

A Validation tool for Traffic Signs Recognition systems

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Abstract—During the last few years many Advanced Driver Assistant Systems have been developed and a larger number of new car models every year is going to be equipped with these systems. However the product/function scenario lacks of common evaluation methodologies and tools for testing and improving performances of these systems. In this paper a validation methodology and a tool for Traffic Sign Recognition Systems evaluation (TSRs) is described.

Keywords: traffic sign recognition, performance evaluation, automatic report generator.

I. INTRODUCTION

Traffic Sign Recognition (TSR) as Advanced Driver Assistance System (ADAS) helps the driver detecting and classifying traffic signs that define dangers and limitations on roads.

TSR systems can be distinguished in systems working on a traffic sign specific subset (e.g. speed limitation signs) [1], [2] and systems working on almost the complete set of signs ([3], [4], [5], [6], [7] the last two related with Italian and Spanish traffic signs).

Even if the research community is very active on the topic of TSR, no wide accepted evaluation methodologies and tools have been developed yet. Sometimes the performance analysis are computed related to a specific TSR system under test which strongly biases the method [8].

Another item to be considered is the errors rising from the subjective evaluations.

This paper will explain how the proposed tool (Validation tool for Traffic Sign Recognition system - VTSR) can be used for an objective evaluation of the TSR performances. One of the most important feature of the proposed system is the high flexibility: it can be used for all TSR, either grayscale or color camera based and can be customized to cope with the sign database of every country.

The paper is structured as follows: in Section II the hardware and software architecture of VTSR is explained. In Section III how to manage real application is described; In Section IV

some formulas about the statistics used are given. In Section V the tool's performances are proposed in terms of timing parameters. In Section VI the next steps of VTSR development are depicted. Finally, in Section VII summary and conclusions are provided.

II. VTSR DESCRIPTION

To have an objective performance measures of traffic sign recognition systems, a methodology and a proper hardware / software have been studied and deployed.

The architecture has been thought to have high flexibility and to avoid interferences with the TSR system under test as shown in Fig.1.

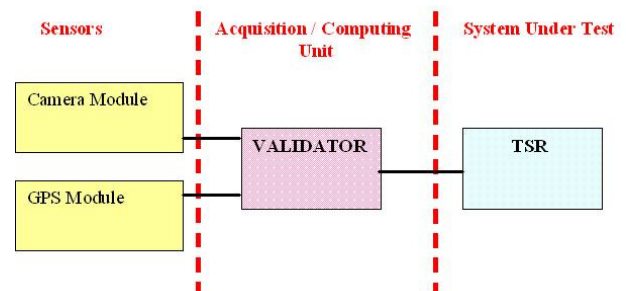


Fig.1. Block Schematic of the VTSR Hardware Architecture

The hardware structure is composed by:

- a color camera module (e.g. a webcam) to monitor the road and the traffic signs encountered;
- a GPS module to record the position of the signs;
- a PC based system to get and process the information coming from the camera module and the other serial interfaces (using transceivers, CAN cards, etc...).

system; in the DC tool a link between the video stream coming from camera and the data coming from the TSR under test (available for example through a serial CAN interface) is present.

As shown in Fig.5, in a periodic task a single frame is captured and named with an up counting name: this is the common data time frame at which the TSR result data are referred to and data buffers is emptied.

All these information are reorganized following this logical structure in a specific file. This will guarantee the correct synchronization and storage of all the information coming from systems and devices.

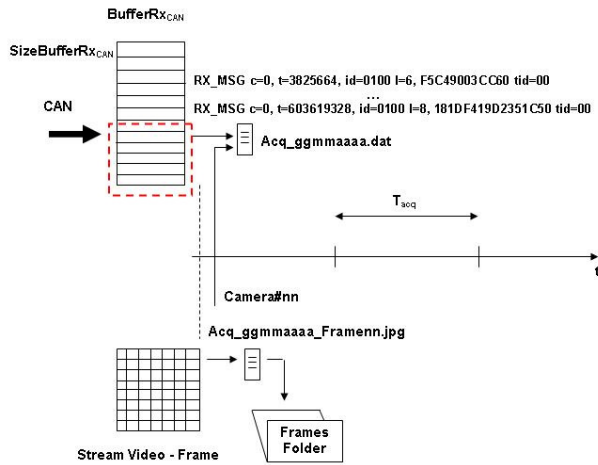


Fig.5. Synchronous data capture – camera video and CAN busses

A first embodiment of the tool interface is shown in Fig.6. It is easy and user friendly and allows to monitor current activity status of the TSR system under test.

