Traffic Signs Inventory System

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Abstract – The paper is focused on practical application of Cambridge Correlator. The goal is to propose a traffic signs inventory system by using excellent characteristics of correlator in the rapid optical correlation. The proposal of this inventory system includes obtaining of traffic signs to create the database either collecting the GPS coordinates. It is necessary to know the traffic signs position and also to document the entire surface route for later evaluation in offline mode.

Keywords – Traffic Signs, Inventory System, Optical Correlator, Color Model.

I. Introduction

Nowadays, high emphasis is put on safety in all sectors. The traffic sector is not an exception. The protection of passengers in a vehicle can be divided in to the passive and active. Passive protection includes safety belt or airbag, for instance. Active protection consists of systems that warn the driver of impending danger. It can be vehicles distance alarm, speeding alert, or warning of missing traffic sign.

The proposed system is designed to help solve last-mentioned problem. Brief description and history of traffic signs are in Chapter II. The shape and color of the signs are important factors in traffic sign recognition. Used color models are discussed in Chapter III. Chapter IV describes the proposal of traffic signs inventory system and hardware tools used in practical realization. That is an optical correlator designed at the University of Cambridge, a digital camera and a laptop. Chapter V is devoted to the program TSIS (Traffic Signs Inventory System) to check the vertical road signs. Results of TSIS experiments are discussed in Chapter VI. Conclusions of the proposed system are summarized in Chapter VII.

II. Traffic Signs

Traffic signs are the most important element of transport infrastructure today. They were evolved over time as the traffic grew. In the beginning there was only the need to indicate the directions at unclear crossroads, later also the distance to the certain objectives. Signs indicating the direction and distance, called milestones, were created already in the Roman Empire around 123 BC.

The largest shift in the road signs development was caused by development in cycling and then by the growth of automotive industry in the 19th century. First consolidation and standardization of the traffic signs was done successfully in 1908 at the meeting of the Permanent International Association of Road Congresses, PIARC, when 4 road signs were standardized. That was the birth of their present form. The most important milestones in the traffic signs development were years 1926 (Paris Convention), 1949 (Geneva Convention OSN, Protocol on Road Signs and Signals) and 1968 (Vienna Convention of European Economic Commission on Road Signs and Signals, OSN). The last mentioned, Vienna Convention from 1968 was the unifying standard that was accepted by most European and many other countries of the world. Overview of differences of some selected road signs is shown on Fig. 1.

In the picture we can seen how particular signs differ, mainly in the background, icons and shapes. For a comparison we can take typical American diamond-shaped warning signs with yellow background and European ones in the shape of a triangle. It is worth to say that significant number of American signs is using only text form instead of generally known traffic pictograms [1].

Fig. 1. Comparison of using traffic signs

III. Static Color Images and Models

Colorful static images (color image) are obtained by digitalization of an analog video signal color components. Transmission and processing of color images made it necessary to create color image models that allow decomposition of color images to components. Because the human retina contains three types of receptors for color perception, color image models include three components to describe the colors, which determine the position of the color in so-called colorimetric space. Colorimetric space is a mathematical representation o the human color perception. Most color models use three numerical components (coordinates) to describe the color. These components determine the position of a given color in colorimetric space. When working with colors it is necessary to solve two basic tasks:

- determine the set of basic colors,
- determine the method of mixing colors.

Color perception is a subjective characteristic of the human eye, and it is known the human individual is able to recognize four basic colors, that are red, green, blue and yellow. The result of mixing two or more colors can be various image of a new color for different people. In general, one can distinguish two basic approaches of color mixing, namely:

- additive mixing,
- subtractive mixing.

Additive color mixing is cumulative mixing, where the resultant color is gained by the instant incidence of two or more colored light beams on a white surface with a constant reflection factor for all color components.

Subtractive color mixing generates the resultant color by deduction certain color components from white light, thus alters the ratio of other components to white light. It is a differential color mixing that results in complementary colors to the additive colors with a regard to white [2].

