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Increasing the Ergonomics at the Workstations of CCTV Operators

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Summary. The work of an operator of the Closed Circuit TeleVision (CCTV) system is associated with the observation of an image recorded by a camera on the screens of monitors, management of work of devices available within the system of visual monitoring (camera turntables, recorders, control panels), and making decisions concerning the initiation of the provided neutralizing proceedings in the case of detection of abnormal situations and emergency situations for people or property. The presented study focuses on demonstrating the available technical means supporting the work of an operator of a CCTV system. These means, when appropriately used, enable an improvement of ergonomics at the workplace of an operator and, consequently, result in an increased comfort of an operator's work and greater effectiveness of the surveillance system management process. Possibilities are presented related with the use of techniques for the processing and analysis of images in order to automatically detect abnormal situations and, therefore, support the process of decision-making by the system operator and create the workplaces of virtual operators managing the work of the CCTV system, characterized by parameters which are individualized and adjusted to a given object. The described technical means in the form of image processing techniques and virtual control systems allow the reduction of hazards detection time, increase the possibilities related with the steering and management of the work of devices within the system and thus improve the effectiveness of the processes of hazards detection and neutralization.

Key words: supervision and surveillance system, CCTV systems, identification of hazards, ergonomics at an operator's workplace.

INTRODUCTION

The primary task of surveillance systems, especially CCTV systems, is the recording and analysis of technical parameters in order to evaluate the state of the protected object and, simultaneously, enable the correct functioning of the object and provide appropriate work conditions for the surveillance system [1, 2, 5, 6, 13, 16, 20]. The achievement of the expected protection goal concerns the performance of assumed procedures associated with prevention and neutralization of the detected hazards. For this purpose the technical means are used which enable the performance of surveillance tasks in an autonomic way, or merely by supporting the users of the system during the process of an analysis of the current state of the system and identification of hazards. The supervision and surveillance systems as well as the use of technical means for the detection and elimination of hazards create a man-machine system with the user. The major task of the Closed Circuit TeleVision systems, which fall within the technical means of property protection, is providing the proper units of an object's protection system with comprehensive information concerning the current state of the controlled area. The carrier of information concerning the state of an object within the CCTV system is the picture image [5, 7, 8, 10, 17, 18, 19, 20].

In order that the visual monitoring system performs its task, it must enable the imaging of the largest area possible. Due to this, the user has a possibility to thoroughly observe the protected object. The work of an operator of a visual monitoring surveillance system consists in the observation of the image produced by cameras on monitor screens and management of equipment available within the system [6, 7, 10, 20, 22].

In order to provide the optimum work conditions for operators, it is necessary to take care of spatial shaping of their workplaces, which should be appropriate and in accordance with the ergonomic recommendations. The operator's workplace should be adjusted to the psychophysical properties of an individual with respect to the type and character of the work performed. The effectiveness of the work of an operator is related to th informatione number of cameras available, observation zones under surveillance as well as the method of equipment management within the system. Therefore, it becomes important to configure the CCTV system in such a way that, according to the occurring situation, at a given moment the user can obtain the most complete and adjusted to the current needs information. This may concern: checking the protected area, confirmation of violation of a given zone, recognition of an intruder or analysis of the created risk. In this article, attention is paid to the new functional capabilities of the CCTV systems and the effect of algorithmic support on the work of the system operator [3, 4, 6, 7, 9, 21, 22, 26].

The objective of the study is to attract attention to the possibilities of reducing the work load of the CCTV system operator related with the performance of the surveillance process by appropriately adjusted and selected technical means, which would allow the support of the decision-making process and of the process of controlling the work of individual elements of the CCTV system by the operator. The scope of study covers the presentation and analysis of technical means enabling an improvement of ergonomics while using the system through the application of a computer camera. The technical means presented in the article allow the supporting of the tasks related with identification of hazards as well as the tasks associated with the work of CCTV system equipment, due to the use of image processing techniques for the analysis of the recorded image. The presented concept is based on the use of individualized virtual steering systems adjusted to an individual object, which enable the performance of algorithm for simultaneous steering PTZ camera, and therefore reduce necessary activities by the user while performing tasks related with the surveillance in the protected object.

