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LOCALIZATION OF VEHICLE LICENSE PLATES IN IMAGES USING FUZZY LOGIC AND MORPHOLOGICAL OPERATIONS

Summary. The paper presents a method of localization of licence plates in a traffic scene image. It is assumed that the input data comes from a colour camera and the results are grey scale images of isolated license plates. The method was implemented and tested. Test results confirm that it can be incorporated in a system for traffic monitoring or parking supervision.

LOKALIZACJA TABLIC REJESTRACYJNYCH POJAZDÓW Z UŻYCIEM LOGIKI ROZMYTEJ I OPERACJI MORFOLOGICZYCH NA OBRAZACH CYFROWYCH

Streszczenie. W artykule przedstawiono metodę lokalizacji tablicy rejestracyjnej z obrazu uzyskanego z wideorejestratora. Przyjęto założenie, że danymi wejściowymi, analizowanymi przez algorytm, będą kolorowe obrazy, a efektem obrazy w odcieniach szarości z wyodrębnioną tablicą rejestracyjną. Metodę zaimplementowano i przetestowano. W metodzie wykorzystano elementy logiki rozmytej. Algorytm ten ma stanowić część systemu automatycznego rozpoznawania tablic rejestracyjnych.

INTRODUCTION

License plate constitutes an unambiguous identifier of a vehicle participating in road traffic. Reading a license plate is the first step in determining the identities of parties involved in traffic incidents.

An efficient automatic license plate recognition process may become the core of fully computerized road traffic monitoring systems, electronic fee collection solutions, surveillance devices and safety supervision systems. It is important that the recognition accuracy of such a process is very high. Tracking and registering dangerous behaviour in traffic may be used for prosecuting offenders.

Currently used algorithms for detecting image regions with license plates incorporate time consuming morphological operations [1]. Attempts at utilizing frequency, wavelet or fractal based analysis lead to algorithms of much computational complexity that are of little use in real time implementations.

1. ALGORITHM FOR LOCALIZING A LICENSE PLATE

1.1. Assumptions

Correct localization of the license plate position and subsequent reading of its content may be hindered by a number of factors:

- the license plate blurs in with the sight of the vehicle,
- ambient light changes,
- the license plate is smudged,
- image contains objects similar in shape to license plates,
- image contains regions with alphanumeric characters,
- right angles of the plate shape are not preserved.

It is assumed that the process of localizing the license plate is to be performed iteratively that is candidate regions are isolated and reading tests are to be performed until successful verification. Read characters syntax must conform to license plate templates if the syntax is correct the candidate becomes the sought after region.

Therefore the first step is to extract, from the image, regions which probably contain a license plate. In order to diminish the complexity of processing applied to the image contents, the processing task types were restricted to pixel neighbourhood operations.

The algorithm is based on obvious practical observations:

- the plate is a rectangular region mostly filled with characters,
- the plate is situated near the vertical axis of the vehicle, rather low,
- plates are black- white or at least “very bright” – “very dark” and constitute the brightest or darkest objects of the image,
- these are usually regions of high contrast and two coloured – “little coloured”,
- the place of the license plate is marked by plate edges or various mounting brackets.

Distinctive feature of the observation descriptions is the use of ambiguous attributes or adverbials such as “mostly”, “near”, “very”, “high”, various”. Although without a precise definition of their meaning such descriptions may be allowed if some fuzzy rules can be devised for processing them into useful statements for controlling processing steps.

The camera setup should provide images with a resolution adequate for correct recognition of license plate characters. It is assumed that characters depicted by about a two hundred pixels are legible. The preliminary step of finding candidate places for plate positions does not require such a high image resolution so the image data can be decimated 2-3 times. This operation also reduces processing requirements by 4-9 times.

The algorithm uses pixel selection instead of conventional local averaging, for determining the scaled image, which further reduces the number of processing operations. Tests have shown that no significant deterioration of results was observed. Additionally some operations can be carried out concurrently.