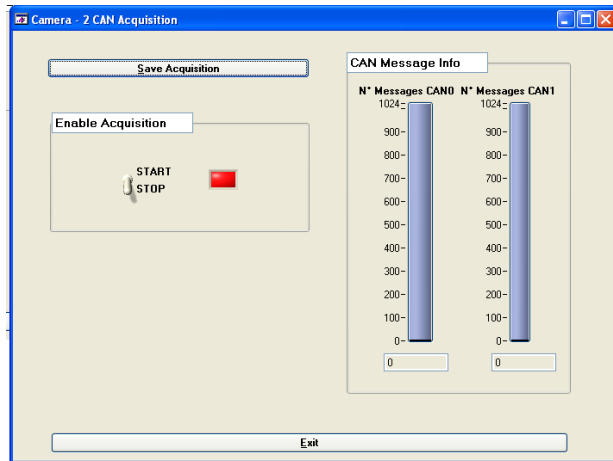


Fig.6. Data Capture Tool Interface

In order to identify each TSR system a specific ID is assigned..

2.A Performance Analyzer Tool

The PA Tool uses the information coming from the tools used in the previous steps (MTSR and DC tools) to show to the user the scenario captured in order to analyze it.

Unlike from the work of Schneiders [8], a more complete classification of the traffic signs status has been defined and it is summarized in Table 1.

TABLE1 ATTRIBUTES AND CLASSIFICATION OF THE TRAFFIC SIGNS

<i>Hidden</i>	<i>Not Hidden</i>	
	<i>Not Temporary</i>	<i>Temporary</i>
	<ul style="list-style-type: none"> • TRUE • MISSING • FALSE - MISMATCH - NO SIGN 	<ul style="list-style-type: none"> • TRUE • MISSING • FALSE - MISMATCH - NO SIGN

The target is to classify all the road signs in clusters like the ones listed in Tab.1. Due to the experience coming from TSR system developing and testing activities, the classification reported could be considered exhaustive and cover all the real situations.

Here follows a brief description of the classification attributes:

- *True*: sign is present and TSR detects it correctly;
- *Missing*: sign is present and the TSR system doesn't detect it;
- *False mismatch*: the sign is confused with an other;
- *False no sign*: a sign not present in the scene is detected;

These sign topologies can be classified as:

- *Not Temporary*: the sign is fixed;
- *Temporary*: the sign is mobile.

Finally, a further hierarchical classification is *Not Hidden* or *Hidden*. A sign is defined Hidden if it is completely hidden by something.

The user is supported in the validation of the TSR system by an interface (shown in Fig.7) that allows a presentation of the scene, of the collected data and of the validation data.

The user can compare both real situation and TSR results using the different sections of the interface, that are:

- Real sign: shows the next road sign (database);
- Detected sign: shows the results of TSR system under test;
- File Report: allows to manage the analysis and the automatic report generation file;
- Validation status of sign: allows to define the status of the signs detected;

- Video acquisition: shows the real scene captured;

Video control: offers the possibility to have a control on the video and the related data information, more this control allows to go in the significant points (frame) where the signs has been detected by the TSR system.

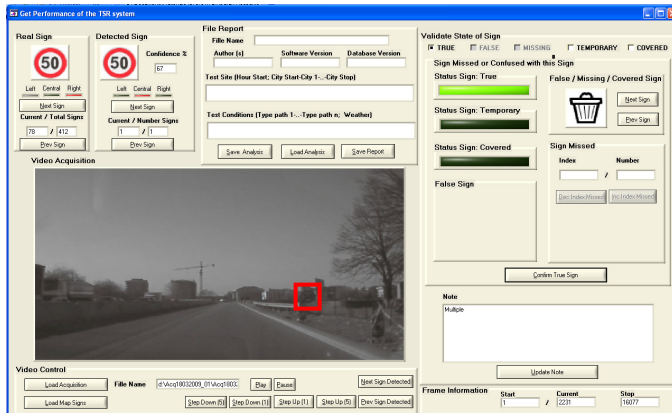


Fig.7. Performance Analyzer Tool Interface

In case of false, missing or hidden sign, it is possible to define the mismatch sign or the real sign not recognized using the *Validate Status of Sign* section. Another field that allows the user to indicate both comments and take care of special cases (using one of the keywords of Table 2) is the field named *Note*.

Using one of this keyword it is possible to build up specific statistic on the special cases that could occur.

