Optimisation of Video-Data Transmission in Telematic System

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Abstract. *The goal of this paper is to analyse, define, and summarise the requirements on networks connecting telematic technologies based on Intelligent Transport Systems (ITS). The paper describes the methodics of setting and a general concept of technological networks interface based on available and applicable standards Focus is set on optimisation of data transmission in the form of a video-stream and its tunnelling through xDSL transmission technology. The implementation of the designed compression algorithm and interface between open and technological-type networks is described. The summary describes a proposed subjective method for quality evaluation of transmitted video-flow for the needs of telematics supervision systems dispatchers.*

Keywords

Optimisation, telematics, video-data.

1. Introduction

The increase of the 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. 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. 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 the 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 a local level of traffic node (crossroad), eventually multiple crossroads in coordination. Video-detection systems of road light signalling controller are being used. Broadband Fixed Access (BFA) is technology serving for the provision of high-speed access to data networks using installed lines. In the access network, mostly symmetric metallic lines consisting of a twisted pair, originally intended for transmission of analogue signals on analogue subscriber telephone attachment. Despite that transmission parameters of these lines are "unsuitable" for broadband access needs, they are also being utilised for this purpose, because a total replacement by modern media in some areas would be extremely expensive. Technologies which establish themselves more massively on the communication market and satisfy the requirements for internet connectivity, mainly for small- and medium business, include, along with wireless and optical, primarily Digital Subscriber Loop (xDSL). The effort is comprehensible to integrate internet as a universal communication environment into hybrid networks so it is possible to safely and with predefined level of security access through the public open network to technological processes running inside network for the purpose of control and remote diagnostics. For determination of the current state of the process (for ITS primarily the road transport) progressive supervision methods are being utilised including video-supervision and video-detection of moving objects (vehicles, pedestrians, or other objects on the road line).

2. Image Processing

Video-detection system in general 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. The next of important parameter in image processing is the process of the way of transmission and data compression.

When processing an image (not only for ITS applications) several levels can be distinguished [1]. Typical functions (steps) which are found in many image processing systems (Fig. 1):

- image acquisition (digitalisation, storage, compression),
- pre-processing,
- segmentation,
- features extraction,
- classification.

The contents of each image, whether an individual static image or a frame in a video-sequence, can be divided into several hierarchically levels of abstraction. The first level consists of pixels, the substance of each image, which features information about brightness and colour. The next level deals with features or properties such as edges, corners, curves and colour areas within the given image.

The higher abstraction level combines and interprets these features as objects and to them corresponding attributes. The highest level uses concepts of image processing and abstraction similar to human perception, which join one or more objects and define relations between these objects. The object detection in a video-sequence includes determination of object's occurrence in the images sequence as well as accurate as possible determination of its position in the further recognition process. Then the principle of object monitoring is detection of changes of its position, size, shape and so on in space and time within the images sequence.

2.1. Lowest Processing Level

On the lowest level we deal with operations, for which no special decisions from the system are necessary.

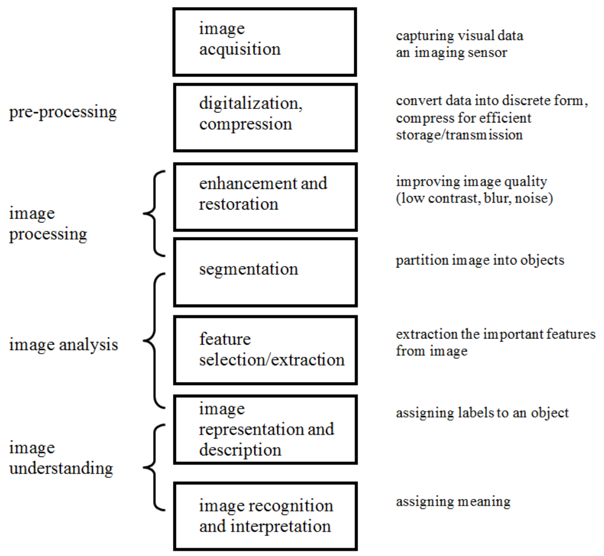


Fig. 1: Digital image processing scheme.