Colorimetric spaces can be divided into:

- machine-dependent - the resulting color depends on the specific instrumentation and settings,
- machine-independent - produced color is always the same irrespective of where it is applied.

Color image models are characterized by a set of basic colors, sequences of mixing and rules determined for changes in color characteristics. Today there is a significant number of three-component color image models.

A. RGB color model

Three-component RGB color model (Red, Green, Blue) is the additive mixing color model based on the trichromatic theory. For these three basic colors of this model is characteristic the very thing that the human eye has the best sensitivity just for their wavelength. In the technical practice its normalized interval of values (0; 1) quantizes 8 bits what includes 256 brightness levels although for the human perception 100 levels would be sufficient. RGB color model is mostly presented as a unit cube placed in R, G, B coordinate system (Fig. 2).

Each component is usually represented by 8 bits, which means 24 bits per pixel and thus the total number of colors is 2^{24} [2].

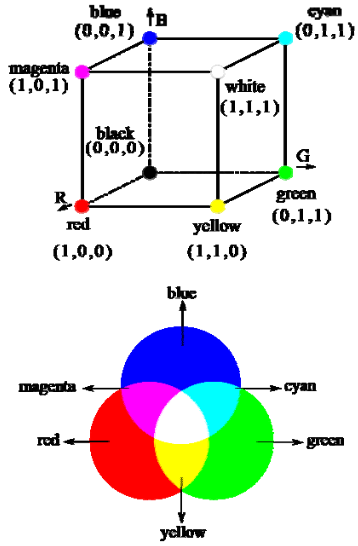

Fig. 2. Color model RGB

B. CMY color model

In the three-component CMY color model (Cyan, Magenta, Yellow) the colors are created by subtractive color mixing. For colors in this color model it is typical to respect the human empirism of mixing colors by artists based just on subtractive color mixing. Therefore is this method more natural and used in the printing industry for reproduction of color images. The resulting color image is obtained by simultaneous printing of three images on the basis of particular components.

In practice is used also four-component representation of color model. CMYK is obtained by adding the color component K (blacK) to the original CMY model. CMY color model is the most common represented as the unit cube situated on the axes C, M, Y (Fig. 3).

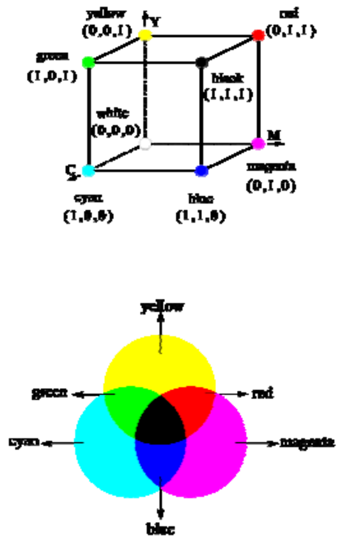

Fig. 3. Color model CMY

C. HSV color model

Three-component HSV color model (Hue, Saturation, Value) also known as HSB (Hue, Saturation, Brightness) was developed for computer graphics applications to analyse digital images. Both of these color systems are derived from RGB model, therefore they are conditioned by color space created from the RGB cube, while HSV can be also graphically represented as color cone.

In the case of change the hue component values in the range (0,1), corresponding colors vary from red, through yellow, green, cyan, blue, purple and then back to red. Its value is given as a position, or also as a particular degree of rotation on the spectral color cone (0° to 360°), which is shown in Fig. 4.

Saturation or admixture of other color, sometimes also referred to chroma, color purity, represents the ratio of the number of gray to color shade and is given as a percentage between 0% (gray) and 100% (fully saturated color). Saturation increases from the center to the edge on the spectral color cone.

If the value or also brightness changes interval (0,1) the corresponding colors become brighter, resp. darker. Brightness expresses how much light the color reflects so it indicates the number of added black in the ground color [2].