TABLE 2 THE KEYWORD FOR THE NOTE FIELD

Keyword	Meaning
Multiple	Multiple signalization on the same sign.
True Multiple (#n False)	Multiple signalization on the True same sign but #n notices are false.
Little Sign	A sign smaller than standard dimension
Truck	The TSR system has detected a speed limit on the tail of a Truck.
Tail Light	A false positive has been detected. The TSR system has recognized a tail light as a sign.
Vehicle	A false positive has been detected. The TSR system has recognized a part of a vehicle as a sign.
Thing	A false positive has been detected. The TSR system has recognized a thing different to a car or a speed sign on the tail of a truck as a sign.

This tool offers also high versatility, allowing to stop and restart the analysis using the save and load functions.

Furthermore the user can add his own keywords in order to have customized simplified statistic and report.

2.B Automatic Reports Generator Tool

The Automatic Report Generator Tool computes the generic and the specific statistics and produces the report files as follows:

- Generic Statistics on the *Not Temporary* and *Not Hidden Signs*;
- Specific Statistics on different topologies such as *Temporary* or *Not Temporary - Hidden* or *Not Hidden Sign*, *Multiple Sign*, *FALSE No Sign* and *Little Sign*.

An important feature of the tool is the automatic generation of report files, in DOC format. In case of *not hidden* and *not temporary* signs also single sign specific statistics are generated (see Fig.8 and 9).

Symbol Sign	Code Identification
	305

Sign Occurrences	True	False (Mismatch) 2 ID= 301 (2)	False (No sign) 0	Missing 4
21	15	2	0	4
Percentage (%)	71.43	9.50	---	19.07

Fig.8. Example of the Statistic Table with the left dangerous curve

Symbol Sign	Code Identification
	349

Sign Occurrences	True	False (Mismatch) 0	False (No sign) 1	Missing 3
8	5	0	1	3
Percentage (%)	62.50	0.00	12.50	37.50

Fig.9. Example of the Statistic Table with the left dangerous intersection

If a false mismatch happens the report gives the information about the specific sign by which the mismatch occurs (Fig.8).

III. APPLICATION

One of the main purposes followed in the development of the VTSR has been the capability to cope with a plurality of TSR systems.

We have tested the VTSR by evaluating simultaneously two different TSR systems. The first one is a color camera based [6], traffic sign recognition system developed by Magneti Marelli & Vislab (University of Parma), while the second one is a greyscale camera based system.

The two TSR systems have different outputs, the first one a serial RS232, the other one a CAN bus interface. The two systems work with reference to different cluster of signs.

The VTSR overcomes these issues.

Concerning communication interfaces, a dongle CAN RS232 converter to adapt a serial RS232 output to CAN bus is used, as shown in Fig.11.

As far as regard cluster of signs in VTSR it is possible to choose among different traffic sign database.

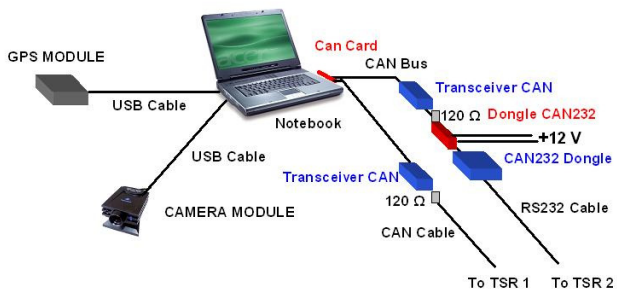


Fig.11. Hardware architecture

IV. STATISTICS: FORMULAS

Here are shown the most significant formulas used to define the statistics.

For example, the rate of the *not hidden and not temporary* signs R_{NC_NT} is calculated as in (1), with $N_{True_NC_NT}$ the number of the *true not hidden and not temporary* signs, $N_{FalseMISM_NC_NT}$ the number of the *false mismatch not covered no temporary* signs, $N_{MISS_NC_NT}$ the number of the *missing not hidden not temporary* and $N_{TotSigns}$ the number of the total signs presented on the chosen route.

$$R_{NC_NT} = \frac{N_{True_NC_NT} + N_{FalseMISM_NC_NT} + N_{MISS_NC_NT}}{N_{TotSigns}} \quad (1)$$

The rate of the *true not hidden and not temporary* signs $R_{True_NC_NT}$ is expressed as in (2), with $N_{True_NC_NT}$ the number of the *true not hidden and not temporary* signs and $N_{Tot_NC_NT_Signs}$ the number of the total signs *not covered and not temporary* presented on the chosen route.

$$R_{True_NC_NT} = \frac{N_{True_NC_NT}}{N_{Tot_NC_NT_Signs}} \quad (2)$$

The rate of the *false mismatch not hidden and not temporary* signs $R_{FalseMism_NC_NT}$ is expressed as in (3), with $N_{FalseMism_NC_NT}$ the number of the *false mismatch not hidden and not temporary* signs and $N_{Tot_NC_NT_Signs}$ the number of the total signs *not hidden and not temporary* reported on the chosen route.

$$R_{FalseMism_NC_NT} = \frac{N_{FalseMism_NC_NT}}{N_{Tot_NC_NT_Signs}} \quad (3)$$

The false no sign *not hidden and not temporary* signs don't have any rate, but is only represented by the absolute value $N_{FalseNoSign_NC_NT}$ because this parameter depends to the type of road, to the cars on the route, to the light conditions, ...