CCTV VISUAL MONITORING SYSTEMS

A visual surveillance system is used for the observation of a specified zone under surveillance by means of proper equipment. Observation allows recognition of the situation in a given place and the state of this place. A picture image in the CCTV systems is the carrier of information enabling an assessment of the state of safety in the object, identification of hazard, and evaluation of its effects. A visual surveillance system (Fig. 1) includes basic elements for recording the image (observation subsystem), elements for visual signal transmission (transmission subsystem) and for its display (reception subsystem), as well as supplementary systems (subsystems) for archiving the recorded image and steering the settings of individual elements of the system (cameras, turntable, etc.) [13, 20, 24].

The camera is the basic element of each visual surveillance system. Two types of cameras may be distinguished according to their functions in a system: fixed and tube cameras or dome cameras. Usually, fixed cameras are applied for the observation of general surveillance zones, whereas dome cameras – due to more possibilities of settings – for surveillance of especially important (neuralgic) zones in a protected object. By changing the parameters of the optical system of the camera and its setting, it is possible to adjust the size of the surveillance zone observed to the current requirements of the user. A change of the PTZ parameters (P – pan, T – tilt, Z – zoom) is possible by using the controls.

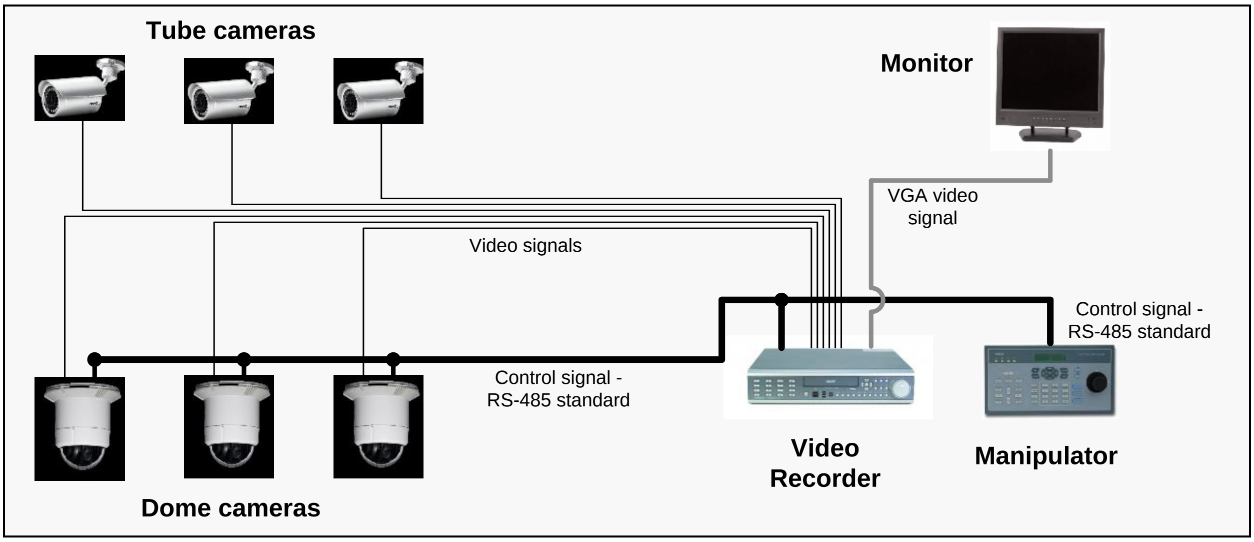

Fig. 1. Scheme of installation of CCTV visual system monitoring

All the elements of the CCTV system are combined from the technical aspect, and may be presented using the system of a star-shaped structure. The major component of such a system is the component managing the work of the system, using individual functioning units for the performance of its tasks. Functional units allow the provision of the managing component with indispensable information. In the CCTV systems, these units are cameras. The managing component are physical elements which enable the recording, archiving and display of imaging information and steer the work of individual hardware available within the CCTV system. Surveillance over these elements is executed by the system operator. From the aspect of organization, the control room is the place where operator's tasks are performed. The control room is the primary functional unit of the control centre, a distinguished physical space related with the performance of steering and surveillance tasks, where there are operators performing the tasks, including steering, surveillance and management of the CCTV system. The main instrument of an operator's work is the control system. Often, in construction objects, in control rooms there are elements controlling and imaging many control and surveillance systems (Fig. 2). The placement of decision-making systems in one place helps to obtain a better organization of the work of operators of individual systems, characterized by quicker information exchange and making coherent decisions associated with the functioning of an object, as well as responding to the occurring hazards.