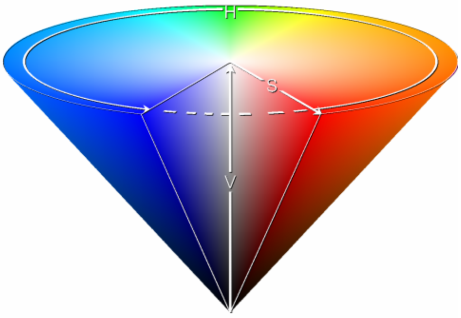

Fig. 4. Color model HSV

IV. SYSTEM DESIGN

The basic idea of the proposal is shown in Fig. 5.

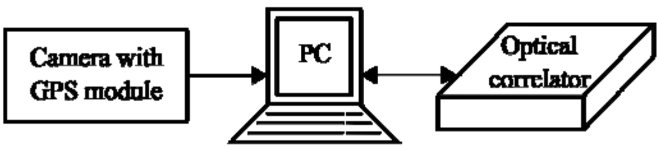

Fig. 5. Hardware implementation

To create a traffic signs inventory it is necessary to make a video record of the selected part of the road. The GPS (Global Positioning System) coordinates corresponding to selected path must be obtained periodically in very small intervals and simultaneously with the video recording. In addition, we have to obtain also the GPS of every traffic signs along the route. All the data are processed by computer and for comparison and control of traffic signs the CC is used. To check and control the vertical traffic signs in off-line mode, video and GPS coordinates data of the road must be started. During the video playback the coordinates alter and at the same time they are compared with the data of traffic signs GPS coordinates. When a coincidence occurs between the positions obtained from the road and those of particular traffic signs, TSIS program takes a snapshot of the video and seeks for estimated traffic sign according to database. If the sign is recognized program shows the reference road sign following the traffic signs standard [6] and the sign found in the video. Accurate and more detailed proposal of the whole concept process is shown in Fig. 6.

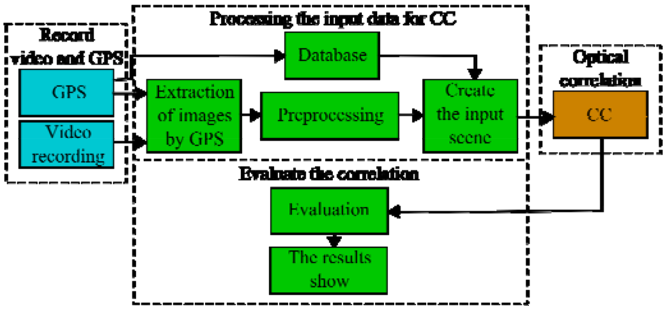

Fig. 6. Block diagram TSIS

A. An optical correlator

An optical correlator identifies the content of the image by combining the incoming image with a reference image to determine the correlation intensity with the intensity of the light beam output. The optical correlators perform complex recognition faster than previously known digital techniques. They are able to process large quantity of data from the data stream and are useful in the detection, acquisition and classification of the information requested. They are used in many optical signal processing applications [3, 4].

Implementation of an optical interconnection in hybrid optoelectronic parallel computers is using technology of artificial neural network. Correlators are usually occurred in optical communication systems for signal detection. Data is transmitted over a light carrier, whose frequency and wave increase with the gradual development of technology. Optical correlators implement the technology used spatially modulated light (SLM).

Since the implementation of the optical correlator concept it is regarded as very useful especially in tracking techniques and military applications. Such applications are interesting because of their in-the-real-time image processing characteristics. With the implementation of this technology in to the commercial environment, the general view of this issue has changed. In spite of that applications are still more oriented on the industry. There is no doubt that the years of research invested in filters and algorithms will be reflected in the benefit of industrial as well as commercial applications. In our solution was implemented the optical correlator CC created by the Department of Engineering at Cambridge University. This correlator uses Joint Transform Correlator (JTC) [5, 6, 7].

