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**ACTRIS brings its expertise in a new approach  
to improve knowledge and quality of topological  
and regulatory data dedicated to road,  
for OPTICITIES project needs**

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**Abstract**

In this paper, we propose and validate a new system used to explore road assets. In this work we are interested on the vertical road signs as well as road marking features. To do this, we are based on the combination of road signs detection, recognition and identification using data provides by sensors. The proposed approach consists on using panoramic views provided by the innovative device, VIAPIX® [1], developed by our company ACTRIS [2]. We are based also on the optimized correlation technique for road signs recognition and identification on pictures. Precise extraction of road marking features is also a critical task. Based on inverse perspective mapping and color segmentation, the presented solution enables to examine images automatically, rapidly and also to get information on road marks, their surface conditions, and their geolocation. We illustrate this algorithm and its robustness by applying it to a variety of relevant scenarios.

**Keywords:**

Data acquisition, image processing, algorithm, correlation, road sign recognition, VIAPIX

## **Introduction**

Road sign recognition is a challenge which attract, since several years, the computer vision community either on the industrial [3] or academic research field. In fact, this interest on road sign recognition is justified by its utility in several applications. Among these applications, we quote road assets management, navigation assist and driver assistance system. All of these points of views meet interests and needs of the OPTICITIES R&D project.

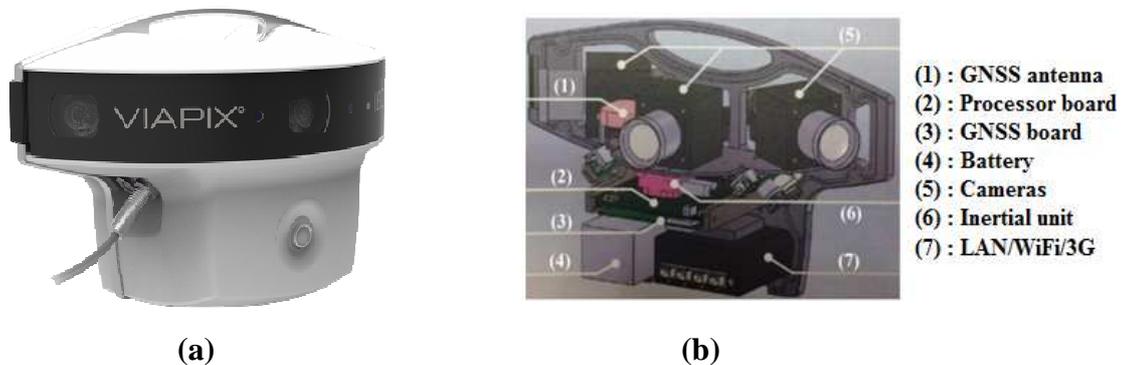
Several works have been proposed these last years for automatic road sign recognition according approaches divided into two parts, detection and recognition. All these approaches, treat either synthetic images ignoring brightness variations and the poor condition of road signs, or real images, but from a single camera which does not detect all existing signs on the road. Thus our approach presented in this paper consists on using optical correlation method in order to propose a numerical implementation for automatic road sign recognition. We are based on using panoramic images provided by VIAPIX® device. In fact, the choice of using these images is the possibility to have a 180° view of the scene which allows a more effective recognition.

On the other hand, the promise of augmented driver assistance and robotics technologies for tasks such as extraction of road marking and automatic lane finding features [18] is motivating the study of novel and optimized image processing techniques. The sensitivity of typical images to color lightning and shadow make achieving such objectives extremely challenging, and significant research efforts over the past two decades have focused on addressing these challenges. In this work, we consider a new approach for automatic detection of road marking. Our approach differs from existing work on road marking detection in two aspects. Firstly, to perform our analysis we develop a color segmentation algorithm and an adaptative thresholding method which allows lane and road marking detection. Secondly, we introduce a general and automatic recognition procedure that is relevant to search within an image which is the most appropriate zone containing several juxtaposed bright objects.