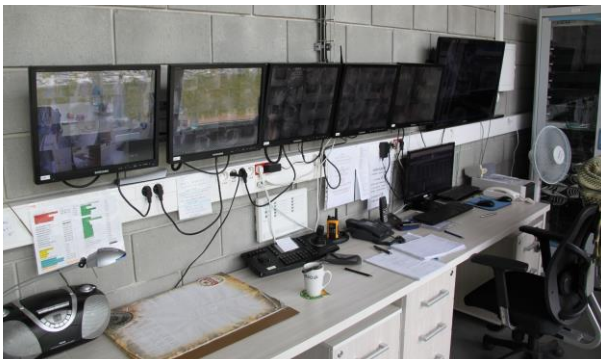

Fig. 2. Control room in control and surveillance systems, including CCTV visual monitoring system

ERGONOMICS AT WORKPLACES OF CCTV SYSTEM OPERATORS

Work conditions of an operator of the control room in CCTV visual monitoring depend on the construction of elements of the computer workplace, spatial structure of the workplace, and elements of the material environment exerting an effect on the operator. The elements of equipment at a workplace (e.g. table, chair, monitors, keyboard, manipulators), their spatial distribution and the effect of the physical environment, should neither cause an excessive muscle-skeletal and vision load at work nor create a source of risk for the operator. Computer workplaces should fulfil the minimum requirements of occupational safety, work hygiene and ergonomics [23].

The work of an operator of a CCTV system is performed in a sitting position and is associated with long-term observation of screens. Therefore, special attention should be paid to the parameters of a workplace which are responsible for assuming a correct body position and provide optimum conditions for visual work. Elements of equipment at a workplace to be observed should be placed within the operator's visual range, while the elements which are most frequently observed, i.e. monitors – within an optimum range. It often happens that the operator's workplace in a control room is equipped with several monitors of computer sets. In such a case, special attention should be paid to the distribution of screens and input devices with relation to the operator. The size of the surface occupied by signalling devices (monitors) is a very important factor. It is considered that the best solution is the distribution of devices on a spherical surface, the radiant being equal to the distance between operator's eyes and the control panel. In the case of using several screens/monitors, the obtaining of such a distribution is hindered. An advantageous solution is the use of a system which, viewed from above, resembles the letter V, letter U or semicircle. In addition, information displayed on the subsequent monitors should be distributed in accordance with the principle of functionality, importance, order and frequency of use [26].

The use of ergonomic software with clear graphics and uncomplicated operation equivalent to the tasks performed, which provide the possibility of adjustment to individual needs, experience and level of knowledge of the system and applications operator, allows the reduction of psychological load and stress at work. Monotony of work, amount of information received by an operator, and importance of decisions made also affect psychological effort and feeling of fatigue.

Work at a workplace of a computer hardware and electronic CCTV system operator consists in the performance of assumed protection goals. The task of an operator is especially the management of system elements settings, including the adjustment of parameters of PTZ dome cameras, reaction to the events recorded, and control of the correctness of CCTV system operation. Monitors equipped with an appropriate graphical user interface serve the communication between the user and the system. Work conditions at a workplace equipped with a screen monitor (monitors) should provide the operator with safety and comfort while performing work and, consequently, result in not committing mistakes by the operator.

Thus, the task of the person performing management processes in the CCTV system is controlling the state of the object, watching over the correctness of the course of the process of registration and control, initiation of individual phases, procedures and functions, as well as interference in the case of irregularities. The characteristic feature of the surveillance process is constant tracing of information in the form of an image recorded by cameras, interpretation of video material and making corrections in the settings of cameras in the case of deviations from the assumed profile, as well as making decisions in the situation of detection of hazard or an irregular state threatening the correct functioning of the object.

COMPUTER SYSTEMS SUPPORTING THE WORK OF CCTV SYSTEM OPERATORS

Computer systems for registration, control and surveillance enable the collection of data, data processing and presentation to the operator in an adopted way. The tasks of an operator consist in the observation of information occurring on the screens of imaging equipment, display of indispensable information concerning the state of the process, introduction of supplementary information, assessment of the situation, decision-making and introduction of these decisions into the computer system [5, 6, 7, 15]. A correctly constructed system supports the work of an operator by the performance of monotonous, repeated procedures and activities; however, it does not replace the operator in the decision-making process. The computer system performs algorithms and procedures which, due to arduous but precisely specified tasks, may take time and distract the operator's attention away from the main goal, which is the management of safety in the object under surveillance. Expanded hardware interface (a component of information exchange technology), supplemented by software creating a graphical user interface, enable an exchange of information between the operator and the system. Work with an inappropriately designed interface may also be the source of noxiousness for the operator, resulting in a quick feeling of fatigue or stress, which may lead to the commitment of mistakes and lack of meeting the requirements with respect to the quality of tasks performed [9].

