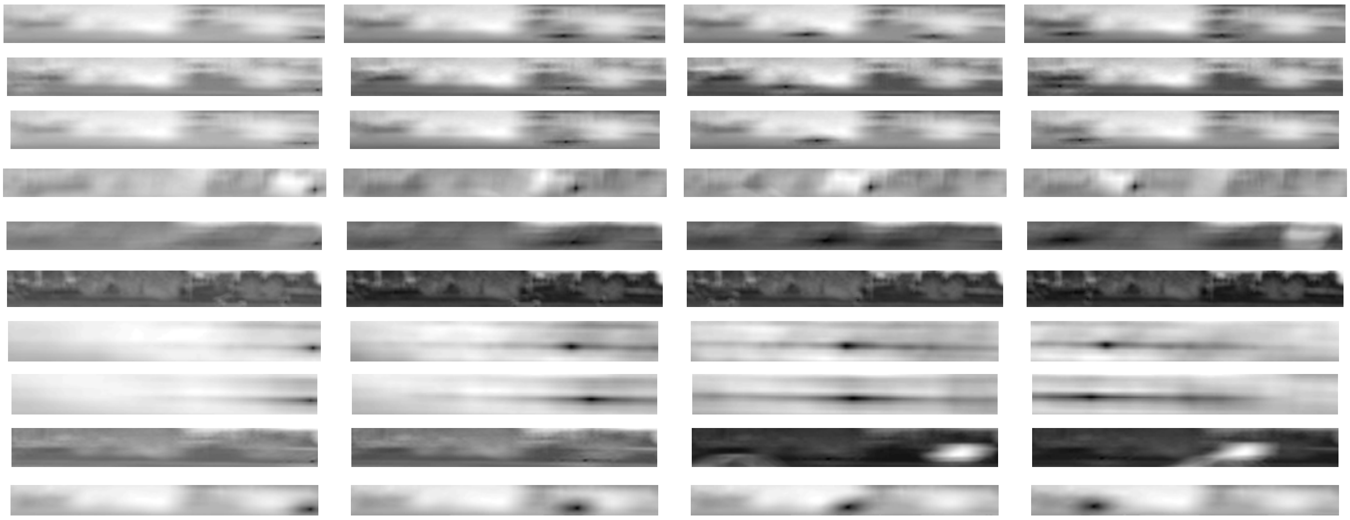

Fig.4 Visualisation of the results presented in Table 1 (RGB colour space).

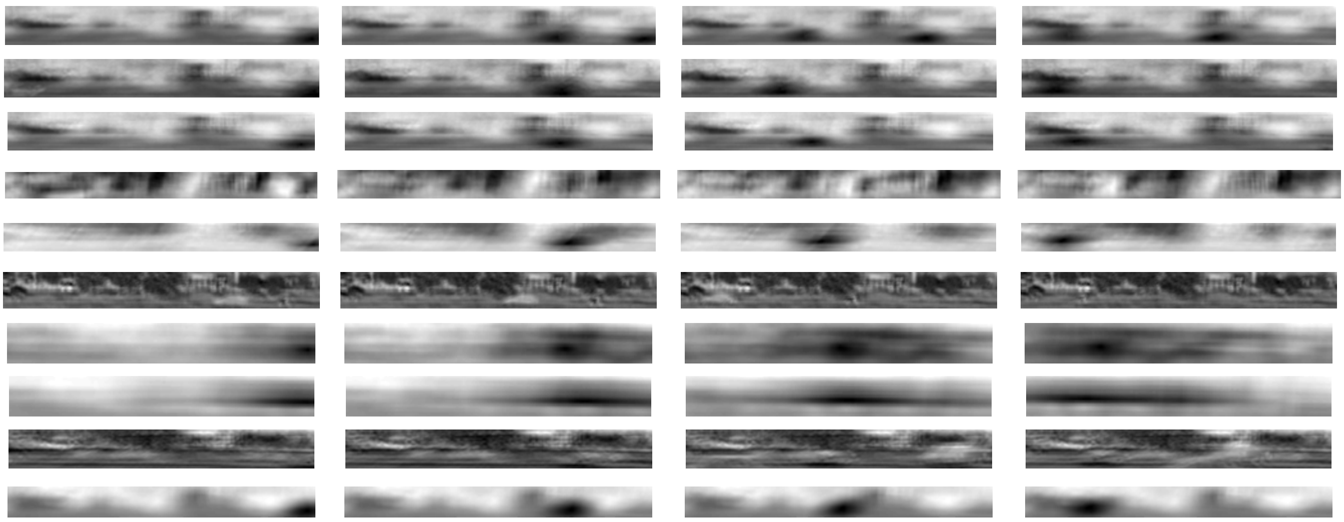

Fig.5 Visualisation of the results presented in Table 1
(H-S colour space).

In order to compare the effectiveness of using only RGB colour space and the additional conversion to Hue-Saturation model the set of 40 images divided into 10 groups has been used. Each group consists of one reference image (numbered as 1) and three images with the same vehicle visible in some other locations. Each of images has been cut to the area of interest and the pattern of the vehicle has been chosen from the first images in each group so the results obtained for them are usually the best ones. The example reference frame with the pattern cut out from it is shown in Fig. 2.

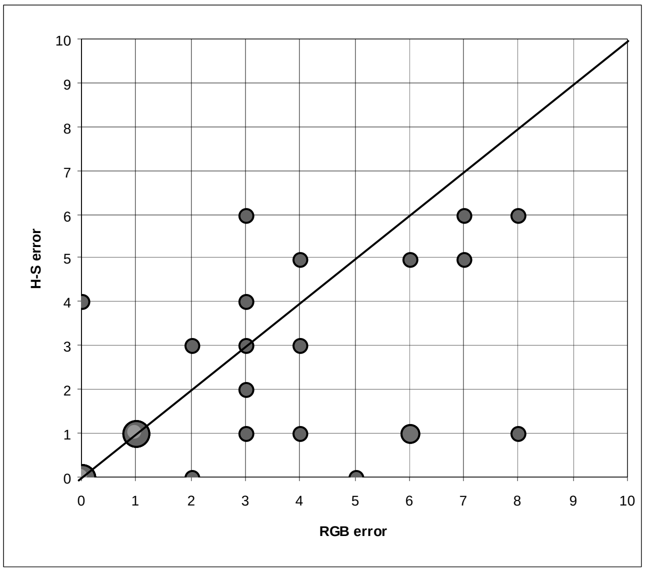

Fig.6 Comparison of absolute errors obtained in RGB and H-S colour spaces with outliers' elimination.

5. Conclusions

Comparing the absolute errors (Fig. 6) achieved for both techniques it can be noticed that for most images application of H-S colour model leads to better results. The size of the circle in Fig. 6 is proportional to the number of images with specified combination of errors expressed in pixels.

Nevertheless, using H-S model there may be the situation of inappropriate detection ("outliers" not visible in Fig. 6) so the best solution seems to be using hybrid. For the most of the images with similar results obtained in RGB and H-S colour model the value obtained using Hue-Saturation model is closer to the reality. If the difference between both results is too high, the result obtained using H-S model should be rejected and the value achieved sing RGB model should be treated as the final result.

6. Bibliography

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