The particular functions work automatically according to a predefined procedure. The basic steps are considered to be:

1) Image acquisition

A digital image is produced by one or several image sensors, which besides various types of light-sensitive cameras include range sensors, radar, ultra-sonic cameras, etc. Naturally, in case of analogue signal acquisition digitising by a suitable AD converter is necessary. Depending on the type of sensor, the resulting image data is an ordinary 2D image a 3D volume or an image sequence. The pixel value correspond to light intensity in one or several spectral bands (grey images or colour images), but can also be related to various physical measures.

2) Pre-processing

The image obtained in the former step is often unsuitable for utilisation on higher processing levels. The key task of pre-processing is to improve the digital image so that certain image outlines are improved and the overall success of methods in the subsequent steps is increased. Mostly the techniques of contrast modification, removal optical errors, noise reduction or blur or being utilised. Pre-processing methods utilize the image data redundancy. Neighbouring image elements are largely the same or similar brightness. It is important to note that during pre-processing will not receive any new information. We can only supress any information or highlight. Some pre-processing methods are luminance correction, gradient operations etc.

2.2. Middle Processing Level

On the middle level the tasks of extraction and characterisation of parts - image areas are solved. Unlike the lower level a much higher flexibility is required during analysis. Following steps are typical.

1) Segmentation

Generally, the task of segmentation is to separate the input image into its individual parts or objects. Objects are, similarly as in general system theory, considered the parts of image in which we are interested for the further processing. Mostly it is one of the most challenging tasks during digital image processing. So during segmentation the knowledge of image interpretation (semantics) is often used. The outputs of segmentation are sets of image's elementary parts - pixels representing either regions boundaries or a region with all points which form it.

2) Representation and description

The data (sets) obtained has to be converted into a form suitable for further processing. It is possible to it quantitatively using a set of numerical characteristics and at the same time qualitatively using relations. It is necessary to take a decision for set representation by boundaries and regions according to the type of task and according to the interest in inherent (content) or external (shape) properties of the object.

The data description method has to be specified to emphasize the property of interest. The result of description can be certain quantitative information on an object or a property, which is a base for distinguishing of one class of objects from other ones.

2.3. Highest Processing Level

The last and the highest level includes steps of content recognition and interpretation, which are primarily related to applications requiring automated digital image analysis. Image analysis here represents the discovery, identification and understanding the meaning of patterns acquired from the image processed, about which generally no assumptions are defined before. Following steps are characteristic.

1) Recognition and interpretation

Comprehension is based on knowledge, goals, setting of plans for their achievement, and also on the use of feedbacks between different processing levels. The basic task of these steps is to equip a machine/computer at least partially with abilities similar to human beings in conjunction with vision and perception problem resolution. For a successful recognition and interpretation knowledge from geometry, statistics, neural networks, artificial intelligence, or fuzzy sets are used [1].

Nowadays, image processing methods are also being applied in many areas of intelligent traffic control systems. For each video image processing system (VIP), which task is to monitor and acquire parameters of traffic processes, following general requirements are set:

- Automatic recognition of each object from the others and from the background so that all objects of interest in the scene are identified.
- Correct recognition of objects types - freight and passenger vehicles, bicyclists, pedestrians, locomotives, sets of uncoupled wagons, etc.
- Functionality assurance with regard to a wide spectrum of possible situations, which occur in conjunction with traffic process.
- Independence from light sources, or in case of a thermo-vision, independence from thermal conditions of the monitored scene - day and night, winter and summer and so on.
- Operation in real-time.

The degree of fulfilment of the stated requirements depends on specific application. Most frequently we encounter telematics image processing systems in road transport. However, the principles, on which these systems are based on, don't interfere with applications in other transport modes.

