ANNALS OF FACULTY ENGINEERING HUNEDOARA
– INTERNATIONAL JOURNAL OF ENGINEERING
Tome X (Year 2012) – FASCICULE 2 (ISSN 1584 – 2665)

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VIDEO-DETECTION OF HYBRID ITS INTERFACE

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ABSTRACT: *The paper presents some applications of acquisition and processing of image information in transport exploitation for the purposes of remote control of technological processes in ITS (Intelligent Transportation Systems). Most commonly the transport applications use methods and algorithms of image processing, which are modified for road situation analysis. For a reliable evaluation of image information the quality of video signal is important. The video signal is usually acquired via video cameras, so proper selection of video camera is needful. The article sets out some selected parameters that are necessary for acquisition of a quality record while reducing the volume of transmitted image data with the use of suitable digital processing compression algorithms.*
KEYWORDS: *intelligent systems, transportation, objects detection, information transmission, image processing*

INTRODUCTION

The increase of road network traffic load affects the formation of congestions, traffic accidents and environment. By implementing the intelligent transportation systems it is possible to effectively utilise the existing road network and to increase its capacity and safety. Currently in the area of intelligent traffic control systems digital image processing methods are being applied [Bubeníková & Moravčík 2011]. The article describes a design of hybrid communication interface and implementation of an image information processing algorithm for compression of image data acquired from a video-detection system used for detection of moving objects.

Following general requirements are imposed on each image processing system used for gaining traffic processes parameters [Pirník 2009]:

- Automatic recognition of each object from the others and from the background so that all necessary objects of interest on scene are intercepted.
- Correct recognition of object types – for example goods and passenger vehicles, bicyclist, pedestrians, locomotives, uncoupling etc.
- Provision of functionality regarding a wide spectrum of possible situations which can arise in relation with the transportation process.
- Independence from light or, in case of thermal-vision, thermal conditions of the scanned scene – day and night, winter and summer and so on.
- Execution in real time.

METHODS FOR OBJECTS DETECTION AND MONITORING

In the traffic environment the implementation of image processing techniques may be characterized on two levels, namely:

- image data processing tasks – we consider tasks like image filtration, correction, and segmentation, of them derived object modelling, tracking, and identification of these models while using morphological, geometrical and statistical methods;
- technical tasks – we consider systems for image data acquisition, video sequences transmission within these systems and the subsequent frames extraction.

Image processing systems can operate based on two principles of input signal acquisition:

- sensor – the systems utilise sensors which can be realised primarily by laser or ultrasonic sensors and measure on the basis of radar;
- camera – data is acquired from a wide-angle camera located based on application.

Considering the variety of practical tasks, techniques and methods used, it is useful to separate the solution of the problem of image processing from the conceptual view into three processing levels, applicable for the area of ITS (Figure 1):

- the lowest image processing level,
- the medium image processing level,
- the highest image processing level.

The highest level features the very image understanding, evaluation of the recognised facts and a particular system output depending on the requirements. To understand the image at all, it is necessary to process it on the lower levels first, in which it is processed based on brightness, colour, and their variance, or based on other simple or more complex pixel and area properties, which help to distinguish objects from the background, reduce noise and so on.

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The basic principle of image processing systems is Computer Vision. It is a term to describe systems and methods for acquiring, processing, analysing and understanding images from the real world. Image processing or Machine Vision is used in many different application areas – such as industrial automation, medical imaging, security and traffic technology. The organisation of a computer vision system is highly application dependent. There are, however, typical functions (steps) which are found in many image processing systems (Figure 1):

1. *image acquisition (digitization, storage),*
2. *pre-processing,*
3. *segmentation,*
4. *features extraction,*
5. *classification.*

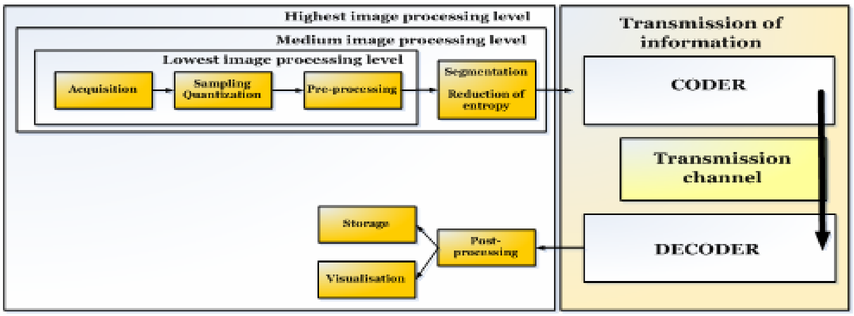

Figure 1: The sequence of image processing and recognition

Image acquisition and digitization. *The first stage of any vision systems is the image acquisition. Digitization creates a discrete image function of the electrical signal through two steps: sampling and quantization. This will get the smallest picture elements called pixels.*