Before describing our approaches and its performances, we first introduce the principle and the architecture of VIAPIX® solution. Then, we present features and an example of panoramic image provided by this device. In the last sections, we detail the proposed approach for detection and recognition of vertical road signs and road marking applied to panoramic images and we present obtained results.

## Data acquisition system

VIAPIX<sup>®</sup> is a vehicle-borne image-base mapping system designed for real-time image geo-referencing. A miniature inertial sensor directly merges inertial data with GNSS and odometer information to optimize performance. It consists in two modules, namely VIAPIX<sup>®</sup> Acquisition and VIAPIX<sup>®</sup> Exploitation. We refer the reader to Refs. [1-2] for more details. VIAPIX<sup>®</sup> Acquisition combines a high-resolution panoramic imaging system with an accurate geo-referencing solution, based on the global navigation satellite system, inertial measurement unit, and desktop management interface. VIAPIX<sup>®</sup> Acquisition gets 6 MPixel panoramic images over 180°. The panoramic picture enables to collect data from the entire road pavement and also from road-side, but also to focus on region of interest (exclusion of the sky and clouds). Figure 1 below shows the 3D simulation VIAPIX<sup>®</sup> Acquisition module with its architecture:



**Figure 1 - (a) VIAPIX<sup>®</sup> Acquisition module, (b) Architecture.**

Currently used by road engineering companies and road managers, VIAPIX<sup>®</sup> enables to reference, inventory and measure road assets in order to produce data for GIS (Geographic Information System). Composed of its innovative acquisition device, VIAPIX<sup>®</sup> Acquisition and its powerful processing software, VIAPIX<sup>®</sup> Exploitation, VIAPIX<sup>®</sup> is the essential solution for road network management.

VIAPIX<sup>®</sup> Acquisition is controlled and configured via a software interface WEB 2.0. Once the computer (PC or tablet) is connected by WiFi or RJ45, the user has a real-time feedback: images, position, control indicators.

In this system, VIAPIX<sup>®</sup> Exploitation software (Figure 2) enables to build and update a linear referencing system (LRS), navigate from your office in your road network in an immersive street level view, measure any object directly from images, position and inventory road assets, and export tracks and objects in various file formats. For example, the user can easily click on milestones in the picture. VIAPIX<sup>®</sup> Exploitation automatically creates the LRS of the road whatever the survey direction (negative or positive). Once the LRS is generated, pictures and

data survey (cant, declivity, events, etc.) are geo-referenced by the software in the: LRS (curvilinear abscissa), or geographic coordinate (latitude, longitude and altitude). VIAPIX® Exploitation features an image access in single or panoramic view. Immersive panoramic enables an easy-to-use navigation in the road network. Because image and objects are linked with a map representation, users have access to acquisition conditions, geographic position and orientation of the image pickup system for each picture.



**Figure 2 - VIAPIX® Exploitation software.**

Figure 2 shows an illustration of the VIAPIX® Exploitation software. It allows to get road images in simple (2) or panoramic (3) view, to perform measurements (width, length, and depth) in the image (1), and build a network repository (4). Finally, after generating data from image, the software is used to export pictures, GPS tracks and inventoried objects in various formats.

### *Panoramic images*

The VIAPIX® Acquisition module is composed of three cameras arranged to cover an angle of view of 180°. Indeed, the images acquired by these cameras are combined “on the fly” by VIAPIX® Exploitation to produce panoramic images. An example of the images used for producing panoramic images is given in Figure 3.



(a)

(b)

(c)

**Figure 3 - Examples of images used to generate panoramic view.**

Based on the correspondence area between images and the lighting parameters of each camera, VIAPIX® Exploitation allows to provide a panoramic image as shown in Figure 4.