3. Communication Systems in Transport

Communication networks built up for the ITS sphere are in general defined as closed (trustworthy) transmission systems managed by a single legal subject. In case of the Slovak republic (SR) it is the Slovak Road Administration (SSC) and National Highway Company (NDS). These organisations manage first class roads (SSC) and national highway network (NDS). Today, the construction of communication networks on costs of these companies is defined in the Technical Conditions (TP) [2] and [3]. These TP define the use of optical transmission systems on the individual levels of the OSI model. Technological network which provides the control and operational communication is of class L1 and has to be in accordance with [3] based on the following standards:

- on the network layer (OSI layer 3): Internet Protocol IPv4, IETF STD 5,
- on the link layer (OSI layer 2): Ethernet IEEE 802.3 + IEEE 802.1,
- on the physical layer (OSI layer 1):
  - Ethernet 100BASE-T,
  - Ethernet 1000BASE-T,
  - Ethernet 100BASE-FX,
  - Ethernet 1000BASE-LX,
  - Ethernet 1000BASE-ZX.

The demands on standard communication networks have to correspond with basic transmission characteristics and have to ensure requirements on their availability, security, and reliability.

1) Availability

Presents the time, during which the service (application) is provided to the customer and the communication network is operational. The value can be determined in time (for example as a period, during which the system can be out of operation) and can be expressed mathematically and economically, too.

2) Security

Assurance of information protection as such. In case of fixed networks the security of information transmission can be resolved by the software equipment of centres and the individual applications. In case of wireless facilities the security is resolved by telecommunication network itself and by transmission protocol.

3) Reliability

The reliability of transmission in regard to telecommunication environment has to be viewed within reliable function of the individual technologies leading to an early delivery of information as such. It has a direct relation to the term availability; therefore it can be watched in all segments of transmission chain. It expresses the reliability of devices, physical layer, quality of workmanship, but also robustness of chosen technical equipment against interference (Electromagnetic Compatibility, EMC).

From the data transmission point of view is it necessary to divide ITS applications into:

- Applications providing only data acquisition for subsequent utilisation, so called off-line applications without the real-time transmission requirement.
- Applications which provide dynamic operations with information. These applications require online transmission and a high degree of communication network availability.

Nowadays, based on stated facts, it is necessary to impose high requirements on transmission quality and sufficient network transmission capacity when building a communication infrastructure for ITS.

3.1. Current Legislative Situation

Government resolution Nr. 22/2009 from January 14^{th} 2009 to Intelligent Transport Systems development programme defined a framework for the realisation of the National Traffic Information System (NSDI in Slovak). The system environment of NSDI is partitioned into 4 frame projects. Project I - ITS of largest SR agglomerations (further referred to as IDSNA) is focused on the realisation of intelligent transport systems in the 11 largest Slovak towns, with the exception of Bratislava.

Currently effective legislation in the area of intelligent transport systems in SR presented in [2] and [3] does not make possible to construct ITS communication components using metallic data circuits with xDSL technologies. In case of highways and expressways this approach is fully acceptable.

In case of building ITS within town agglomerations it is necessary to consider the utilisation of already established transmission technologies covering the town areas. We consider among the most perspective in the first stage of town ITS building the use of access metallic network by Slovak Telecom company.

3.2. ADSL Transmission Technologies Utilising Metallic Lines

At first sight, it seems that the connection of intelligent transport systems using ADSL technology is not possible in terms of capacity. But a solution exists in this direction, too. Today a large number subscriber lines not utilised. Therefore this lines can be used for the transmission of data from ITS to the nearest Digital Subscriber Line Access Multiplexer (DSLAM). For this purpose it is possible to merge several free metallic pairs to achieve the required transmission speed for video transmission. Fig. 2, [4], depicts the current situation of ADSL technology coverage in Slovak republic. It is obvious, that within designing and building (or expansion) of intelligent transport systems within agglomerations of larger towns this technology is the most suitable from the view of availability.

Fig. 2: Map of Slovak Telecom ADSL service availability.

The further text describes a design of compression algorithm suitable for consequent transmission of motion picture (data stream) over public data network interface and so called hybrid networks. Video compression is concerned based on interframe codecs principle with the requirement on preservation of transmitted and consequently reconstructed image information. This way composed and modified data streams containing data from the recorded video transmitted over a hybrid communication network used to evaluate the traffic situation, with quality degree, which is defined in the technical directives TP 09/2008 and TP 10/2008.