Pre-processing. *After successfully obtaining the digitized image and we have a digital image of the observed scene. The picture may be distorted due to the method of capture or unsuitable conditions for its progress. Noise is an invariable issue anywhere in image analysis. Noise reduction methods generally tend to reduce the effect noise for better performance of algorithms. As far as the distortion character is known, it is possible to correct this error using corrections, which are one of the image pre-processing methods. Its objective is to reduce the noise and distortion.*

Segmentation. *Segmentation is the process of finding the boundary between foreground and background of an image. Image segmentation process may also partition the scene into more than two mutually exclusive and collectively exhaustive regions. Segmentation uses operations like edge detection, boundary identification etc.*

Features extraction. *Features extraction involves the extracting the meaningful information from the image. Features that are extracted from whole image are known as the global features and the features that are extracted from blocs identified during segmentation or from subdivision are known as local features.*

Classification. *The final step in image processing is the classification (understanding). In most cases it is the inclusion of objects in the image in advance of the groups. Methods of classification of objects are divided to two groups, which are associated with the way of the description of objects (symptom recognition and structural pattern recognition).*

VIDEO-DETECTION SYSTEM IN GENERAL

This subsystem provides a base for traffic control. Traffic data is acquired (scanned) from traffic detectors which mediate the image about behaviour of the traffic flow in the required area. It is primarily the input data for evaluation of intensity, speed and composition of the traffic flow. The recognised data are evaluated to provide not only information on the current intensity, but also to predict shock waves or detect accidents.

The construction and selection of a suitable camera for video-detection depends on the used technology and addressed utilisation. While solving the problems it is necessary to respect specifications like choice of optics, camera calibration, placement, connection and communication between system's units and so on.

For example each parking-site with video-detection requires an individual approach for finding a proper camera installation. Generally, following conditions hold:

- □ *placement with a view on as many parking positions as possible;*
- □ *view on monitored positions so that a covering of a lower vehicle by a higher one is avoided (e.g. a van covers a position with a passenger vehicle), as shown in Figure 2.*

The important criterion is also the focal length of lens. It is determined by the scene or area that the camera should follow. It is necessary to determine the area distance (D), which in terms of us interested in monitoring the location of the camera and width of the shooting area. The focal length affects the angle of view. Depending on the width of the scanned area and the distance the focal length is determined scanning chips with sizes 1/3", 1/2", 2/3" or 1". Most cameras are made with a chip size of 1/3". The aspect ratio is a relation between horizontal and vertical resolution, for instance resolution 640x480 has 640 horizontal pixels and 480 vertical pixels with aspect ratio 4:3. Typically used resolutions are for example 352x288, 512x492, 512x582, 640x480, and 768x582 pixels [Bubeníková & Moravčík 2011]. Pixels are usually square but can sometimes be rectangular with a defined pixel aspect ratio.

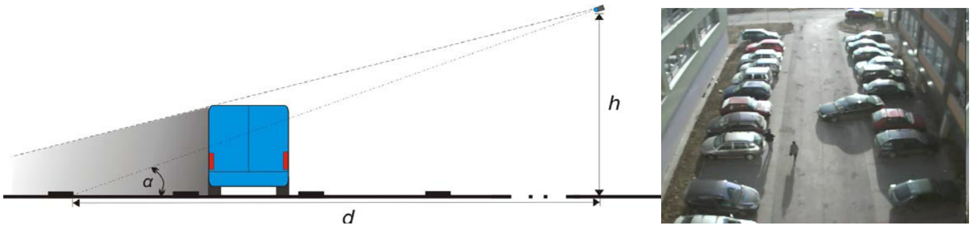

Figure 2: a) Overlapping the parking place by a vehicle, b) general view

The image resolution has impacts on the quality of the scanned image. It is the term used to describe the number of picture elements (pixels), used to display an image. This parameter is related to the parameters of lens focal length. The image quality depends on the number of pixels in one meter scanned area. Standard cameras provide resolution 720x576 pixels per frame (PAL TV standard). If we want to reliably identify the person's face or license plate, we need to have a record with a minimum 263 pixels/m. It means, that the largest surface area that we can scan is about 3 x 2 m (720/263 = 2,73 it is cca 3m; 576/263 = 2.1 m it is cca 2m). It is clear that if a person or vehicle license plate will be closer to the camera the image will be more readable. That means, the width (W) and distance to area (D) from the camera should be set as a maximum, where it is still possible to make identification.

