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Method for Analysis and Classification of Pavement Based on Quality

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Abstract

The main objective of automated systems for pavement quality control is the detection of cracks and other surface defects, as well as the analysis of their corresponding parameters. On pavement areas the quality assessment is performed based on video surveys, followed by image processing with the corresponding mathematical methods.

In this paper, a method for classification of video survey frames from pavement with and without cracks is proposed. Each frame is processed with previously proposed methods of binarization and segmentation. As a result, two classes are formed for classification experiments based on the proposed procedures. The method of comparison with etalons is used, with application of proximity measure based on structural properties of images.

On experimental data it is shown, that the proposed method of pavement classification gives acceptable results (the average of classification inaccuracy is about 26%).

Keywords: Pavement, Crack, Classification, Gradient magnitude, Weibull distribution, Proximity measure.

1. Introduction

For execution of regular works of pavement quality control, inspections and monitoring are essential. It will allow to have certain and updated information about deviations in pavement quality, such as cracks, potholes, roughness and other types of deviations from predefined criterion, which inevitably occur during road exploitation. Depending on the type of the road and the rank of the observed pavement quality, corresponding works for collecting and processing information may be performed either manually or by using automated systems, which contain special sensors, high-speed cameras and other devices. Manual surveys and processing of information require more time and financial expenses, they may be dangerous for surveyors on active roads, also, there can be issues about objectivity of processing and achieved results [1]. Therefore, in scientific literature the problem of automated analysis and pavement type classification is actual.

During last decades, more attention is paid to analysis methods of pavement quality, which is based on techniques of computer vision and image processing. But a universal method for analysis and assessment of pavement important parameters does not exist. Thus, the methods for solutions of this problem, which are proposed on literature are limited to certain, quite specific situations, which, however, are also many.

In literature, a number of difficulties of automated crack detection are noted, which are related to low contrast difference between crack and background, intensity heterogeneity of crack itself, presence of shading, pollution and other types of artifacts [2, 3]. The most common method of crack detection uses methods of binarization, followed by analysis of the resulted image.

In [4] a method of binarization and segmentation is proposed, which allows to distinguish forms of cracks, presented on the image alongside with background of artifacts.

The visual comparison of images containing or not containing cracks, shows that there are significant statistical properties of parameters of these images, which allow to separate them into two types (classes) of situations. Therefore, a procedure of classification can be developed, which, during automated pavement quality monitoring, can distinguish frames, which contain or do not contain cracks.

This paper is dedicated to a simple method of classification, which is based on the usage of image structural properties, which are related to various behaviors of gradient fields of two types of examined images. To solve this problem, we followed the method of classification [5], which is applied to textured images. The reason for it is the possibility of considering images with cracks as textures.

As it is known, texture classification is one of the important areas of image processing, computer vision and their applications. The goal of classification is to set the unknown sample to one of the predefined classes. Usually, the class of objects is defined by an array of images, which were selected by a certain content based on formal features. The solution to this problem requires to set (or to find an appropriate) description (descriptor) and proximity measure of images, which correspond to this description.

As stated above, suitable description of pavement images may be the distribution of segment sizes, which may be counted with the method described in [4].

2. Method for Pavement Type Classification

Following [5], we consider images, the structure of which may be characterized by the aggregate of edges and borders contained inside the image. Most procedures working with these types of structures, use descriptors, which use specific properties of gradient field of the image. In [5] a method for proximity measure of two images is proposed

$$W^2 = \frac{\min(\eta_1, \eta_2)\min(\sigma_1, \sigma_2)}{\max(\eta_1, \eta_2)\max(\sigma_1, \sigma_2)}, \quad 0 < W^2 \le 1, \tag{1}$$

where the parameters η_i and σ_i are statistical estimates of parameters of Weibull distribution $f(x;\, \eta, \sigma)$, which describe the gradient magnitude of the examined images.

Proposed classification procedure is based on the method of comparison with etalons and contains the following steps:

Step 1. For each image from training and testing samples, Weibull distribution parameters η and σ are assessed;

Step 2. The mean values of $\overline{\eta}_i$ and $\overline{\sigma}_i$ are counted from parameter estimates $\hat{\eta}_i$ and $\hat{\sigma}_i$ for two specified classes by the corresponding items from the training samples. These values are stored as etalons for the next comparison with testing samples with them. Also, mean values of $\overline{W^2}$ are counted and standard deviation s_i of proximity measure W^2 over all pairs of samples inside each class. These values are used during assessment of proximity measure inside each class of training models.

Step 3. According to (1), for each testing sample the proximity measure is counted with each etalon. Belonging of sample to one of the two classes is determined by the highest value of proximity measure.

3. Experimental Results

Experiments were made to test effectiveness of the proposed method of classification between two types of pavement. Classification is done for classes, containing images with only artifacts or with cracks. These images were chosen manually by means of visual analysis of frames from video sequence, collected from real road with bad quality. 40 objects were included each inside each class, where 21 objects were chosen by random rule and used for training, and the rest for testing.

Inside the class of images with cracks were included images with various types of cracks, such as, longitudinal, transverse, block, alligator etc. [6], and in the class without cracks - images not containing any obvious defects.

