DETECTION OF DRIVING SPACE

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ABSTRACT

Road detection is one of the basic tasks for automatic guidance of vehicles in driver assistance system. In this paper an approach to detect road is proposed, which firstly transform RGB image into gray-scale image, then edge detection algorithm is applied and finally line extraction and highlighting is preformed. This algorithm has been tested on an images downloaded from the internet and on some photographs scanned by mobile phone equipped with camera.

Keywords: *image processing, road detection, line extraction, dilatation, Hough transform*

1. INTRODUCTION

Detection of driving space is one of the basic tasks for intelligent vehicles. It is important for the vehicle recognition system to know where the potential candidate for the vehicle might be found. Important issues of road detection are edge detection and line extraction from images. Road recognition must discriminate between road and surrounding areas. Borders of well maintained roads such as highways with sharp lane lines are good features to detect. But there are also unstructured roads such as marginal rural roads with fuzzy road/non-road border with low intensity contrast and also the shape of the border lines may not have spatially smooth curves.

But there are some global features, such as geometry and edges of the road. These key features can be used to extract information about road and non-road object from the image.

2. ROAD DETECTION

The process of road recognition is segmentation of image into two parts: road and non-road. The main attribute for road are its edges which are lane lines or in rural roads end of asphalt if lane markings are not present. Other attributes such as colour, edges and lines are often common for most types of roads.

2.1. Colour

This feature is chosen because roads have often gray or little blue colours, while non-road space have mostly green, yellow and other types of colours. This difference between these regions in the image allows us to subtract non-road region and hence only road region to be processed and verified.

Image taken by camera placed on a vehicle is usually RGB image. In our algorithm we use transformation from RGB space to grayscale image (1).

An RGB image, sometimes referred to as a "true colour" image, is stored as an m-by-n-by-3 data array that defines red, green, and blue colour components for each individual pixel. The colour of each pixel is determined by the combination of the red, green, and blue intensities stored in each colour plane at the pixel's location. The conversion between these two types of images is based on reducing m-by-n-by-3 data array into one data array with values representing values of intensities within some range. RGB image is converted to intensity image using common formula which is weighted sum of R, G and B colour components (values).

$$Y = 0{,}3.R + 0{,}59.G + 0{,}11.B \qquad (1)$$

Then the grayscale image is converted into the binary image. Output of this conversion results in replacing all pixels in the input image with luminance greater than threshold with the value 1 (white) and replaces all other pixels with the value 0 (black). Threshold is automatically computed using Otsu's method [4], and it is computed from all pixels in the input image. Otsu's method chooses the optimal threshold which maximizes the between-class variance (classes are pixels of background or foreground) (or, conversely, minimizes the within-class variance).

Images containing lane markings have this region in binary images highlighted and rest of driving space is black Fig. 1. This outcome is suitable for detection of edges.

Fig. 1 Binary image of road after transformation to intensity image

2.2. Edges

Next step in our algorithm is to find edges in the image and hence the borders of our driving space. For this purpose we use edge extraction to find edges of all objects in the image. This method of finding edges may show some changes on the road such as sand, gravel and mud that appear as objects. Some of small inhomogeneities can be suppressed by using dilatation and erosion [5]. This part of algorithm makes all straight lines after edge extraction more significant to find.

Dilatation and erosion are basic morphological operations. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image. This structuring element is predefined object (binary matrix) which is added or removed from the image in dilatation or erosion process. Center pixel of this element is called origin and identifies the pixel that is being processed. The shape of structuring element is vital feature, to remove small pixels in the image, which represents inhomogeneities such as gravel, sand, dirt etc.

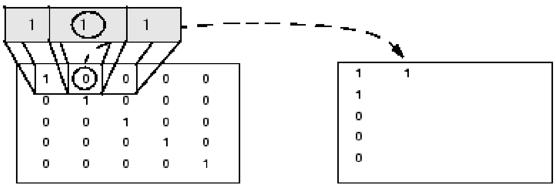

Fig. 2 Dilatation process of binary image with 3-bit line structuring element

2.3. Line extraction – Hough Transform

The Hough Transform (HT) has been used as one of the most popular methods to extract parameterized lines from an image [2], [3]. The HT maps a line in the image space (x, y) into a point in the HT parameter space. A line can be described by the equation

$$y = m.x + c \tag{2}$$

in the Cartesian coordinates (see Fig. 3a). Alternatively, in polar coordinates, this is

$$\rho = x.\cos\theta + y.\sin\theta . \tag{3}$$

Now, if we want to draw the same line in the (θ, ρ) space, each point of the line generates a sinusoid. The (θ, ρ) space is also named the Hough space, and is illustrated in Fig. 3b. All points in straight lines in the image are transformed into sinusoids that cross each other in Hough space which makes bright points – peaks [2] (see Fig. 4). Every point in Cartesian space will generate a sinusoid in Hough space. That means the longer the lines are, the brighter the peaks will be. Less bright peaks are considered to be shorter lines and thus are not interesting for our purpose, because only long lines such as lane markings are the ones we are interested in. Number of peaks we consider to use in our algorithm as an important parameter for highlighting straight lines which may represent lane markings and that is our goal.