The correctness of decisions made by an operator depends on the possibilities of perceiving signals and understanding information contained in them. Control devices should enable an individual an efficient, safe and correct performance of the process of steering, through the optimization of communication between the operator and the technical system. The workplaces of operators are usually equipped with many signalling and steering devices. Their correct design (e.g. location, size) and work conditions may exert a great effect on the number of mistakes committed by an operator and his fatigue [26].

In the case of CCTV systems, the computer support of the work of the system operator may be related with the performance of processes allowing the use of information technology equipment for the analysis of video material recorded by cameras (supporting the process of identification of hazards), and algorithmic performance of the process of control of equipment available within the CCTV system (supporting the control process). The role of computer and software support of the process of managing the work of the CCTV system may be associated with the performance of the following tasks:

- supporting procedures related with identification of hazards (limitation of the human factor in the process of video material analysis).
- automatic setting and positioning of PTZ dome cameras (possibility of simultaneous steering the settings of many PTZ cameras);
- cooperation with other systems of surveillance and creation of one integrated system allowing mutual exchange of information between individual elements of the system (reacting to signals related with the detection of hazard from the alarm systems);
- instruments supporting the control process (touch screen monitors, voice control).

Computer support of the process of identification of hazards

Computer systems supporting the process of identification of hazards are used for the detection of selected, precisely specified features of the image. They are based on the process of processing and analysis of the image, performed on the video material recorded. In order to find specified qualitative and quantitative parameters of the given feature of image pattern, the techniques are used based on the processes of filtration, segmentation and indexation. The final stage of the recognition process is the decision-making. Most frequently, the qualitative features subjected to analysis are colour (specified content or change in the components of RBG image) and shape. In turn, the quantitative parameter is specified based on the number of elements of the image (pixels) subjected to a given characteristic area.

Computing processes concerning the processing of the stream of data pertaining to the video material recorded are defined as techniques and methods of image processing or imaging techniques. They are equivalent to the term digital image processing, and contain methods related with detection, acquisition and processing of an image, its display, as well as its recognition and generation [10, 11, 12, 14, 25].

The performance of tasks associated with identification of changes in the video material recorded and recognition of assumed image patterns do not have to be related with the use of the whole video signal recorded. For this purpose, it is enough to compare the declared features of the image (quantitative or qualitative parameters) on the photos selected from the entire video sequence. The selection of subsequent photos for comparative analysis may take place on the principle of a constant or changeable time key algorithm. In the case of comparative analysis of image parameters it is important to specify the area in which the desired feature may occur, and the scope of parameters, which are characteristic for a given pattern. For the needs of identification of the assumed pattern, one may also be limited to analysis of selected components of the RGB image. Due to this, as early as at the beginning of the process of image recognition, it is possible to define threshold values or dynamics of changes of individual components of the RGB image. Thus, it is possible to narrow the area of seeking the pattern, shorten the duration of analysis of individual areas and increase the possibilities of authentication of the occurrence of a given feature in the image as well as increase the scope of comprehensive analysis of the recorded material.

The basic assumption of the designed software algorithm, enabling the obtaining of the goal related with supporting the process of hazards identification, was the use of material processing method in such a way that the number of computing operations performed enabled the recognition of quantitative and qualitative changes taking place in the video material recorded, and did not affect the stable work of the system in on-line mode. Fig. 3 presents the block diagram of the programme algorithm.