The problem of processed data volume is directly related with scanning itself and with image digitalisation. Table 1 defines parameters of a commonly used CCD camera in ITS. From equation (1) we obtain the data volume necessary to transmit per time unit at full resolution while transmitting all 30 frames without compression [Bubeníková & Moravčík 2011].

$$bit\ rate = H \times W \times fps \times bpp \times channel$$

$$bit\ rate = 640 \times 480 \times 30 \times 8 \times 3 \approx 211 Mb/s \qquad (1)$$

Table 1: Table of CCD cameras parameters

variables		value
W	image width [pixel]	640
H	image height [pixel]	480
fps	frames per second [-]	30
bpp	bits per each colour [bit]	8
channel	number of colour channels (RGB) [-]	3

Obviously from the previous text, such a transmission of uncompressed information for the traffic control centre is very demanding on available transmission capacity. If the existent telecommunication infrastructure is used for transmission of this type of information, it is necessary to resolve the processing of image information before transmission, for example using a hybrid interface. The proposed hybrid communication interface is based on assumption, that the acquired data have to be pre-processed before transmission through public telecommunication network and then split into a form usable in the control centre. Following requirements have been specified on video-flow processing algorithm:

- high speed of compression and decompression – enabling coding in real time and subsequent fast editing,
- highest compression ratio – record quality has to remain as accurate as possible in comparison to the scanned original.

The data volume can be decreased for the purposes of ITS using following techniques:

- Decreasing the resolution of scanned image. It is necessary to consider the size of the smallest details in the analysed image and depending this to specify the minimal resolution. Some CCD cameras have the option to access arbitrary pixels enabling a change of resolution independently in both axes (down sampling).
- Decreasing the fps i.e. the necessary number of frames per second. This parameter depends mainly on the corresponding application for which the system has been specifically adapted.
- Decreasing the bpp. In this case it depends primarily on properties of the scanned image and on technique of its further processing.
- Decreasing the number of colour channels. In many applications only the brightness component is sufficient (foe example for edges detection).
- Methods based on image compression (intraframe).

In combination with decreasing the resolution it is possible to consider as a possible solution the usage of CCD camera with microprocessor and image memory integrated on a single PCB. It is not

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necessary to transfer such large data volume, but for the further processing only the relevant information about objects in image is sent.

VIDEO-DETECTION SYSTEM IN ITS

A necessary foundation for traffic control is traffic data acquired from traffic detectors which mediate an image of traffic behaviour in a location requiring traffic-flow control. Primarily the input data for evaluation are the intensity, velocity and composition of the traffic-flow. The data detected are evaluated in such a way to not only provide information about the current intensity but also to predict formation of impulse waves or to identify accidents.

The traffic control is designed in two levels: tactical and strategic. For the tactical level the traffic requirements are determined by a detection system on local level of traffic node (crossroad), eventually multiple crossroads in coordination. Video-detection systems of road light signalling controller are being used.

On the strategic level the traffic situation is monitored on level of the dispatcher workplace central control system, namely by a detection system consisting of traffic survey devices divided according function into:

- *Traffic Flow Analyser (TFA) - traffic survey detector, which function is detecting of immediate characteristics of traffic flow to monitoring and traffic controlling in real time,*
- *Traffic Incident Detection Device (TIDD) - traffic survey detector, which function is in real time to identify of specified incidents in traffic flow.*

VDS (Vehicle Detection System) is a system to collect traffic data from TFA (such as traffic volume, speed, share, time gap, etc.) or traffic incidents from DTID and provide them to Traffic Control Center for traffic management strategy.

The problem of insufficient transmission capacity of such systems can also be solved with the help of the proposed hybrid interface, which uses the designed algorithm for video-sequence processing. The interface as well as the algorithm is described in following chapter.

ARCHITECTURE OF HYBRID COMMUNICATION INTERFACE

The technological architecture of hybrid transmission systems interface includes design and solution of adaptation unit and its two basic user blocks (Figure 3) from the perspective of ITS technological network:

- *Communication block – serves for transmission of data concerning traffic process (processed information from sensors and actuators)*
- *Information processing block – this functional block processes analogue signals (sensors with analogue output, analogue video-flow from cameras etc.) into a form suitable for transmission over an open communication system.*

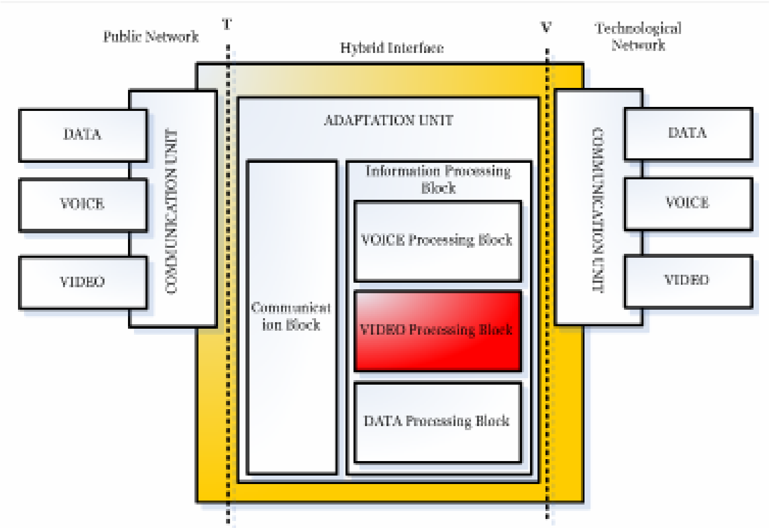

Figure 3: Technological architecture of the HI-ITS interface

In this case, for video compression a method has been applied, which uses a fact, that the individual frames are similar to each other. From this point of view, it was possible for the ITS area to design a video-flow compression algorithm based on intraframe coding principle.