The main objectives of the work [5], which outputs are primarily processed in this contribution, were design and subsequent application:

- model of hybrid transmission system for the support of remote control of traffic processes in ITS-ADSL,
- compression algorithm for the needs of hybrid ITS-ADSL interfaces.

The problem of video-streams processing for the purposes of hybrid network on the application layer of control systems in the area of ITS brings many tasks which had to be solved within [5]. Primarily it were these tasks:

- Design of an algorithm for pre-processing, detection, and find the boundaries of moving objects and testing of the proposed solution.
- Building a simulation model (program) for testing video-flows processing for hybrid network interface on application layer in MATLAB environment.
- With the aid of designed simulation model to determine the optimal configuration of modified parameters on testing video-sequence.
- Perform experiments on testing video-flow for the purpose of determination of the optimal ratio of transmitted differential objects data to compression ratio with emphasis on preservation of defined quality of final reconstructed video-flow in MATLAB environment.
- Comparison of reconstructed video-flows with original input video-flows with objective SSIM (Structural SIMilarity) method.
- Propose a method of subjective quality appraisal of reconstructed video-flow by an ITS dispatcher.

The highlighted areas are further described in more detail. 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 the formation of impulse waves or to identify accidents.

Traffic control within the Traffic Control System (TCS) of district towns is designed in two levels: tactical and strategic [9]. For the tactical level the traffic requirements are determined by a detection system on a local level of traffic node (crossroad), eventually multiple crossroads in coordination. 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 Analyzer (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 a 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. There are video detectors designed on 32 locations and this type of detectors covers both functions - traffic flow analysis and traffic incident detection, too.

The camera system and image information transmission within the TCS system have the highest demands on available or build transmission capacities. For the traffic control system according to TP 10/2008 a L1 technological network [2] has been designed, which consists exclusively from optical transmission lines. However the establishment of optical network for image information transmission between all video detectors and center in large agglomerations is too expensive. Therefore it was necessary to design a system utilizing the resources of present telecommunication infrastructure.

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 chapters.

4. Hybrid Communication Interface for TCS Purposes

The designed hybrid communication interface is based on the assumption, that the data detected need to be pre-processed before transmission, subsequently transferred across public telecommunication network and after that decomposed into a form usable in the control center. Following requirements were defined for the interface and algorithm:

- high compression and decompression speed - to enable real-time coding and subsequent fast editing,
- highest possible compression rate - to accommodate the videodata flow to the ADSL system transmission capacity in upstream. However the record quality has to remain visually as accurate as possible in comparison to scanned original.

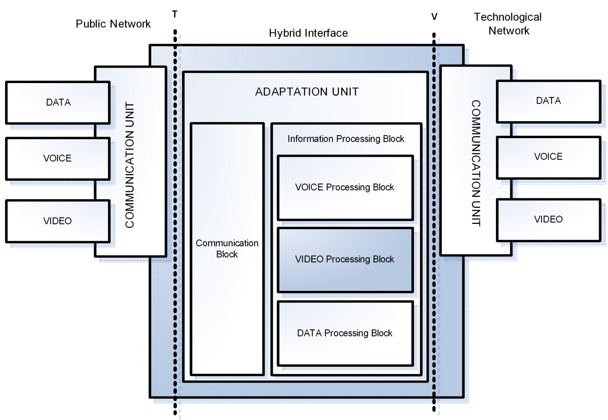


Fig. 3: The hybrid communication interface architecture [5].

In this case for video-stream compression a method has been applied, which utilises the fact that the individual frames are similar to each other. The compression algorithm is then based on intraframe coding principle of video-stream [8].

4.1. Concept of Hybrid Communication Interface

The architecture of the interface designed for hybrid transmission systems (Fig. 3) joining open and closed communication systems contains a design and solution of adaptation unit and its two basic user blocks from the TCS technological network point of view:

- 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.

4.2. Video Processing Block

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.

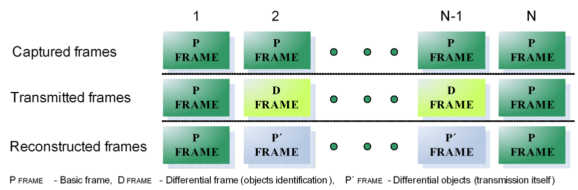


Fig. 4: Compression algorithm.