The main information technology instruments used in the process of identification in the recorded video material of important changes in the image parameters were image processing techniques. The methods related with both contextual and non-contextual methods of image processing were used (convolution filters and threshold filters) [12, 25]. Based on the obtained imaging data concerning individual photos, characteristic image parameters were determined related with histogram and number of points classified into border areas between the

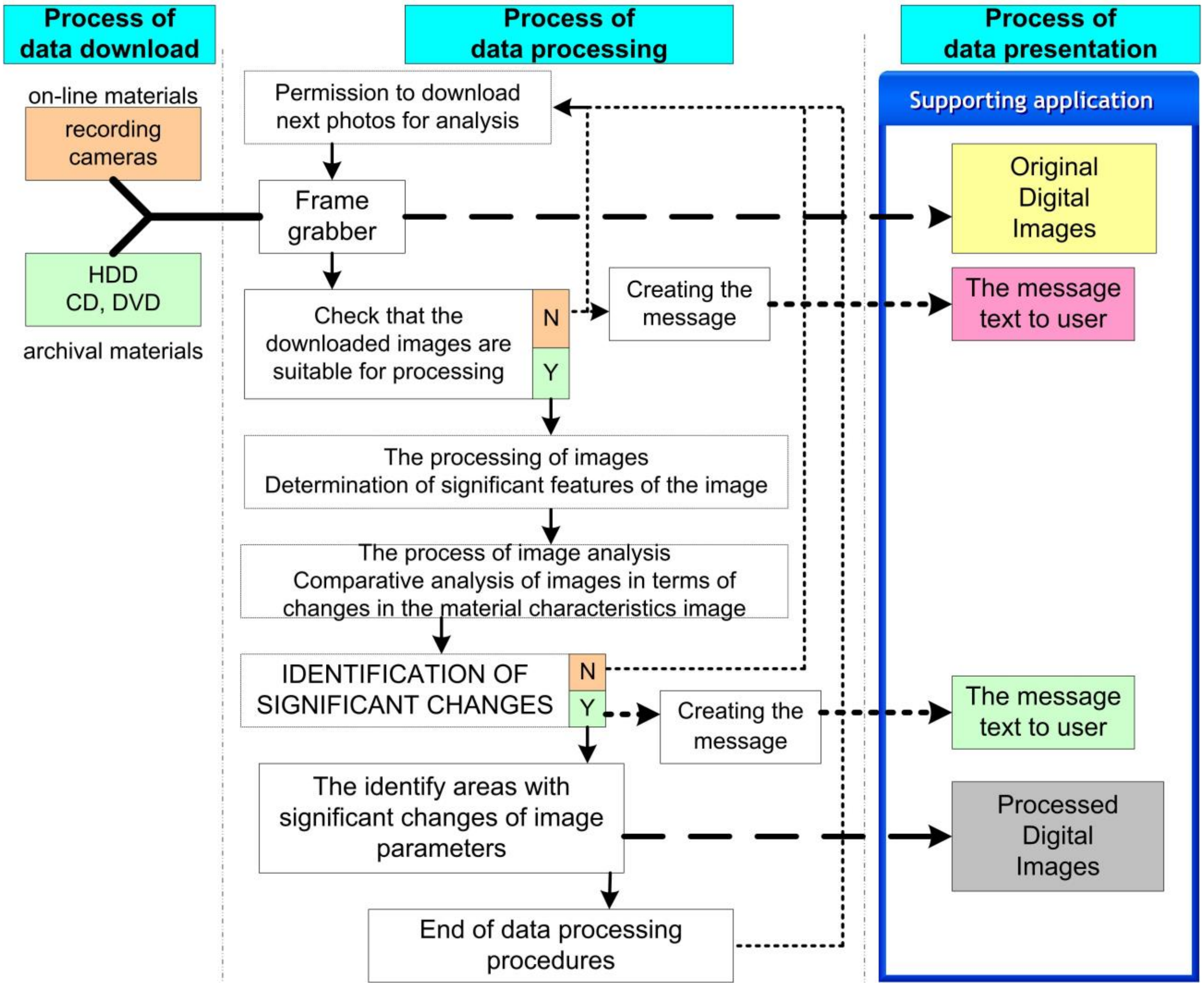

Fig. 3. Block diagram of algorithm enabling the support of the process of identification of hazards

distinguished structures of the image. Individual imaging data concerned both the whole image and its selected parts; thus, the process of analysis of changes could be more precise. The situations which might evidence the occurrence of an irregular situation were determined based on comparative analysis of image parameters occurring in various images.

The preliminary selection of video material is followed by the stage related with the processing of video material enabling the distinguishing of the assumed qualitative and quantitative image parameters. This stage begins with the procedures associated with image filtration enabling the preparation of individual images for analysis. The filtration methods applied were limited in this case to convolutional image processing using averaging and gradient filters. The key stage of the process of video material processing is the stage of determining qualitative and quantitative parameters concerning the whole image. Based on the processed photos obtained after the filtration of the video material, parameters are determined concerning the character of individual areas. The final task associated with the detection of disorders in the recorded image is a comparative analysis of qualitative and quantitative parameters for the subsequent images analysed.