**Figure 4 - Panoramic view computed using images of 3 cameras.**

### **Automatic data extraction**

#### *Road signs recognition*

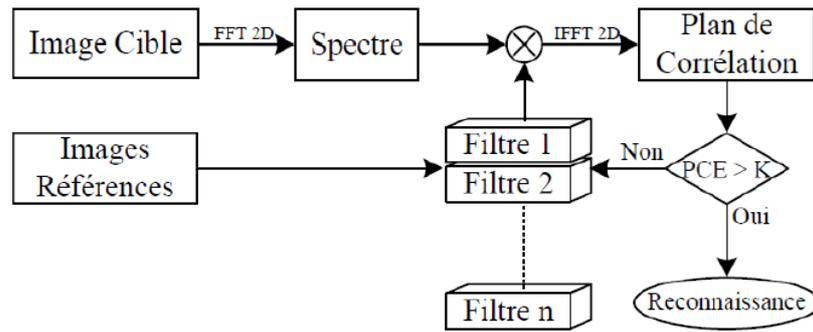
The proposed approach is composed of two steps, the detection and the recognition, computed in post-processing mode. Firstly, we research on images all objects which may correspond to road signs. Then, a correlation-based recognition technique is applied to these objects in order to recognize and identify road signs. The first step for the road sign identification consists on extracting all objects with the same features as road signs.

An example of color segmentation representation is given in Figure 5.



**Figure 5 - Color segmentation.**

After extracting the objects with the same features as road signs, it is necessary to validate this detection by a recognition step in order to identify road signs and remove all false detections. The technique we propose to use in this step is the correlation method. The choice of the correlation method is motivated by several reasons. In fact, correlation has a very good level of discrimination and can identify with near certainty, a target object [12-17]. Its principle consists of comparing a target image (to recognize) with one or more images references stored on a database (Figure 6).



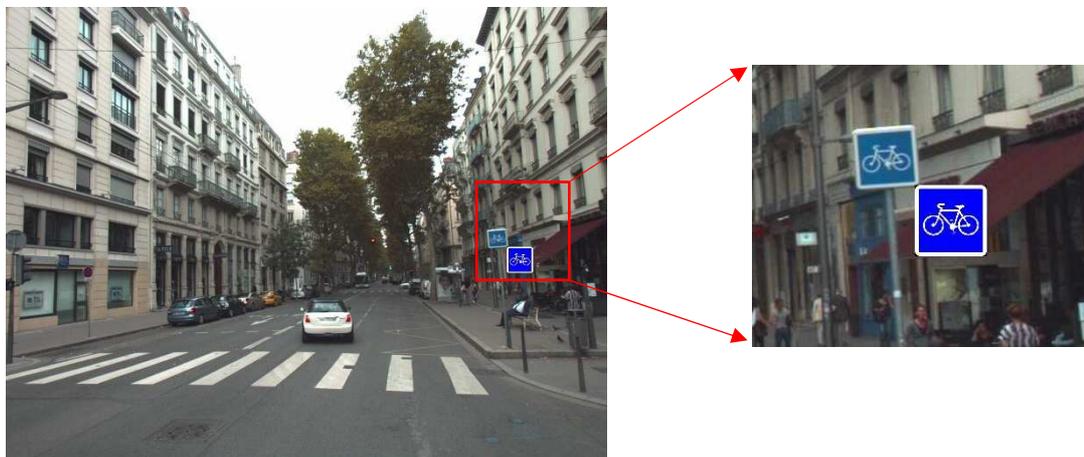
**Figure 6 - Correlation principle.**

In a first stage, a filter for each reference image of a road sign is manufactured in an offline way and stored in a database containing all filters. Then each detected object is compared with all references images and the maximum of obtained PCE (Peak to Correlation Energy) is returned. Finally this maximum is compared to a threshold set in advance. In the case where the maximum of PCE is higher than this threshold, the detected object is associated with the corresponding road sign. In the opposite case, the detected object is not considered as a road sign.

