Introducing Automatic Control Method of Speed Limit Signs Safety Standards before Horizontal Curves via Mobile Mapping System

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ABSTRACT

Provision of a safe situation in the road transport has a great importance and might require huge costs. To reach to a safe situation, general and specific information about road specification would be essential and provision of such information might require major costs. Mobile mapping can be addressed as a modern tool by which users (auditors) would be able to do inspection remotely via gathering various data and integration of related data. The main aim of such a research is to automate the required procedure, specially focusing on "allowable speed" signs at horizontal curves. Such automation saves time and money and increases the accuracy of audit via replacing the task of audit from human to machine. In the proposed methodology, two steps might be taken: while in the first phase the geographical data of the centerline will be gathered in the second phase image processing would take place to recognize whether there is a consistency between signs and geometric design of the curve. The data gathered through these two phases will be compared with thresholds addressed in road design manuals to check whether road meets standards or not. The accuracy of the proposed method for horizontal curves was proved to be 90% for the horizontal curve radius calculation and it was 97% for the beginning point of the horizontal curve determination. Besides application of support vector machine leads to 92% accuracy in identification of the signs and 97% accuracy in speed limit distinction.

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1- Introduction

To secure safe conditions for road transportation enjoys great importance and calls for high cost to control the unrestrained trend of road accidents. Safety is a fundamental element that the fruitfulness of road life depends on its unceasing presence. On the basis of the safety theory, the prerequisite for the improvement of road safety is to study the factors and their manner affecting safety [1]. Control of the safety standards and identification of the ring related to road in the chain of the accidents factors are one of the main goals of safety audit. Preventive method, founded on field observations; is the main method of identification based on the geometrical specifications of road and identification of its safety defects.

The researches done into the effect of geometrical design of road on accidents suggest that the presence of each sharp curve in every kilometer results in a 34-percent increase in the statistics of single-car accidents [2]. Additionally, the sharp curves are instrumental in the instability of drivers in positioning themselves on the passing line and in head-on collisions [3]. In general, accidents are usually severe on curves leading to different degrees of injuries. Therefore, curves can be considered as one of the vulnerable points of roads [4] which should continuously and accurately be protected and inspected. Speed limit signposts as the warning parameters are one of the most important factors to enhance the attention and concentration of drivers [5]; their presence before the curve also indicates the sharpness rate of the curve while inducing an appropriate understanding of the rate of the curve to the driver [6].

The requirement for the reduction of high-risk behavior and safe passage over the curve is in-time warning of the change of the linear path in order to predict the required preparations such as speed reduction at a safe distance before the curve and vehicle control [7]; reduction of speed over the length of the curve depends on the radius of the curve and the entrance speed over the curve [8]. The presence of signs and warnings such as speed limit signs in a clear and appropriate manner along the road and at a safe distance before the curve are of the most important factors for the law-abiding drivers in determining the speed over the curve [9].

Identification and distinction of the speed limit signs before the horizontal curves at two identification phases of the presence or absence of signs at suitable locations and distinction of the speed limit value on them also present a new trend in the area of image processing and the distinction of the pattern; at the stage of intelligent network training, a far less number of the initial sample is required and the distinction precision also improves compared with similar cases. The ultimate goal of this paper is to present a new method to be able to automatically control the safety standards related to speed limit signs before the horizontal curves in addition to the processing of the image data and analysis of the geographical coordinates of the road centerline points. In the direction of the above goal, rural undivided two-lane roads have been taken into consideration. The speed limit signs over these roads in Iran are both in Farsi and Latin fonts. It is worth mentioning that the signs and safety equipment such as speed limit signposts on the roads are always exposed to damages resulting from environmental unfavorable factors, collision of transit traffic, and social anomy. Therefore, continuous and regular auditing performed by MMS to control the appropriate functioning of their physical conditions is essential. By the use of the method proposed in this paper, it is possible to control the safety standards related to speed limit signposts before the horizontal curves automatically and report the existing defects to the operator.