The rate of the missing sign *not hidden and not temporary* signs $R_{Missing_NC_NT}$ is expressed in formula (4), with $N_{Missing_NT}$ the number of the false not sign not temporary signs and $N_{Tot_NC_NT_Signs}$ the number of the total signs *not hidden and not temporary* presented on the chosen route.

$$R_{Missing_NC_NT} = \frac{N_{Missing_NT}}{N_{Tot_NC_NT_Signs}} \quad (4)$$

V. TOOL PERFORMANCES

The tool proposed offers high performances in terms of flexibility to validate any Traffic Sign Recognition System. Furthermore, thanks to lot of details (see Table 1 and 2) the VTSR can be used as support for developing new TSRs. The solution compared to other equivalent systems reduces both the evaluation time and reporting time as shown in Table 3.

TABLE 3 TIMINGS: MAP ROAD WITH 412 TRAFFIC SIGNS

Activities	Timings
Evaluation	10 h based on 1 h Acquisition
Analisis & Reporting	20 min (*)

(*) TSR's database composed by 133 Road Sign

An other advantage is the possibility to acquire lot of TSR systems without increasing the acquisition time.

VI. FUTURE WORKS

An analysis based on the GPS parameters (Latitude, Longitude, Altitude) will be implemented, in order to speed up the evaluation work.

Generation of new statistics based on further keywords inserted by the user to identify significant attributes of signs or events (e.g. over / under light environment) will be developed.

VII. SUMMARY AND CONCLUSION

In this paper VTSR, an easy to use and high flexible validation system tool for TSR, has been presented. The tool proposed offers high accuracy in statistics computation and a significant reduction of the analysis time. VTSR has been used to evaluate two different TSR systems, a color camera based system and a greyscale camera based system. The use of VTSR has been useful both to identify specific development issues and to measure performances.

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REFERENCES

- [1] L. M. Eichner and T. P. Breckon, "Integrated Speed Limit Detection and Recognition from Real-Time Video", In Proc. IEEE Intelligent Vehicle Symposium, Eindhoven, The Netherlands, June 4-6 2008.
- [2] C. G. Keller, C. Sprunk, C. Bahlmann, J. Giebel and G. Barattoff, "Real-time Recognition of U.S. Speed Signs", In Proc. IEEE Intelligent Vehicle Symposium, Eindhoven, The Netherlands, June 4-6 2008.
- [3] L. Priebe, V. Rehrmann, R. Schian and R. Lakmann, "Traffic Sign Recognition Based on Color Image Evaluation", In Proc. IEEE Intelligent Vehicle Symposium, Tokyo, Japan, 1993, pp. 95-100.
- [4] R. Janssens, W. Ritter, F. Stein and S. Ott, "Hybrid Approach for Traffic Sign Recognition", In Proc. IEEE Intelligent Vehicle Symposium, Tokyo, Japan, 1993, pp. 390-395.
- [5] C. G. Keller, C. Sprunk, C. Bahlmann, J. Giebel and G. Barattoff, "Real-time Recognition of U.S. Speed Signs", IEEE Intelligent Vehicle Symposium Eindhoven University of Technology, Netherlands, Eindhoven, June 4-6, 2008.
- [6] A. Broggi, P. Cerri, P. Medici, P. Porta and G. Ghisio "Real Time Road Signs Recognition", In Proc. IEEE Intelligent Vehicle Symposium, Istanbul, Turkey, June 2007, pp.981-986.
- [7] A. Escalera, J. M. Armingol, J. M. Pastor and F. J. Rodriguez, "Visual Sign Information Extraction and Identification by Deformable Model for Intelligent Vehicles", IEEE Transactions on Intelligent Transportation system, Vol. 5 No. 2, June 2004.
- [8] S. M. Schneiders, C. Nunn, M. Meuter, "Performance Evaluation of Real Time Traffic Sign Recognition System", Wuppertal, Germany.
- [9] NMEA protocol: <http://www.nmea.org/>