Preface

Video surveillance techniques and technologies have improved and matured drastically over the past several decades. Internet Protocol technology, digital video cameras, and intelligent video analytics have taken over analog tapes and security personnel. Especially tremendous advances in video surveillance technologies happened over the past few years, as well as significant decreases in the cost of those technologies. As a result, there has been an explosion in the use of video surveillance as this evolution provides organizations with significant opportunities to improve security and reduce operating costs.

Considering increased terroristic activities all around the world, public agencies are faced with a critical need to protect citizens and assets from possible threats with a security system that enables rapid response to security breaches and prompt investigation of events. Besides governmental institutions, various businesses, municipalities, agencies, educational institutions, mass transportation centers, financial institutions, utility plants, and medical centers must also plan for threats and protect the security of their assets, employees, and clients. The critical areas that need video surveillance are: public zones where increased threats have caused many government agencies to apply video surveillance systems, university and school campuses' entry and exit points which prevents vandalism, airports, seaports, and railways where mass transit businesses and agencies protect passengers, staff, and physical assets from terrorist threats and security breaches, retail stores where video surveillance reduces fraud, theft, and administrative errors, financial institutions with 24/7 human video surveillance requirements needed in order to reduce threats of robbery and fraud.

The oldest version of video surveillance systems and the most widely used is an analog video surveillance system that uses analog video cameras coupled with closed-circuit television. Closed-circuit television represents the first generation of visual surveillance. German scientists deployed it for the first time in 1942 for remote monitoring of rocket launches. In 1969, the London Metropolitan Police used two temporary cameras in Trafalgar Square to monitor Guy Fawkes Day activities, which represented its first "open-street" application. These systems are used for online monitoring and recording movement of people and property. The drawbacks of these systems are: huge amounts of video-tapes that must be manually viewed by security guards which is a tedious, boring, and inefficient task, the necessity of security personnel to monitor hundreds of cameras, poor image quality, storage and deterioration of videotapes, lack of the ability to distribute video information across the network and to automatically extract useful information.

Invention of digital video cameras, IP video cameras, networked video recorders, Web video, consumer cameras, video processing intelligent algorithms, and application of automated signal analysis and pattern recognition to video cameras and sensors introduced intelligent digital video surveillance systems. These systems automatically extract useful information from video and sensor streams in real-time by detecting security incidents. They eliminate the need for monitoring and reviewing videotapes and enable integration of multiple events captured from various video analytic technologies and non-video sensors

simple and easy. These systems provide a wide range of queries on events that may or may not have been previously defined as alerts, remote monitoring and analysis of events, real-time alerts for known "threat conditions," events and patterns of the past to be used to help predict potential threats, capability to track human movement used to study and understand traffic patterns, capability to carry out efficient data analysis of video sequences, either in real-time or recorded video and real-world events via sensors (video cameras, radar, or audio inputs). Web networking gives these systems the functionality to virtually anytime and anywhere access real-time and historical event data.

Motion detection, movement and color analysis, and people counting are available as commercial off-the-shelf products with a decent track record, but the quality of these functionalities in commercial domain is difficult to determine. Intelligent video surveillance systems are applied in many domains on CCTV systems, either distributed on the cameras or centralized on dedicated processing systems. Implemented video analysis often coexists and complements audio analysis.

The terrorist attacks of 9/11 as well as the Boston marathon accident that happened more recently raised the public awareness of security issues as well as tremendously increased the importance of intelligent automated video surveillance systems placed in public spaces.

The book *Video Surveillance Techniques and Technologies* offers, described in detail, various original mathematical models and algorithms aimed at automatic video sequence analysis with the goal to detect, track, and identify moving objects based on a sequence of images. It also includes biometric algorithms for anthropometric measurements and iris recognition. The main value of this book lies in its practical implementation in numerous domains and wide spectra of applications like video surveillance, homeland security, military aircraft radar ISAR image analysis, healthcare, quality control, industry, safety, etc. These algorithms can be implemented as software either on general purpose machines or in specialized video processing units.

This book is aimed to be educational material for graduate students as well as a source of valuable information for high-level professionals who build intelligent automated video surveillance systems in the field of signal and image processing applied in static/moving object detection, tracking, and identification. The described mathematical algorithms are employed in security video surveillance systems with a wide variety of applications; some of them are of high priority and important: homeland security and national defense.

This book is the result of my years-long research efforts and acquired experience, which is published in numerous proceedings and journals. The early chapters offer original solutions and mathematical algorithms for the motion detection and object identification problem. They are research-oriented and highly theoretical with the offered simulation results and proofs. The last chapters are oriented towards more practical aspects such as proper digital video equipment selection and more detailed information regarding camera and other video equipment element description. The book also provides IP video surveillance systems data, its basic functions, the advantages of network video, and customizing surveillance applications. It provides explanations related to motion detectors that represent the physical realization and practical application of the algorithms and mathematical solutions offered in the early chapters. Information concerning design guidelines, hardware information, specific examples, and necessary parameters to be addressed while designing representative security video surveillance system applications is also presented.

SECTION 1: MOVING OBJECT DETECTION ALGORITHMS

A new, simple, fast, and effective method for moving object detection to an outdoor environment, invariant to extreme illumination changes, is presented as an improvement to the shading model method. It is based on an analytical parameter introduced in the shading model, background updating technique, and window processing.

A new improvement of a method for the detection of moving objects from image sequences is described. This improvement permits reliable detection of moving objects even in the case of large and fast changes of scene illumination.