B. Camera

The device contains two lenses. Front lens captures situation before the vehicle and the rear lens captures car interior. Wide angle of view provides enough space for retrospective image analysis. The front lens of the camera can still move vertically, so there is no problem to set the shooting area as required. The technical parameters and equipment are following (Table I):

TABLE I. TECHNICAL SPECIFICATIONS OF CAMERA

LCD display size	2.7” (16:9)
Front lens	140º angle camera shooting (exterior)
Back lens	120º angle camera shooting (interior)
Video format	AVI
Memory	MicroSD card up to 32GB
Microphone	built-in
TV - output	NTSC/PAL
DC access	DC 5V
GPS	connectable antenna
frame rate	30 frame/s

Fig. 7. Implementation in vehicle

C. Laptop

All processes associated with processing and video programming of TSIS were performed on laptop Lenovo Z580. The technical specifications are following (Table II):

TABLE II. TECHNICAL SPECIFICATIONS OF LAPTOP

Processor	Intel Core i5-3210m (2,5GH)
RAM	4GB
Graphics card	NVidia GeForce GT630M

V. TRAFFIC SIGN INVENTORY SYSTEM – TSIS

Program for inventory of vertical traffic signs is written in Visual Studio 2008 in language C#. Language C# was selected because the software CC is also written in it.

At the beginning it was necessary to select a section of the road, pass it, make a documentation on it - it means shoot a video, gather position signs on the route and record all the way to the GPS coordinates [8, 9].

After recording a video and collecting all the necessary data, the data were saved to the database via a graphical user interface. The proposed database contains reference traffic signs and to them GPS coordinates of selected road signs are assigned. While recording the video, GPS module in camera simultaneously created a KML text file where coordinates of the current location were stored in the specific time interval.

In the case of conformity of the coordinates of the KLM file and database program TSIS the image was taken from a video. Then an input scene for CC was created, which is composed of the reference signs according to the Decree of the Ministry of Interior of the Slovak Republic [10] and the processed scenes with brand search. The whole process described above is in the Fig. 8.

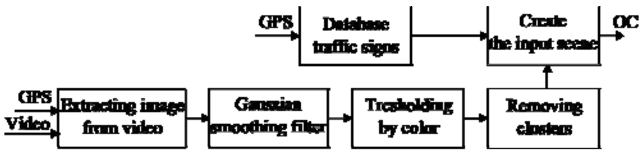

Fig. 8. Block diagram of the processing of input data for CC

The user interface has three main windows through which data are processed.

The first window - "Load information" is used to store information collected while driving a vehicle (Fig. 9).

The second window "Watching road" - is surrounding for choosing the road and connecting attributes of KML file to video. In this window you check the control of signs. In the right hand side program displays reference traffic signs and extracted signs from the video. In the Fig. 10 you can see a preview of the functioning of TSIS.

The third window "Settings" allows to select the source data. It is more accurate way to coordinate database of traffic signs and reference signs (Fig. 11).