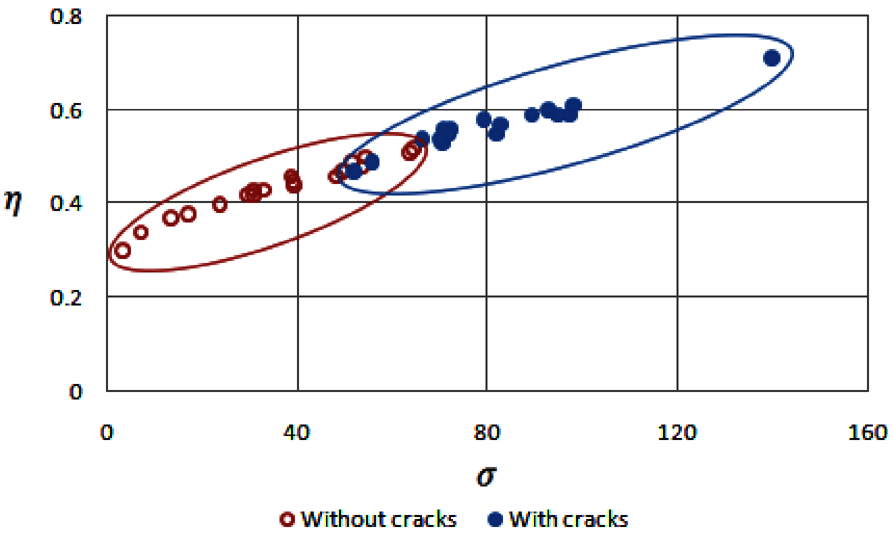

Fig 1. Estimated parameters distribution of training samples.

Described method was applied to the corresponding samples of images with results of binarization and segmentation. Parameters η and σ of Weibull distribution were estimated by the method of moments with data of gradient magnitude for each sample, which was counted by using of Sobel operator [7].

Figure 1 represents the scatters of specified estimates of training samples of two classes. It's visible, that classes with and without cracks are quite clearly separated from each other.

Table 1 contains the etalon values of $\overline{\eta}_i$ and $\overline{\sigma}_i$ for training samples with two classes (with and without cracks), $\overline{W^2}$ and standard deviations s_i of values of proximity measure inside each class.

Table 1. Parameters of training samples.

Classes	*N*	$\overline{\eta}_i$	$\overline{\sigma}_i$	$\overline{W^2}$	s_i
Without cracks	21	80,40	0,56	0,50	0,284
With cracks	21	37,75	0,44	0,52	0,268

Following the described method a classification was made from testing samples, consisting from the half of classes. Results are shown in Table 2. In the first row with class name, the quantities of values of testing images are shown, which were set to each class using the described classification procedure. It's visible, that classification was performed well enough, as the results of inaccuracy percents authenticate in Table 2.

Table 2. Classification inaccuracy distribution by classes.

Classes	Without cracks	With cracks	Percent of inaccuracy
Without cracks	15	4	21,0
With cracks	6	13	31,6

4. Conclusion

For effective defect detection from pavement surface, it is advisable to apply methods of processing, which use structural properties of images by each frame of video survey, alongside with the known methods of data classification. Proposed procedure of analysis and classification of pavement surface by quality allows to confidently distinguish frames from video survey containing or not containing defects of certain type. This procedure may be included in automated systems of pavement surface quality monitoring.

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Ճանապարհային ծածկույթի մակերևույթի որակի վերլուծության և դասակարգման մեթոդ

Դ. Ասատրյան, Գ. Հակոբյան

Ամփոփում

Ճանապարհային ծածկույթների (ՃԾ) որակի հսկման համար նախատեսված ավտոմատացված համակարգերում հիմնական խնդիրը կայանում է մակերևույթի վրա առկա ճեղքերի և այլ արատների հայտնաբերումը, ինչպես նաև դրանց համապատասխան պարամետրերի վերլուծությունը: ՃԾ համապատասխան հատվածներում, որակի գնահատման նպատակով իրականացվում են տեսանկարահանումներ, այնուհետև իրականացվում է պատկերների վերլուծություն՝ համապատասխան մաթեմատիկական մեթոդների կիրառմամբ:

Հոդվածում առաջարկվում է տեսանկարահանման կադրերի ՃԾ ճեղքեր պարունակող և չպարունակող պատկերների դասակարգման մեթոդ: Առաջարկվող դասակարգման մեթոդի փորձարկման համար իրականացվում է յուրաքանչյուր կադրի անհատական մշակում՝ նախկինում առաջարկված երկակիացման և հատվածավորման մեթոդների հիման վրա, որի արդյունքում ձևավորվում են երկու դասի նմուշներ: Օգտագործվում է էտալոնների հետ համեմատման մեթոդը՝ նմանության չափանիշի կիրառմամբ, որը հիմնված է պատկերի կառուցվածքային հատկությունների վրա:

Փորձարարական տվյալների վրա ցույց է տրված, որ ՃԾ դասակարգման առաջարկվող մեթոդը տալիս է ընդունելի արդյունքներ (դասակարգման սխալը կազմում է մոտ 26%):

Метод анализа и классификации поверхности дорожного покрытия по качеству

Д. Асатрян, Г. Акопян

Аннотация

В автоматизированных системах контроля качества дорожных покрытий (ДП) основной задачей является выявление трещин и других дефектов поверхности, а также анализ их соответствующих параметров. Для оценки качества производятся видеосъемки контролируемых участков ДП с последующим анализом изображений соответствующими математическими методами.

В настоящей работе предлагается процедура классификации кадров изображений видеосъемки, содержащих или не содержащих трещины ДП. Выполняется индивидуальная обработка каждого кадра в соответствии с предложенной ранее методикой бинаризации и сегментации, в результате чего образуются два класса образцов для испытания предлагемой процедуры классификации. Используется метод сравнения с эталоном с применением меры близости, основанной на структурных свойствах изображений.

На экспериментальном материале показано, что предложенная процедура классификации ДП дает приемлемые результаты (ошибка классификации в среднем составляет около 26%.).