Computer support of the control process

The main problems and inconveniences occurring at the work of operators in association with the steering process performed in the CCTV system equipped with hardware manipulators are as follows:

- Lack of adjustment of parameters steering the settings of cameras to the reality and characteristics of the object. Lack of adjustment of the steering system based on the spherical coordinate system (Φ, θ, r) to the behaviour of people moving about in the observed zone (Cartesian coordinate system x, y, z);
- Necessity for constant switching of steering options on a hardware manipulator in the case of surveillance over a given zone by a larger number of cameras. Lack of possibilities of simultaneous steering of settings of many cameras. The control of the system's work may take place by steering only one camera within a given time. In order to change the settings of other cameras it is necessary to change a number of turntables in the hardware manipulator. Therefore, the procedure for the quick adjustment of settings of many cameras onto the selected segment of the zone may be time-consuming;
- Standard procedures of calling individual functions non-adjusted to the specificity of a given object. Lack of clear classification of programme settings. Due to the lack of readable procedures and information concerning current settings, the calling of the functions planned (a given pre-set or patrol path) may take a considerable amount of time, which is especially important when an inexperienced operator works with the system.

Computer support of the process of steering an operator's work is primarily relieving the operator from arduous organizational-procedural tasks. The occurring factors restricting the work of the CCTV system operator are procedural factors related with specific and precisely defined procedures for steering and calling individual functions [4, 6, 10, 15, 16, 19, 22]. Therefore, there is a possibility to improve the effectiveness of the work of an operator by using information technology instruments aimed at improving the steering process. It is possible to construct an application steering the work of dome PTZ cameras in the CCTV system, adjusted to the given type of logistic infrastructure (size of an object, number of cameras, setting and mutual connection of presets of these cameras) using the assumed algorithm of work of the system. This also enables the adjustment of the application to a sometimes dynamically-changing situation in the protected object (e.g. change of technology). Fig. 4 presents the procedure for the creation of individualized application for supporting management and steering the work of dome cameras by CCTV operators.

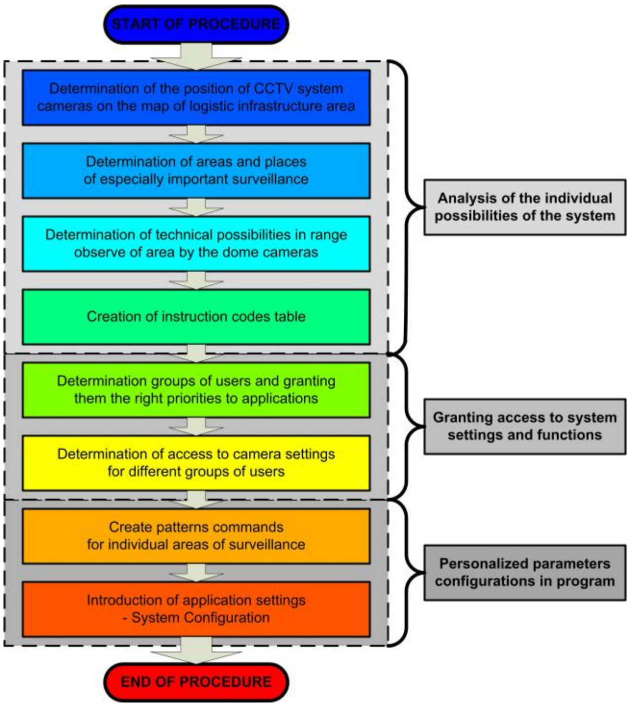

Fig. 4. Procedure for creating an application for steering the work of PTZ dome cameras

Computer support of the process of steering settings of PTZ dome cameras installed in the CCTV system is related with the modernization of the classic model of a visual monitoring system. The classic CCTV system presented in Fig.1 is an autonomous system constructed of elements used only in these systems. The disadvantage of such solutions is their closeness, both hardware and functional. The goal of modernization of the classic CCTV system (Fig. 5) is to increase the functionality of the system. The primary task of the application is generation of the communication signal into the control system (string of instruction codes) enabling the adjustment of dome cameras to the selected neuralgic surveillance zone. PTZ cameras are steered by calling the procedures of previously defined pre-sets of cameras.