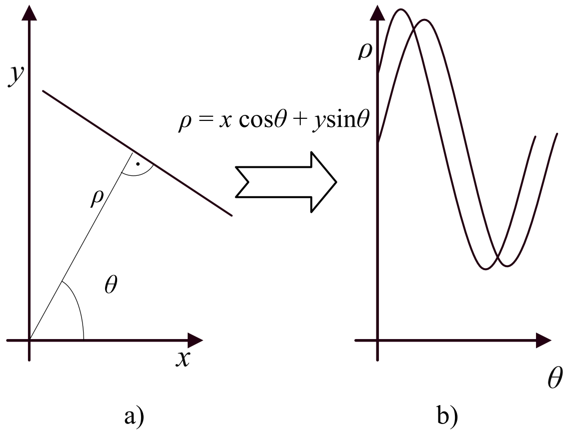

Fig. 3 Hough space

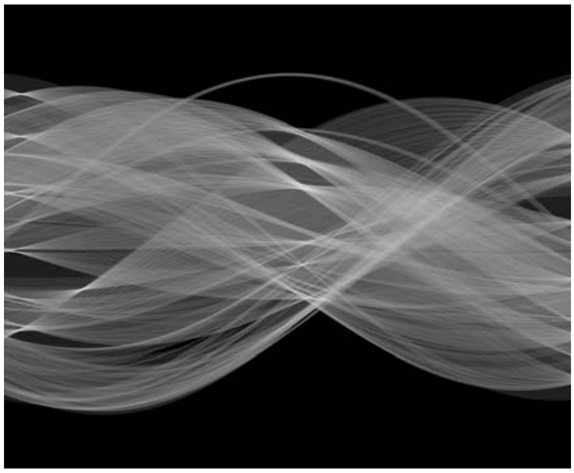

Fig. 4 Hough space with peaks

3. EXPERIMENTS

Several testing images were downloaded from internet and scanned by cell phone equipped with camera (2 mega pixel, which represents pictures with high colored noise level), with different illumination conditions, shadows and road structure. Experiments were not preformed during different weather conditions. Figure 5 show example of images processed by the algorithm mentioned above. Properties of image on Fig. 5a are 540x405 pixels with bit depth 24 bits and 5b was scanned by camera and has 1600x1200 resolution and also 24 bit depth.

Experiments were done on both images to validate accuracy and efficiency of this algorithm. All example images were transformed into grayscale space (1) and after that were transformed into the binary images using threshold described above. Local threshold of every image is responsible for every white object in binary image. White objects were lane markings on image samples with low colour noise level and results on scanned images were not satisfying, because no lane markings were present. Line extraction depended only on binary images and edges of white objects were extracted. First we used erosion with 2x2 structuring element to subtract small inhomogeneities from driving space to ensure that only major lines were present. Dilatation was used before line extraction (HT) with line structuring element of size 1x4 to add pixels to places where lines were incomplete. That part of algorithm ensured that lines before extraction were more significant to find and that some of partial lines that were separated become one straight long line.

Fig. 6 show images after edge detection. There are not present straight lines of lane markings on example picture (b) and there are present edges of trees and roof of the building. In the picture (a) there are straight lines of lane markings on the road.

After edge detection, all edge lines were transformed into Hough space and then several brightest peaks were taken to compute back only the position of longest lines that should be highlighted.

Highlighting of longer lines was preformed with inverse HT [2]. Their positions are characterized by black dots that represent start and end of each line highlighted in Fig. 7. Each peak with his coordinates in Hough space was transformed back into Cartesian coordinates and highlighted.

a)

b)

Fig. 5 Road images used for experiments

a)

b)

Fig. 6 Images of road after edge extraction

4. CONCLUSION

In this paper we proposed a road detection algorithm which in some cases can detect correctly edges of driving space such as land markings for driver assistance system.

Because of good illumination conditions in Fig. 5 a and the results of edge detection, then line extraction was successful as shown in Fig. 7 a. Worse illumination condition and contrast in Fig. 5 b caused failure of proposed algorithm in highlighting edges on the road as shown in Fig. 7 b. Fig. 7a show that our algorithm was successful only in sample pictures downloaded from internet, that have less contrast and had low level of colour noise. Results on scanned pictures were unsatisfying as shown on Fig. 7 b.

In the future we want to ensure that this algorithm should be capable to recognize lane markings and edges of different quality roads under different illumination conditions which will make road detection more effective. It is need note that used pictures were not be optimized for this experiments. The better results can be expected when the optical properties (focal length, scanning area, noise parameters of scanning chip) of scanning camera will be optimized.

a)

b)

Fig. 7 Final outcome images with highlighted lane markings

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BIOGRAPHIES

Ján Gamec (Ing., Ph.D.), was born in Stuľany, Slovakia in 1960. He graduated from the Technical University in Košice with specialization in Radiotechnics, Summa cum laude in 1985. He reached a Ph.D. degree in radioelectronics at the Technical University, Košice, Slovakia, in 1995. Since august 1985, he has been as an assistant professor in electronics and information technology at the Technical University of Košice. His main area of scientific research is digital image processing.

Daniel Urdzík was born on 1986 in Prešov. He is now studying last year of MSc degree Faculty of Electrical engineering and Informatics, in Technical University in Košice. This paperwork is part of his diploma work.