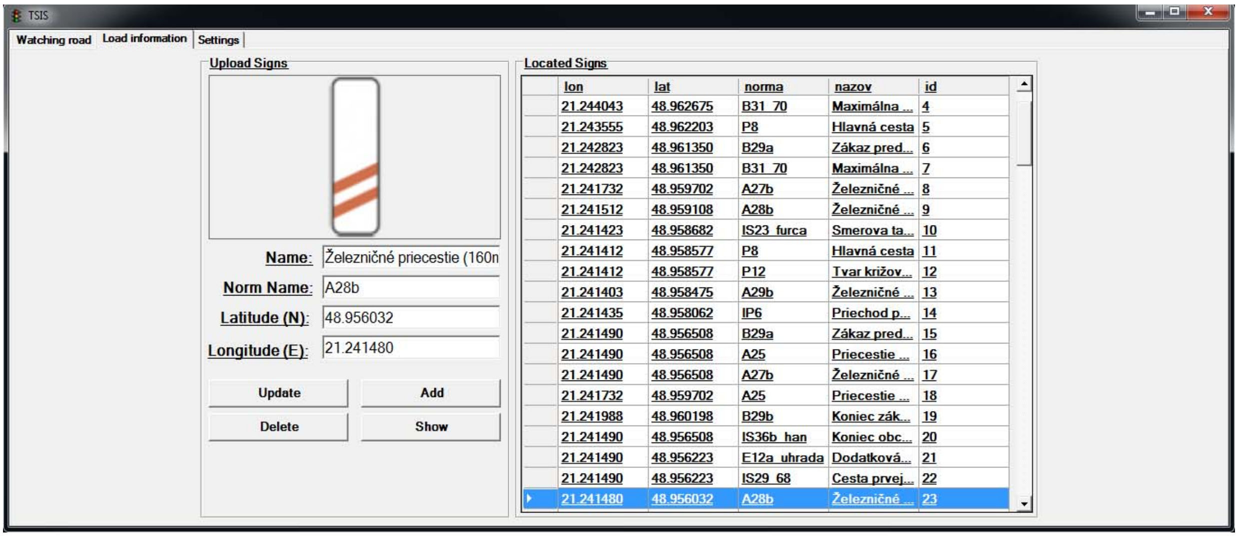

Fig. 9. Program TSIS – segment Load Information

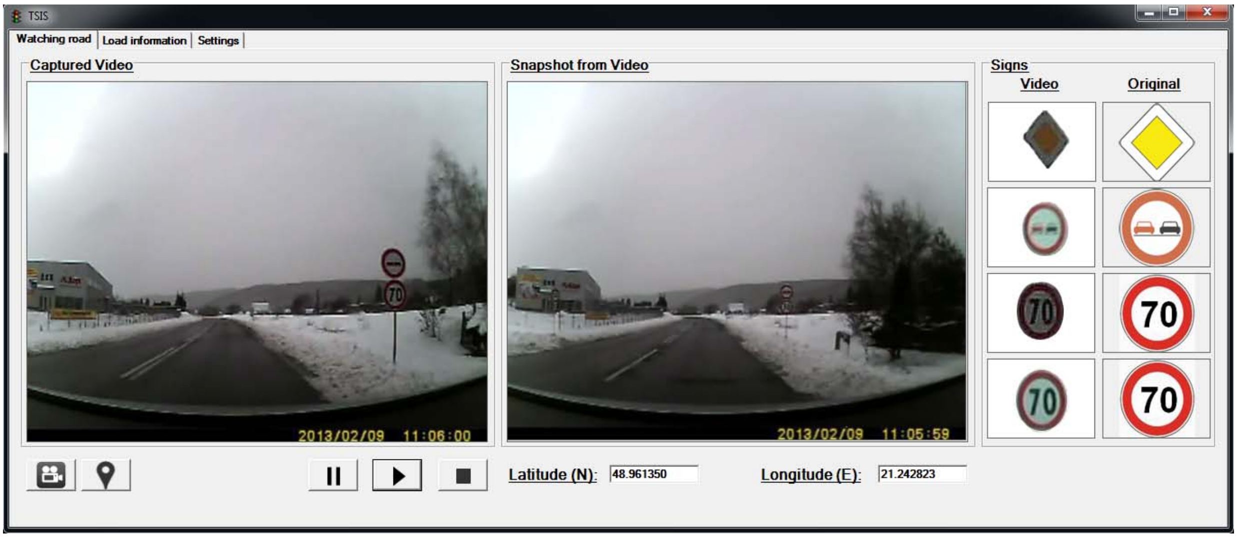

Fig. 10. Program TSIS – segment Watching road

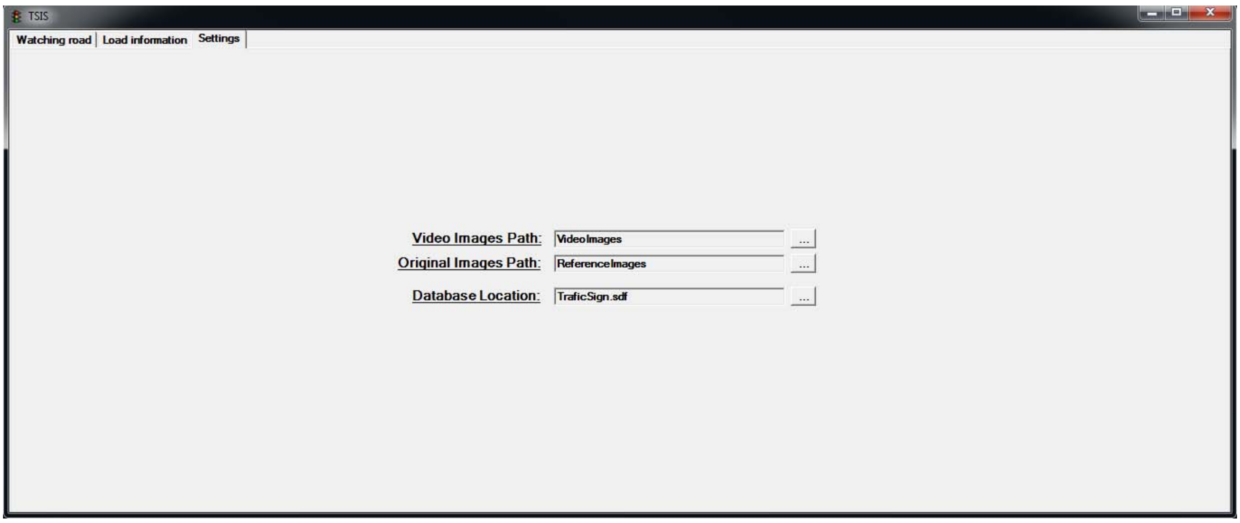

Fig. 11. Program TSIS – segment Settings

VI. Experiments

Path between the villages Haniska and Kandice was chosen as experimental stretch. Selected path included 38 different traffic signs. The total number of signs was 63.

Selected road section was controlled by TSIS. On a controlled path was detected missing sign. System pointed to the situation as follows (Fig. 12). Traffic sign indicating a railway crossing at a distance of 80 meters was missing in its original location. TSIS in segment Signs indicated only reference sign, because in input scene the searching sign was not found. The normal output of locating the wanted sign is shown in Fig. 10.

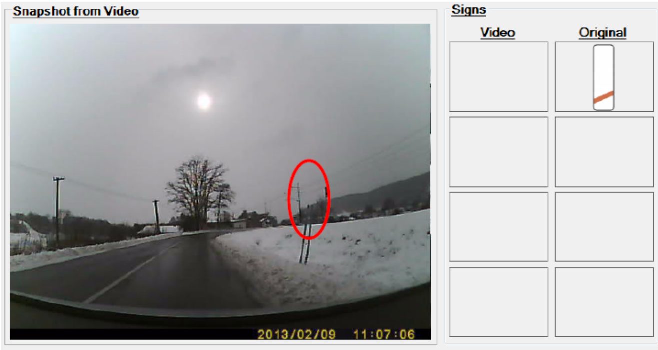

Fig. 12. Program TSIS – missing sign

VII. Conclusion

During the inspection of vertical traffic signs this inventory system has managed to uncover the missing sign. It demonstrated the practical application of the proposed system. In the future the system could be applied for example in vehicles of transport inspectorate, and inspectorate of road control. Checking traffic signs has a very important role, as part of prevention against accidents. The case of missing label can lead to catastrophic consequences, such as destruction of property, or death.

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Biographies

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