The idea of compression algorithm, [5], (Fig. 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, Fig. 5). The result of compression algorithm operation and parts of differential objects creation are shown in Fig. 4.

a) b) c)

Fig. 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 centre (vehicle detection, vehicle velocity detection and so on). Description of differential objects transmission is in Fig. 6.

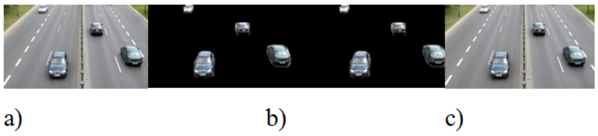


Fig. 6: Description of differential objects transmission a) Basic frame, b) N differential frames, c) Basic frame.

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 compression (on the HI-ITS side) and decompression (on the ITS control centre side) is in blocks depicted in Fig. 7.

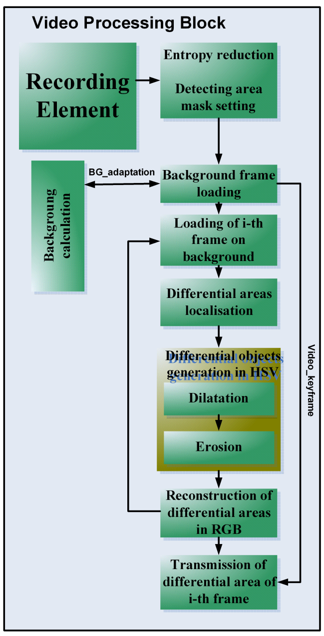


Fig. 7: VIDEO processing block - compression and decompression.

4.3. Compression Algorithm Optimisation

To the verification activities the Video processing block and the subsequent optimisation of its parameters (for the needs of traffic processes monitoring), as a priority parameter for simulation has been chosen the threshold which serves for primary separation of differential areas of background images.

The output of simulation was a value of average bitrate of processed input video-flow in dependence on modification of other parameters (video_keyframe and BG_adaptation) for a set step of Treshold parameter (for example simulation step 0,01). As a source a video-sequence labelled "768x576_traffic.avi" (768x576_skuska.avi) has been used, from which the object "avi-objekt1" has been generated in MATLAB software environment with the use of IDS_main function. Its resulting size was 156,72 Mb (195 frames with resolution 768×576).

Thereafter, using the procedure described in Fig. 7 a frame of background has been generated an image of background and differential objects have been selected as a difference of background of consecutive frames stored into the file "objekt1.avi". The file "objekt2.avi" represents a video-sequence containing reconstructed frames composed by merging of background and the related differential objects of corresponding frames.

1) Quality assessment of the reconstructed video-flow

Objective techniques for video-sequences assessment are based on mathematical models which successfully replace human's subjective perception of transmitted video quality. Objective methods are classified according to availability of original video-flow of which is considered to be of high quality [7]. According to this there are full-reference methods, reduced-reference methods, and reference-free methods.

The most traditional way for quality establishment of digital video processing system (for example DivX, XviD video codecs) is a calculation of Signal to Noise Ratio (SNR) and Peak Signal to Noise Ratio (PSNR) between the source video-flow and video-flow passing through the transmission system. PSNR is one of the objective video quality metrics which can by automatically calculated using a computer. However, a good peak signal to noise ratio does not guarantee a good visual quality because of nonlinear behaviour of the human eye. Currently, more complicated and precise metrics are developed (SSIM or VQM - Visual Quality Metrics).

2) SSIM

In this case the SSIM metrics has been applied for appraisal of difference between source and reconstructed video-flow. It is a numerical index expressing similarity of pixels in the examined frames. The SSIM criterion presents a different approach to video quality measurement. It is based on the fact that HVS is highly focused on structural information within the image and not on errors. All criteria based on structural distortion (including SSIM) provide higher correlation with subjective evaluation.