An important element in the design stage of a CCTV system is the determination of the surveillance zones in the area of the protected infrastructure, both the general surveillance zones (Fig. 6) and detailed surveillance areas (Fig. 7). The determination of certain neuralgic areas should be based on an analysis of the possibilities of hazard occurrence in these areas, or performance of the control and surveillance function over the flow of people and property. Therefore, it is important to distribute the elements of the CCTV system, especially dome cameras, in such a way that these tasks are performed in the best possible way. Such observation should take place only in strictly determined conditions (e.g. as a result of the occurrence of hazard), and one dome camera may be used for the surveillance of several neuralgic zones.

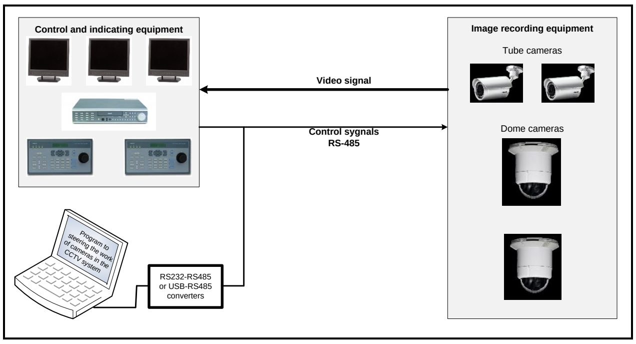

Fig. 5. Conceptual scheme of monitoring with a built-in module of simultaneous steering the settings of PTZ dome cameras using a computer application

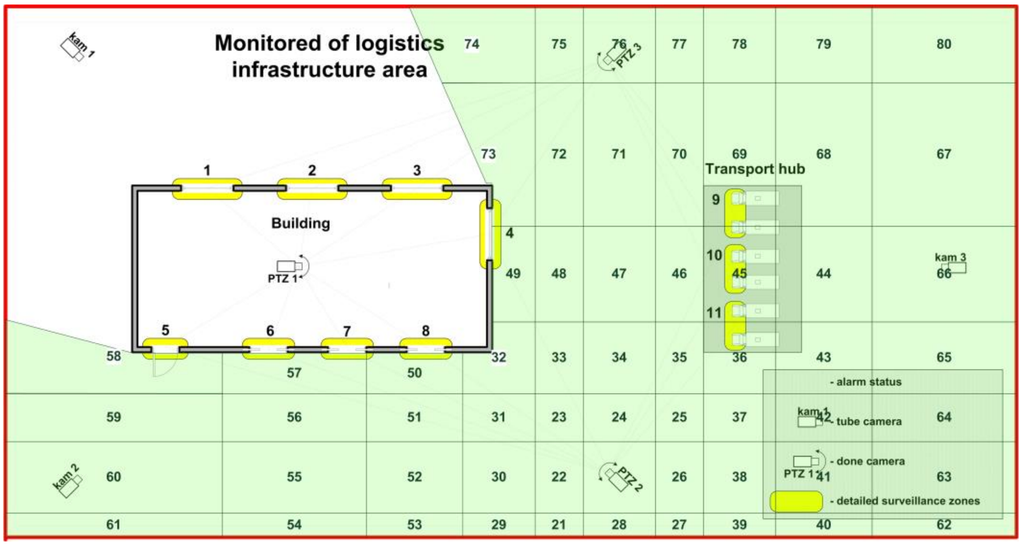

Fig. 6. Territorial scheme of an object with marked zones of general surveillance for PTZ2 camera with equivalent pre-sets