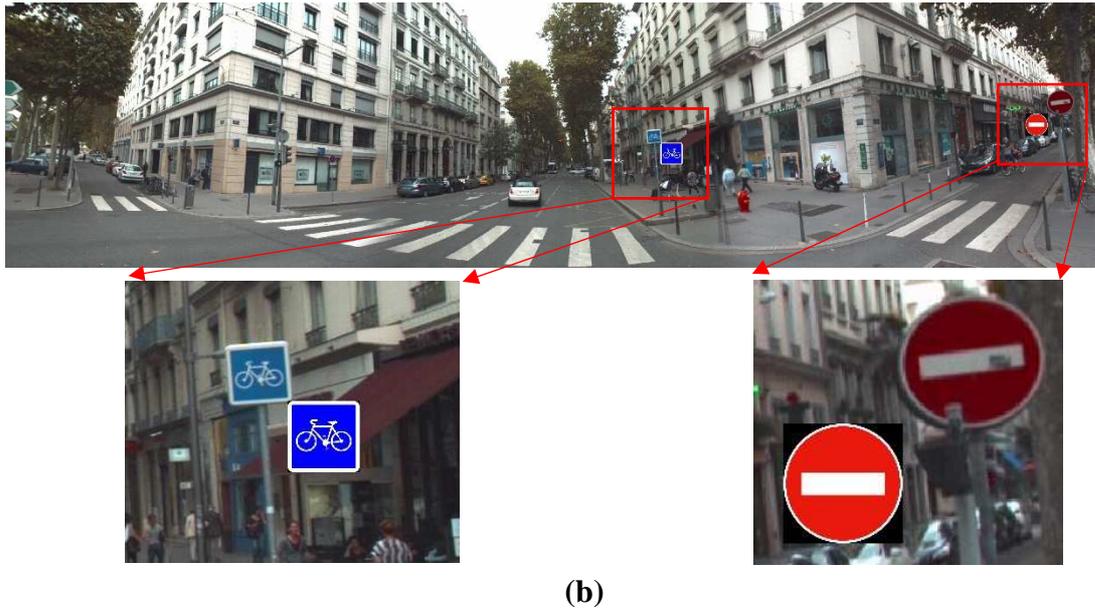
*Experimental results :*

To validate the proposed approach, several tests were performed on panoramic images and images from a single camera. These images were taken in Lyon France. VIAPIX® Acquisition device was installed on the roof of a vehicle and VIAPIX® Exploitation module used to provide panoramic images. The vehicle speed was between 30 km/h and 50 km/h. The images were acquired at an interval of one image per meter.

Obtained results have shown the effectiveness of the proposed approach and the advantage of using panoramic images instead of images from a single camera as shown in Figure 7.



**(a)**



**Figure 7 - Examples of vertical road signs recognitions.**

Figure 7 illustrates an example of detection and recognition of road signs by using in the first case (Figure. 7 (a)) an image from the central camera of VIAPIX® Acquisition device and in the second case (Figure. 7 (b)) a panoramic image. It is shown that by using panoramic images, it is possible to detect and recognize all existing road signs on the road unlike results obtained using the images acquired with a single camera.

During significant tests sessions, we obtained results below :

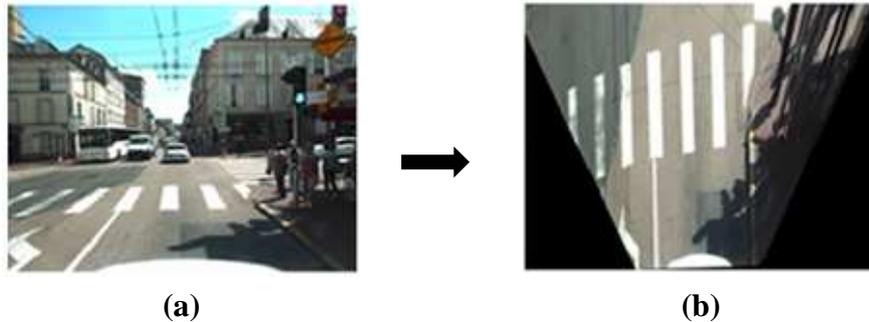
Automatic recognition : 85% | Semi automatic recognition (final operator decision) : 10%

No detection due to damaged signs : 0~5% | Assignment error (masked or damaged signs, lightning conditions) : 0~5%