5. Simulation Example

Following figures present simulations for parameters set: Simulated values for F = Treshold parameter from the set 0,01–0,1 (simulation step 0,01) for parameters A =”768x576-traffic.avi’, $B = 25$, $C = 100$, $D = 0,5$, $E = 25$, $G = 1$ and $H = 576$, where A = input_video, B = video_fps, C = video_quality, D = video_keyframe, E = BG_adaptation, F = Threshold, G = top_boundary, H = bottom_boundary.

Figure 8 illustrates with blue colour the original non-compressed constant data flow with an average value 1,2442 MB/frame, red colour the data flow of transmitted differential objects for the individual frames with average data flow of differential objects 0,6567 MB/frame. Each 25^{th} frame is transmitted non-compressed.

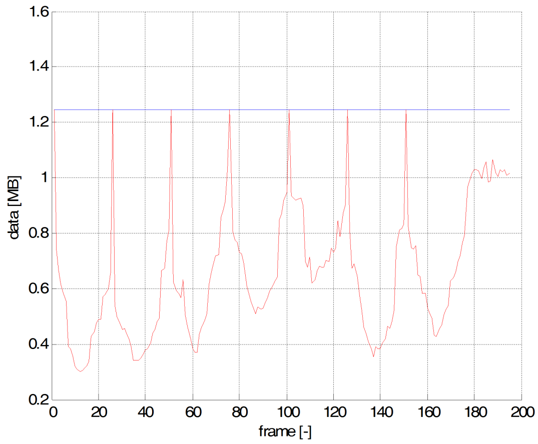


Fig. 8: Comparison of data flows per frame of source and compressed video-flow.

Figure 9 depicts the dependence of differential objects data flow change on time. It can be seen from the graph, that between second 3 and 5 of the record the data flow rises. A large object (a bus) showed up in the recorded video, which influenced the volume of transmitted data in differential frames.

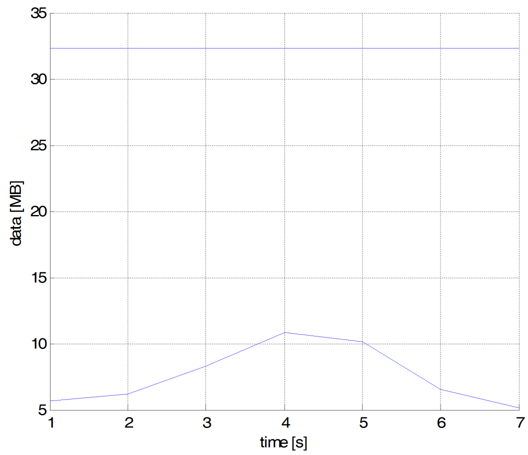


Fig. 9: Volume of data flow of differential objects in time.

Figure 10 describes in the upper part a dynamic quality change of the reconstructed image obtained using a method of comparison of two frames with SSIM. In the lower part the SSIM simulated values are graphically depicted. The difference of original pixels with the reconstructed ones expressed by a nondimensional number was calculated at approximately 93,99 %. Therefrom we can conclude that only approximately 6 % pixels on a frame have been modified.

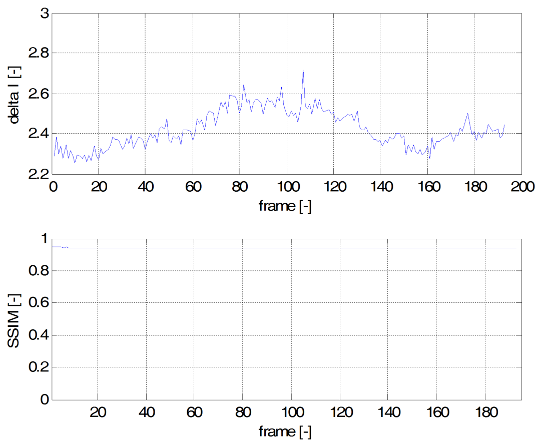


Fig. 10: Rate of pixel accordance of the original and reconstructed image expressed by SSIM parameter.