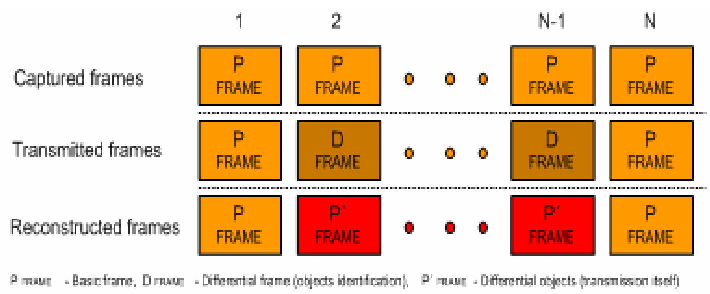

Figure 4: Principle of compression algorithm

The idea of compression algorithm [Pirník 2009] (Figure 4) is based on finding and subsequent separation of moving objects (differential objects) on the surface communication. These differential objects have to be identified and consequently separated from background using mathematical operations (in MATLAB programming environment) (Figure 4). The result of compression algorithm operation and the parts of differential objects creation are shown in Figure 5.

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a) b) c)

Figure 5: The progress of differential objects creation within the transmitted frames a) Basic frame), b) Differential frame (objects identification), c) Differential objects (transmission itself)

Thus coding by channel coder does not include coding of full interframe, but only the differential objects of the individual frames (besides the keyframe). With this procedure a considerable decrease of data needed for transmission over a hybrid communication system occurs. A major advantage is the fact that the differential areas are in this case coded by a lossless compression there through eliminating their distortion. In this way transmitted image information is suitable for further processing in the ITS control center (vehicle detection, vehicle velocity detection and so on). Description of differential objects transmission is in Figure 6.

a) b) c)

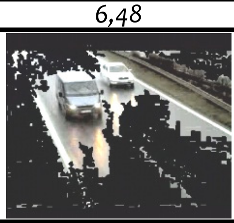
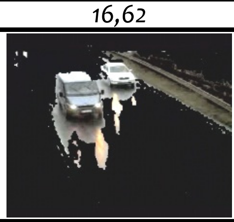
Figure 6: Description of differential objects transmission a) Basic frame, b) N differential frames, c) Basic frame

The search for changes in an image for different applications (especially ITS) requires design of special compression methods. The proposed compression procedure for ITS video-applications does not look at the image as a whole, but divides it into the background and the individual moving differential objects which are on this background. The idea of transmission (on the HI-ITS side) and decompression (on the ITS control center side) is in blocks depicted in Figure 4.

COMPRESSION ALGORITHM – REAL OPERATION

The optimised compression algorithm of Video processing block in ITS-ADSL interface has been tested on a real video sequence from a section of D1 highway in the town Presov [Šimák et al 2010]. Table 2 shows the results of algorithm in dependence on threshold parameter setting.

Table 2: Compression algorithm – real operation

Treshold	0,05	0,1	0,15	0,2
SSIM	91,42%	90,17%	89,66%	89,23%
Source data	0,3041 MB/frame 7,6025 MB/s			
Transmitted data (Average data flow)	0,0469 MB/frame	0,0183 MB/frame	0,0137 MB/frame	0,0112 MB/frame
Transmitted data (Average data flow)	1,1725 MB/s	0,4575 MB/s	0,3425 MB/s	0,28 MB/s
Compression ratio	6,48	16,62	22,20	27,15
Differential objects				

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CONCLUSIONS

The operation algorithm and structure of the video-detection of hybrid ITS interface has been designed based on a set of defined requirements and features. The primary objectives were real-time operation, automated recognition of moving objects (foreground/background separation problem), true recognition of moving entities (truck, car, human, etc.), widely used and robust system in connection to possible traffic situations. The system operation has to be independent on environment parameters, like light properties, temperature or season. An actual implementation in the town Presov has been utilised as a testbed for testing the compression algorithm under various operational conditions.

ACKNOWLEDGMENTS

This work has been supported by the European Regional Development Fund and the Ministry of Education of the Slovak Republic, ITMS 26220220089 "New methods of measurement of physical dynamic parameter and interactions of motor vehicles, traffic flow and road".

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