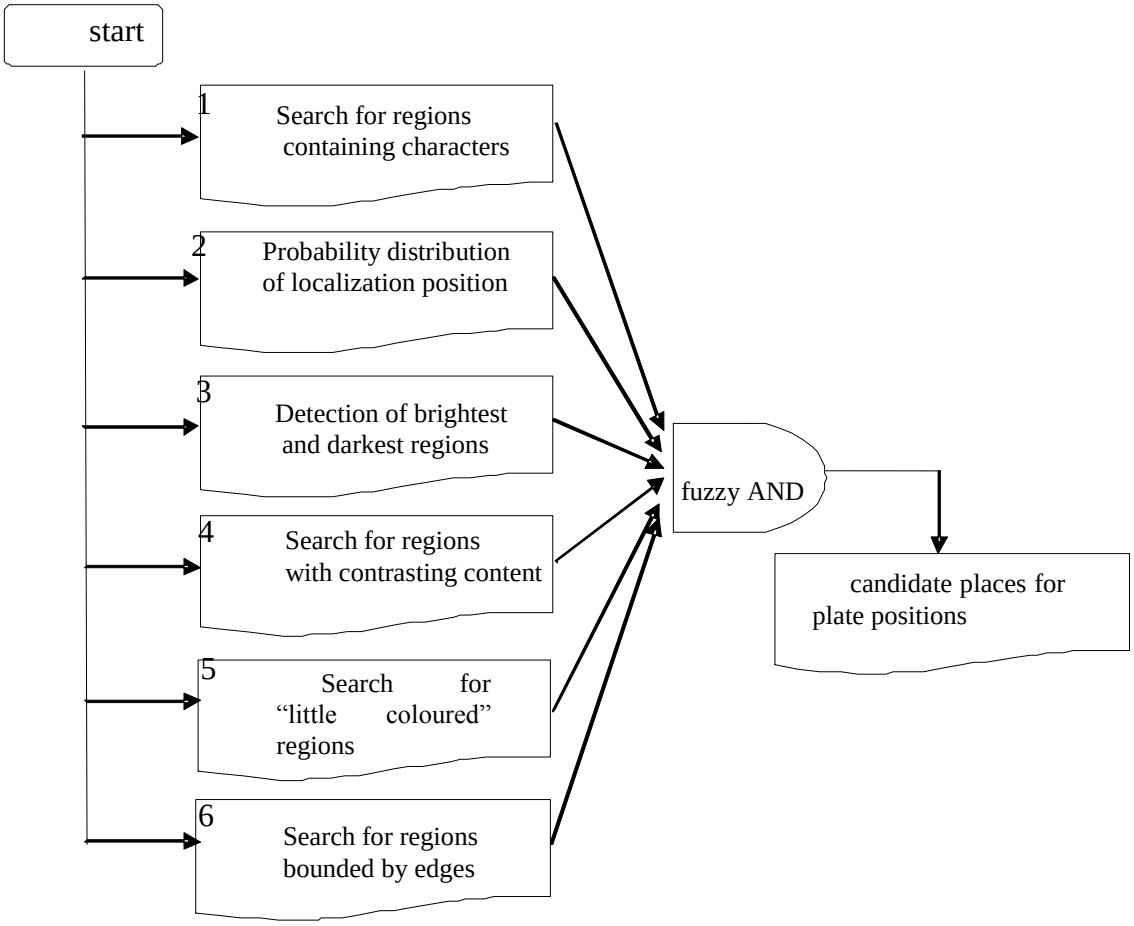

Fig. 1. Diagram of the license plate localization algorithm
Rys. 1. Algorytm lokalizacji tablicy rejestracyjnej

1.2. Search for regions containing characters

In order to detect regions containing details (potentially characters) an edge filter is applied and the resultant image is binarized. A text region contains patches with characters separated by vertical stripes of background. These stripes appear as vertical strokes splitting license plate characters and are easily detected using a local averaging operator on a square of 4 by 4 pixels (Fig. 2c). The operator yields a value proportional to the density of edges which is high in regions with characters and small in other regions even if these contain non text edges. This procedure gives comparable results to FFT (Fig. 2b) based methods but is much faster and less complicated.

a) b) c)

Fig. 2. a) Original image, b)FFT based detection, c) Density of vertical edges
Rys. 2. a) Obraz pierwotny, b) Obraz po zastosowaniu metody FFT, c) Gęstość pionowych krawędzi

1.3. Probability distribution of localization position

In the case of cars the license plate is placed typically near the vertical axis of the image at 1/3 of its height. In the case of trucks it is typically on the left side of the image and again at 1/3 of image's height (Fig. 3). The probability distribution of the localization position can be described:

$$w(x,y) = e^{-\left(\frac{(x-x_0)^2}{\sigma_x^2}+\frac{(y-y_0)^2}{\sigma_y^2}\right)}$$