To determine the progress of SSIM parameter values, on the dispatcher’s side the source file ”768x576_traffic.avi” has been compared with the transmitted and reconstructed file ”768x576_skuska_reconstructed.avi”. The comparison was performed in the MATLAB software environment using the designed simulation which has been performed based on *[SSIM]=Video_Quality_Measurement_main* function. The output of this way realised function is a nondimensional numeric value and the resulting values are converted and expressed in percentage. Figure 11 graphically shows and summarises the simulated courses of values of the SSIM parameter in dependence on modification of the Compression ratio parameter.

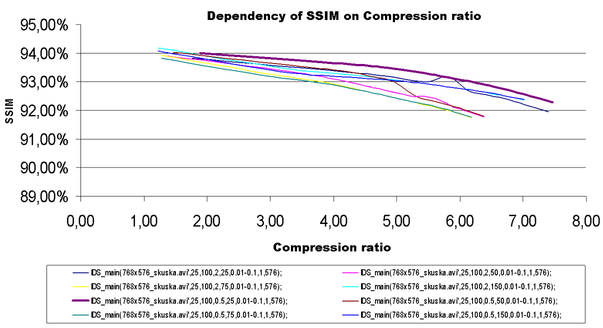


Fig. 11: Dependency of SSIM on modification of Compression ratio (K) parameter - input data stream volume (Vs_D) to output data stream volume (Vy_D).

$$K = \frac{Vs_D}{Vy_D}. \tag{1}$$

Figure 12 graphically represents and summarises the simulated courses of values of the SSIM parameter in dependence on modification of the Compression factor (C) - ratio of output data flow volume to input data flow volume.

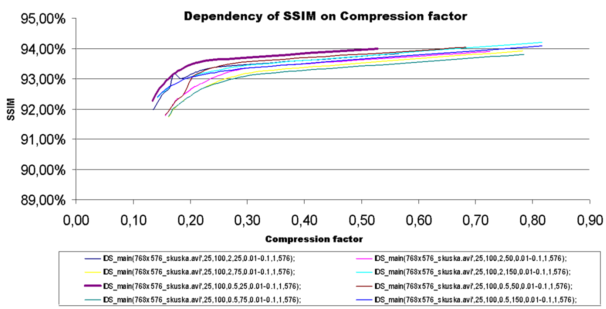


Fig. 12: Dependency of SSIM on Compression factor parameter modification.

$$C = \frac{Vy_D}{Vs_D}. \tag{2}$$

6. Simulation Example Subjective quality evaluation method using HR-CCTV methodics

During the investigation of the current state within the problem of one-directional video transmission for the needs of surveillance and control in ITS, no subjective method has been discovered suitable for quality determination of video-flow on the part of dispatcher. Using the proposed HR-CCTV methodics and based on verbal assessment of transmitted image information by dispatcher himself, is it possible for the internal needs of dispatching to monitor and evaluate two areas:

- Ergonomical area - ergonomics is a science discipline engaged in adapting of working environment for the needs of humans. Usage of computers and monitors during working time brings new health problems and increased demands on the observer's (operator's) sight.
- Technical area - deals with detection of progressive degradation of video transmission chain elements characteristics. Such a degradation may in the negative sense significantly influence the process of control in ITS which are based on image information processing. The impaired properties of the communication chain directly affect the transmitted data stream and thus the quality of output video-flow on the side of control centre.

We assume that the proposal of subjective method for assessment quality video-flow on the dispatcher's side contributes to an operative method for evaluation of the entire system using CCTV and not within the examined ITS area only. For the needs of subjective quality determine of transmitted (in our case reconstructed) video on the dispatcher's side a method for subjective quality assessment method for the displayed video-flow. Dispatcher's perception of video-flow transmission quality is expressed by a composite HR indicator. These are metrics which are functions of source video and network degradations influencing the quality of transmitted video-data stream. Such a statement of service quality appraisal from the dispatcher's point of view is most properly expressed using the MOS method (Mean Opinion Score). MOS represents a virtual numerical evaluation of tested parameters specified evaluators.

For the assignment of received video/flow quality on the dispatcher's side, three priority parameters have been defined, which have been properly quantified and together form the composite HR parameter:

- resolution of details of moving objects,
- image quality (sharpness, brightness, colour purity, colours interpretation),
- fluency of moving scenes.