### *Road marking detection*

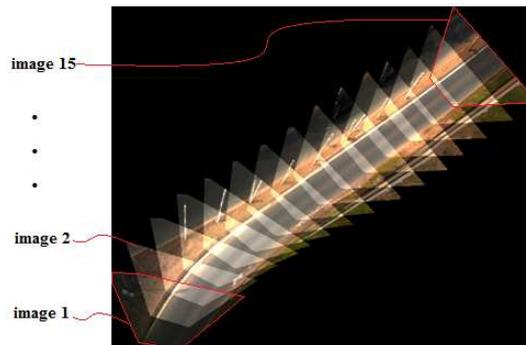
Over the past few years, several groups have considered the issue of lane detection and extraction of road marking features from various types of approaches. Our approach differs from existing works on road marking detection in two aspects. Firstly, to perform our analysis we develop a color segmentation algorithm and an adaptative thresholding method which allows lane and road marking detection. Secondly, we introduce a general and automatic recognition procedure that is relevant to search within an image which is the most appropriate zone containing several juxtaposed bright objects. As we discuss in more details below, the key advance required to carry out our experiment is the ability to directly and robustly position road markings in an image and in a map. Since road markings can be considered as bright-on-road objects that contrast against the road surface we provide our own scheme allowing detection of bright objects in image frames. As a concrete example, our demonstration is based on the pedestrian crossing.

The key for a good detection of road markings is to focus only a specific area of the target image, so we proceed by simplifying the image processing by making use of the perspective transformation. This, however, is not enough for a full criterion for detection, since the road color changes according lightning condition and shadow. Here, we propose a two-steps approach which consists in lane detection as first step and then road markings as second step.



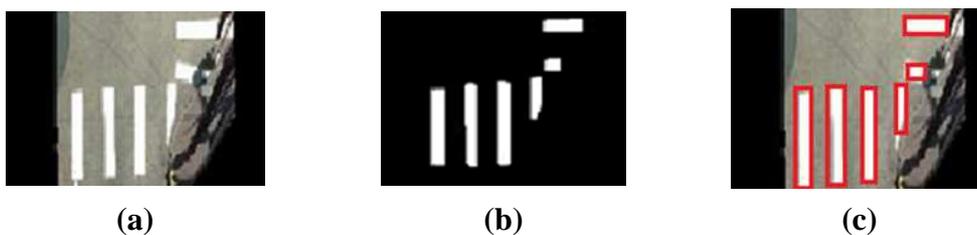
**Figure 8 - (a) Example of VIAPIX® video frame images (b) the transformed image.**

Once the original image is computed via an IPM [33], a thresholding operation is performed to detect the lane. Indeed, VIAPIX® allows to get the GPS coordinates and luminosity for each image. This previous step allows to merge images according to the knowledge of the car direction and GPS coordinates in order to generate an orthophoto, for extracting the lane.



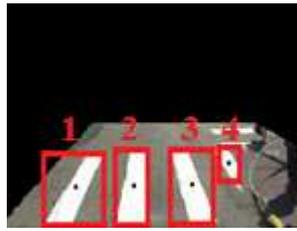
**Figure 9 - The orthophoto obtained by merged images.**

When the lane in front of the car is detected for each image, a segmentation is performed in order to detect the bright areas. To this end, an adaptative threshold is calculated basing on luminosity parameters provided by the VIAPIX® Acquisition module. Figure 10 demonstrates that our approach is able to detect road markings by performing segmentation on the image (Figure 10(a)). Next, mathematical morphology allows to detect the bright areas (Figure 10(b)). The final result is shown in Figure 10(c).