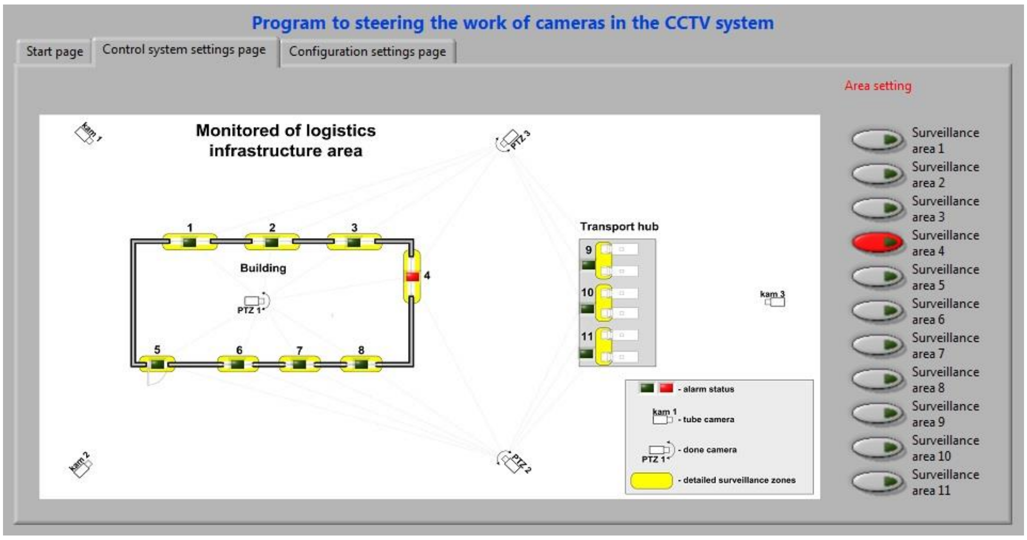

Fig. 7. Territorial scheme of an object with marked zones of detailed surveillance areas

Areas related with pre-sets for all the PTZ cameras within the CCTV system are created in the way similar to the zones of general and detailed surveillance zones presented in Fig. 7 and Fig. 8. The particular areas are field areas which are equivalent to certain areas of the dialogue box of the software displayed on the monitor screen. Thus, to each pixel in a synoptic map (field scheme) of the protected object links are ascribed referring to executive procedures calling precisely determined pre-sets of all the cameras falling within the CCTV system.

The task of an operator is no longer the manual change of settings of the subsequent cameras, but the calling of a procedure on the screen using a computer mouse. There is also a possibility to equip the workplace of a CCTV operator with a touch screen monitor. In this case, the calling of an optional procedure takes place directly on the monitor screen. The presented solution, on assumption, is aimed to support the work of an operator. This is possible by relieving the operator of the performance of the arduous manual process of calling the subsequent settings. According to this solution, the operator calls field areas in a synoptic map of the protected object. The areas are equivalent to the actual areas in the zone. Therefore, an additional advantage of the solution is its intuitiveness related with the simple calling of certain functions.

CONCLUSIONS

1. The correct functioning of the system of visual CCTV monitoring is based on the co-functioning of the operator and the system as well as the correct use of the available equipment by the system operator. Therefore, it is most reasonable to equip the operator not only with the best equipment enabling the registration and archiving of the video material, but also with elements of additional system equipment which would relieve the operator of performing unnecessary, complicated and time-consuming procedures. In the opinions of the authors, such a solution is the use of a programme platform dedicated and adjusted to the characteristics of the object, which would enable the calling of complex procedures and functions directly from the application window. The role of an operator is limited to the choice of a given function, without going deeper into the method of its performance. In such a case, the operator may be occupied with the observation of the object, and not the performance of tasks related with the correct performance of the steering process.
2. Supporting the process of identification of hazards by technical means associated with the processing of the image recorded by CCTV system cameras allows an increase in the efficacy and quality of work of an operator. Due to the computer support system of the hazard identification process, the operator of the system does not have to trace the image on all the screens but may focus on the observation of selected images, where the system supporting the operator's work has observed irregularities. In this case, the role of an operator is related with the process of interpretation of the abnormal situation observed and making a decision concerning the undertaking of further measures. The system supporting the process of hazard identification results in the removal of the operator from performing arduous, wearisome activities related with the observation of monitor screens. Due to this, the operator is capable of better management of a more expanded system.
3. The provision of a classic CCTV system with computer systems supporting management and steering the settings of dome cameras enables a quick and simultaneous preview of the selected neuralgic zone in the protected object by all the cameras available within the system. The operator's task is selection of the area of interest in the synoptic map of the object. A change of current settings of cameras for the settings related with the preview of the specified area in a given camera pre-set takes place smoothly and maintenance-free. This considerably shortens the time of the system settings change, compared to the manual operation of the controls.
4. Further integration of the system of settings control of dome PTZ cameras with other protective systems (signalling systems Intruder and Hold-up Alarm Systems (I&HAS), access control systems (ACC) and fire detection and fire alarm systems, allows an automatic change of the settings of cameras in order to preview a given zone at the moment of occurrence of risk, or for the time related with the course of a complex procedure.

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