2- Methodology

The control automatic method of the road safety standards over horizontal curves of the rural two-lane roads introduced in this article have two separate phases, in a manner that in one phase the data related to the geographical coordinates of the road centerline axis points are analyzed and the road geometrical specifications are evaluated. In the other phase, the recorded video images are processed and the value on the speed limit signs along with their presence or absence are distinguished in the frames. Ultimately, on the basis of the specifications of the components of the MMS, the situation of the road and the results obtained from the above two phases as well as the safety situation related to the speed limit signs before the horizontal curves are automatically studied. If the speed limit sign identified in the road image is positioned at the suitable distance before the curve according to the suitable value on it, the safety standard is approved; otherwise, appropriate message concerning the inappropriate value of speed limit on the sign or its wrong installation is reported to the

operator.

Based on the data analysis related to the coordinates of the centerline points of the road, the proposed method is capable of automatically determine the geometrical specifications of the horizontal curves including the radius and the starting point of the curve and control the safety standards related to the location and the value on the speed limit signposts. Calculations related to the solution of equations concerning the determination of horizontal curve location, radius, the speed corresponding to the radius, and the safety distance before the curve for the purpose of installing the speed limit signpost are done by MATLAB software. Ultimately, it is possible to automatically identify the safe distance before the curve and control the safety condition of the curve in relation to the speed limit signpost on the basis of the speed proportional to the curve radius and the traffic speed over its linear section (operational speed).

With regard to the goal upon which the system is defined, the speed limit signposts are classified into seven separate groups; these groups consist of speed limits of 30 to 90 kilometers per hour (speeds corresponding to the curves with radius less than 300 meters are less than 90 kilometers per hour). Extraction of suitable specification of numerals and their use as the input for the SVM in place of the numeral itself reduces the number of the samples required for training, leading to better results. In this study, the major concentration is on this group of speed limit signposts only because sharp curves with a radius of less than 300 meters are more accident black spots.

The capability of the first phase of the method proposed in this article, relative to other analysis programs and geometrical plan of the road is its automatic identification of the beginning point of the curves, determination of radius, calculation of the safe speed appropriate with the curve radius, automatic control of the safety codes of the curves, and ultimately; presentation of a safe distance before the beginning of the curve for the purpose of the installation of the speed limit signpost for the reduction of traffic speed and safe passage over the horizontal curve. This automatic process is able to have acceptable functioning in the area of the evaluation of the safety condition of speed limit signposts before the horizontal curves with no need for costly local mapping operations and also with no need for the time-consuming manual calculations

to determine the geometrical specifications of the curves.

On the basis of what mentioned in introduction, many studies have been performed in the area of traffic sign processing so far, but by the use of SVM method proposed in this article and application of the features of the numerals on the signs (instead of the use of the whole sign) as the input for the intelligent network, the number of the initial samples for training the intelligent network has decreased relative to other image processing methods and acceptable precision in the area of image processing is obtained. Furthermore, the results obtained from the image processing phase in the method proposed in this article have been used in combination with the results obtained from the data analysis phase related to the coordinates of the centerline axis points and the efficiency of the results obtained from the processing of the image data recorded by the camcorders installed on the MMS vehicle has been proved in the area of automatic evaluation of the safety condition of the speed limit signposts before horizontal curves. Accordingly, by the use of the automatic method proposed in this article, there is no need for the physical presence of experts to inspect the condition of the speed limit signposts on the road in person. It is only done by the use of the images recorded by the MMS providing the suitable background for this purpose.

3- Conclusions

The horizontal curves are more dangerous in comparison with other linear sections of the path. Accordingly, the study of the safety situation of the horizontal curves has always been one of the major concerns of the road engineers. By maintaining sufficient accuracy in the area of controlling the above-mentioned safety regulations, the proposed automatic method minimizes the need for an experienced person in order to detect black spots. On the basis of the results obtained from the application of the automatic method in controlling the safety standards related to speed limit signs before the horizontal curves in the first phase, a precision of 90% and 97% was respectively confirmed on the basis of the data analysis related to the coordinates of the road centerline axis points in determining the value of the curve radius and correct identification of the beginning point of the horizontal curves with a radius less than 150 meters. In the second phase and on the basis of processing the road video images the rate of

precision in the identification section was estimated to be 92% and in the distinction section it was 97%. The output results of the proposed method within the framework of the maps and comprehensible values in the area of the identification of the black spots can be useful for the road engineers and the designers. Of course, the ultimate goal is not only limited to detect the safety defects, but the required efforts should also be taken to find chances for the improvement of the safety of the road and the elimination of the black spots.

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