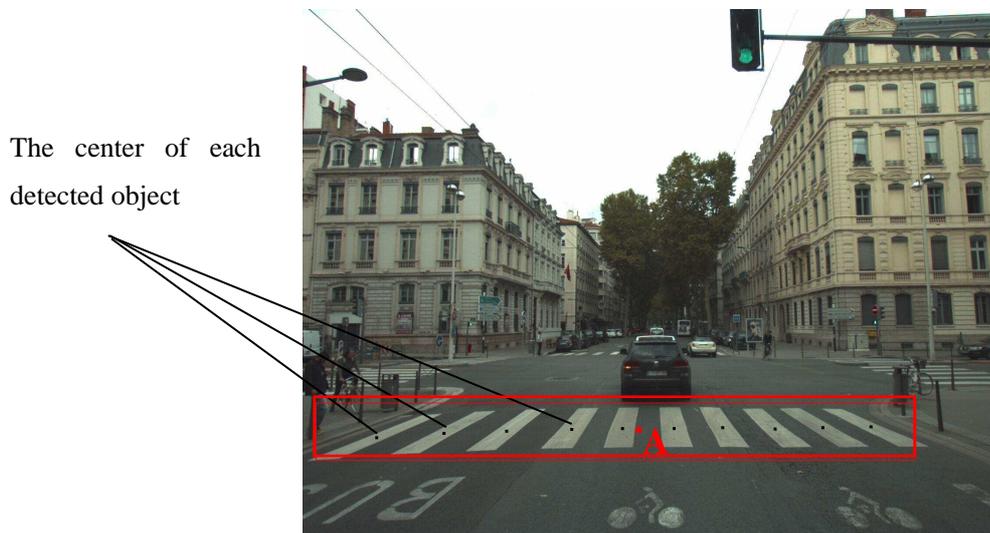
**Figure 10 - (a) Detected road, (b) segmentation and mathematical morphology, (c) result.**

After the identification of the marks on the road we return to the original image :



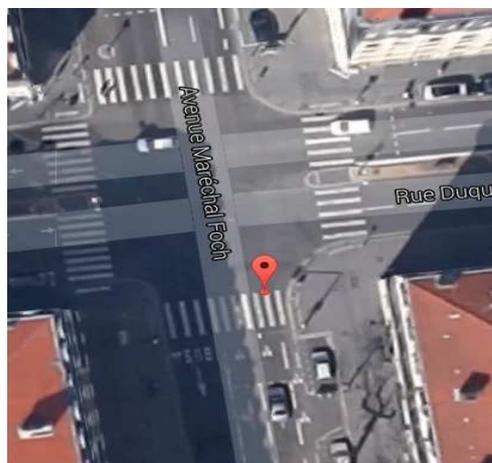
**Figure 11 - Road marking identification.**

Geo-referencing the road marking is obtained by calculating an average point (point A in Fig. 16) using the centers of N objects recognized (for example, recognized strips of the pedestrian crossing) because each object is characterized by its center (black dot in Figure 12).



**Figure 12 - Georeferencing road markings.**

The figure 13 bellow shows the corresponding Google Maps result by using its GPS coordinates.



**Figure 13 - Google Maps representation of point 'A'.**

*Experimental results :*

With generalities out of the way, we now consider several tests performed on images obtained with the VIAPIX<sup>®</sup> Acquisition module. The typical road length for each evaluation was 10 km. All these tests indicate the good performances and accuracy of the algorithm to get information on road marks, their surface conditions, and their geo-referencing.

<b>Weather conditions</b>	<b>Successful detection and identification</b>	<b>Unsuccessful detection and identification</b>
Cloudy day	91 %	9 %
Sunny day	100 %	0 %
At noon (sun and shadow)	88 %	12 %
Sunny day	97 %	3 %

**Table 1 - Pedestrian crossing recognition results using 4 different videos sequences**

Our concern is also to characterize the road marking features (number of marks, their length and width in meter and in % with respect to their respective maximal value) of an identified crosswalk. Our procedure also permits to qualify the state of the mark.



**Figure 14 - Example of identified road markings, Lat = 45.7724° and Lon = 4.8431°.**

<b>Road mark</b>	1	2	3	4	5	6	7
<b>Width (m)</b>	0.51	0.48	0.51	0.50	0.49	0.51	0.48
<b>Width (%)</b>	99.4	94.1	98.4	97.6	95.2	100.0	93.5
<b>Length (m)</b>	2.31	3.82	4.03	3.99	3.77	3.81	3.71
<b>Length (%)</b>	57.2	94.6	100.0	99.0	93.4	94.4	91.9
<b>Distance between two neighboring marks (m)</b>	0.56	0.54	0.50	0.56	0.49	0.53	-
<b>White color level</b>	87	137	170	164	139	140	119
<b>White color level (%)</b>	52	81	100	97	82	82	70

**Table 2 - Specifics of the road markings.**

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