The individual priority parameters stated in Tables 1, 2, 3, 4 have been assessed with scale 1 to 5, where grade 5 means in verbal representation Excellent and grade 1 is verbally expressed by the term Unsatisfactory, whereby the resulting value is obtained by calculating the average grade (average of corresponding values from Tab. 2 to Tab. 4 according to dispatcher's assessment). Thus, it is a composite HR value which should correspond to values from Tab. 1.

Tab. 1: Composite parameter (HRCCTV) of HR-CCTV method.

HR appraisal	**Video quality according to dispatcher**	**Effort spent by dispatcher**
5	Excellent	Surveillance of traffic situation without the need of increased effort when following the video.
4	Good	Surveillance of traffic situation with the need of increased effort when following the video.
3	Fair	Imperfect surveillance of traffic situation – the image is abrupt and outages.
2	Poor	Imperfect surveillance of traffic situation – the image is blurred.
1	Unsatisfactory	Impossible surveillance of traffic situation – the image is abrupt and blurred.

Tab. 2: Priority parameter - Differentiation of moving objects details.

Assessment	**Video quality according to dispatcher**	**Verbal interpretation**
5	Excellent	Distinction of details without the need of increased effort – it is possible to resolve ID of moving vehicle
4	Good	Distinction of details without the need of increased effort – it is possible to resolve ID of moving object
3	Fair	Distinction of details with the need of increased effort - it is possible to resolve objects and their colour only
2	Poor	Distinction of details with the need of increased effort - it is possible to differentiate details but not their colour
1	Unsatisfactory	Impossible to differentiate details in image – it is not possible to differentiate details in image

For the reason of complex quality appraisal of transmitted image another compression effectiveness indicator has been defined called Complex optimality coefficient KKo. This indicator links objective video-

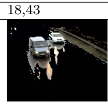
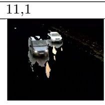
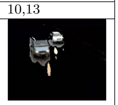
Tab. 3: Priority parameter - Image quality.

Appraisal	**Video quality according to dispatcher**	**Video quality according to dispatcher**
5	Excellent	Image quality is monitored using following parameters and an average is calculated: • image contrast 1-5, • colour purity 1-5, • outer impurity 1-5
4	Good	
3	Fair	
2	Poor	
1	Unsatisfactory	

Tab. 4: Priority parameter - Fluency of moving scenesy.

Appraisal	**Video quality according to dispatcher**	**Verbal interpretation**
5	Excellent	Fluency of moving scenes is assessed
4	Good	
3	Fair	
2	Poor	
1	Unsatisfactory	

Tab. 5: 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/fr. 7,6025 MB/s			
Trans.data (A. data flow)	0,0469 MB/fr.	0,0183 MB/fr.	0,0137 MB/fr.	0,0112 MB/fr.
Trans.data (A. data flow)	1,1725 MB/fr.	0,4575 MB/fr.	0,3425 MB/fr.	0,2800 MB/fr.
Compression ratio	6,48	16,62	22,20	27,15
HR	1	1	2	3
KKO	7,09	18,43	11,1	10,13
Differential objects				

transmission quality appraisal with subjective perspective of dispatcher by means of relation:

$$KKo = \frac{\text{SSIM}}{K}\frac{1}{\text{HR}} = \frac{\text{SSIM}\, V y_D}{V s_D}\frac{1}{\text{HR}}, \quad (3)$$

where: SSIM - numeric value of transmitted video-flow quality; K - compression ratio; HR - composite parameter of subjective HR-CCTV method.

7. 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 [6]. Tab. 5 shows the results of the algorithm in dependence on Threshold parameter setting.

8. Conclusion

The presented paper demonstrates a perspective optimised application of currently highly available xDSL technology within the video-data transmission of an Intelligent Transport System. The main objectives for development of the digital image processing system in video-detection within the presented hybrid ITS interface were automated recognition of moving objects and entities, invariance on environmental conditions (light, temperature, etc.), and real-time operation. The testing phase of the proposed optimised compression algorithm has been performed within a D1 highway section in a district town.

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