Relative to image dimensions the following values are assigned:
x0 = 1/2, y0 = 1/3, σx = 1/4, σy = 1/6,

Fig. 3. The example image with license plate
Rys. 3. Przykładowy obraz z tablicą rejestracyjną

1.4. Detection of brightest and darkest regions

Successive algorithm module classifies image regions based on pixel brightness (Fig. 4). Weights are assigned to regions marking their average brightness level. The brighter the region the higher is its weight.

Fig. 4. Original image and grey scale image
Rys. 4. Obraz oryginalny i obraz w skali szarości

1.5. Search for regions with contrasting content

A region with contrasting content comprises neighbouring pixel sets which differ significantly in values. In order to detect such content the image is divided into 8 by 8 patches. Each patch is characterized by its minimum and maximum value giving in all a max and a min image. These images are fuzzy ANDed with the inverse of the original giving regions with high contrast content (Fig. 5).

Fig. 5. The result of „fuzzy AND" operation
Rys. 5. Obraz po wykonaniu operacji „fuzzy AND"

1.6. Search for "little coloured" regions

If the camera provides colour images this feature can be additionally exploited. Detecting "little coloured" regions – potentially license plate regions, may be done by simple comparison of chrominance and luminance components of pixel data (Fig. 6).

Fig. 6. The original image and result
Rys. 6. Obraz pierwotny i obraz wynikowy

1.7. Search for regions bounded by edges

The search for edge bounded regions is limited to searching for "almost" horizontal lines. Lines skewed by more than 15º relative to horizon signify that it will not be possible to read the license plate. At first the image is binarized and a horizontal edge filter is applied. Radon transform is used to identify lines lying between -15º do 15º off the vertical axis of the image.

The drawback of Radon transform is its low sensitivity to faint lines and erroneous detection of non existent lines so it is necessary to assign probability factors to detected segments.

The probability of horizontal lines crossing the license plate region is zero and their existence in near vicinity is very high. This can be modelled using normal distribution:

$$w(y) = \frac{y}{\sigma_y} e^{-\frac{(y-y_0)^2}{\sigma_y^2}}$$

A typical value of the license plate height relative to image height was chosen as: $\sigma y = 1/10$

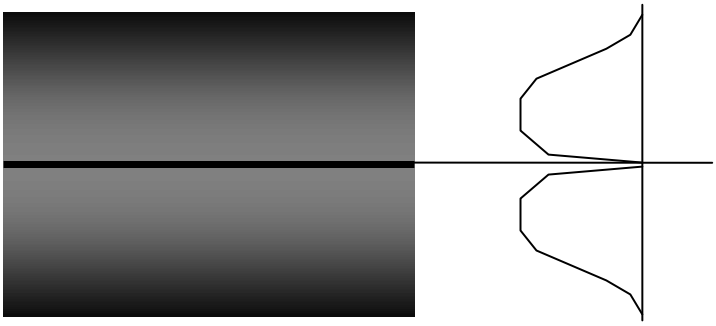

Fig. 7. The probability distribution function of the license plate localization
Rys. 7. Rozkład prawdopodobieństwa lokalizacji tablicy

After performing the "fuzzy AND" operation and further simple processing (thresholding and dilation) images with distinct license plate regions were obtained.

Fig. 8. The results of the license plate localization algorithm
Rys. 8. Wyniki działania algorytmu lokalizacji tablicy rejestracyjnej

After object identification small and large ones are rejected. Usually (in 80% of cases) only one object remains.

The last step is to find license plate edges. This yields regions smaller than the license plate so the regions are slightly enlarged. Next using Hough transform the proper edges are localized and the region is recognized as suitable for reading license plate characters.

2. CONCLUSIONS

The presented algorithm enables the localization of license plates in an image. License plates may contain black characters on white background or white characters on black background (old type plates). The license plates may be skewed horizontally by up to ±15°.

The algorithm was implemented in C++. Preliminary localization tests give results which confirm its usefulness in real time processing of images from a road camera.

The implementation may be incorporated as a module of an ALPR system utilizing a video based vehicle detector device.

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