A real time change detection technique is proposed in order to detect moving objects in real image sequence, independent of the illumination of the analyzed scene. It is based on comparison of corresponding pixels that belong to different frames and combines time and space analysis, which augments the algorithm's precision and accuracy.

The problem of edge-based classification of natural video sequences containing buildings and captured changing lighting conditions is addressed. A strategy is devised in which a fuzzy rule-based classification technique is combined with a method for changing region detection in outdoor scenes.

The efficiency of the described techniques is illustrated on a real world video sequence recorded under significant illumination changes.

SECTION 2: MOVING OBJECT DETECTION ALGORITHMS AND ITS APPLICATIONS UNDER VARIOUS CONDITIONS

An integrated multimedia supported intelligent video surveillance system is proposed. The system alleviates the disadvantages of the existing video-surveillance kits and provides advanced search, notification, visualization, and alarming functionality through integration of artificial intelligence, motion detection and tracking technology, multimedia databases, and Internet/cell phone connectivity.

The resistance of the improved moving objects detection algorithm to various types of additive and multiplicative noise is discussed as well. The algorithm's first phase contains the noise suppression filter based on spatiotemporal blocks including dimensionality reduction technique for a compact scalar representation of each block, and the second phase consists of the moving object detection algorithm resistant to illumination changes that detects and tracks the moving objects.

Performance of the moving objects detection algorithm on infrared videos is discussed. The algorithm has two phases that comprise the noise suppression filter based on spatiotemporal blocks including dimensionality reduction technique and the illumination changes resistant moving object detection algorithm that tracks the moving objects.

A technique that improves precision in classification results using information extracted from video features is introduced. It combines fuzzy rule-based classification with a method for changing region detection in outdoor environment, which is invariant to extreme illumination changes and severe weather conditions.

SECTION 3: SHAPE RECOGNITION ALGORITHMS

The natural process in automated video surveillance systems is to perform correct shape recognition and object identification after the desired moving object is correctly detected.

Two new model-based algorithms for shape recognition are proposed. The proposed algorithms are efficient and tolerate severe noise. They have the ability to identify the close match between the noisy polygon that has a significantly greater number of sides and the assigned polygon. They work for convex and concave polygons equally well. These algorithms are invariant under translation, rotation, change of scale, and are reasonably easy to compute. The proposed criterion is a metric. The polygonal shapes are compared based on their areas and gravity centers.

A two-step process for removing noise from polygonal shapes for the purpose of easier and more efficient shape recognition is presented in this chapter. A polygonal shape is presented as its turning function and then a nonlinear diffusion filter and triangle method are applied. The obtained results demonstrate that the proposed technique successfully removes vertices that should be dismissed as noise while preserving dominant vertices that can be accepted as relevant features and give a faithful description of the shape of the polygon.

SECTION 4: OBJECT IDENTIFICATION ALGORITHMS AND THEIR APPLICATIONS

Two different novel algorithms are offered that can identify aircraft categories from Inverse Synthetic Aperture Radar images that use both the radar reflection pulse shape and the Doppler shifts of different parts of the aircraft. The first method forms numerical equivalents to shape, size, and other aircraft features as critical criteria to constitute the algorithm for their correct classification. The second method compares each ISAR image to unions of images of the different aircraft categories. The obtained results indicate that in most parts of the holding pattern the category of the aircraft can be successfully identified with both proposed methods.

Automatic body detection and identification of a person is one of the most recent research topics that has gained a lot of attention from researchers. Automated systems that will store human biometrics along with personal information can be of a significant assistance in investigations and security issues.

Another topic in this section is a comparative study of the ability of two novel image retrieval algorithms to provide automated touch-free identification of persons by iris recognition. Numerical experiments on a real biometric database indicate feasibility of the presented approach as automated iris recognition tool without special image pre-processing.

SECTION 5: VIDEO SURVEILLANCE APPLIED IN INDUSTRY AND QUALITY CONTROL

The goal of automatic pattern classification of real metallographic images from the steel plant ArcelorMittal Ostrava is to monitor the quality process in the steel plant. The number and sizes of dark dots produced by the production procedure imperfections are automatically determined; that represents a measure of how imperfect each plate is.

Steel Companies use a ladle furnace refining process that refines under a non-oxidizing atmosphere and supports slag-metal reaction through stirring by Ar gas injection. The automatic software capable to analyze the homogeneity of the surface and characterize features of the molten steel level such as presence of slag clusters is developed.

A new heuristic algorithm for porosity segmentation for the colored petro-graphic images is proposed as well. The algorithm automatically detects the porosities that represent the presence of oil, gas, or even water in the analyzed thin section rock segment based on the color of the porosity area filled with dies in the analyzed sample.

A comparative study of the ability of the proposed novel image retrieval algorithms is performed to provide automated object classification invariant of rotation, translation, and scaling. Simple cosine similarity coefficient methods are analyzed. Numerical experiments on real database sets indicate the feasibility of the presented approach.

SECTION 6: VIDEO TECHNOLOGY OVERVIEW

The first chapter in the following section is a description of the technology with which we can: capture an image, transform the image to the video signal format, transmit this signal to a remote location's receiver, display the image on a monitor, and save the image and print it for preservation.

High definition television is becoming ever more popular, opening up the market to new high-definition technologies. Image quality and color fidelity have experienced improvements faster than ever. The video surveillance market has been affected by high definition television demand. Since video surveillance calls for large amounts of image data, high-quality video frame rates are generally compromised. However, a network camera that conforms to high definition television standards shows good performance in high frame rate, resolution, and color fidelity. High quality network cameras are a good choice for surveillance video quality.

Industry experts are predicting that the advancement of video security technology will lead to a general increase in demand for surveillance systems. Over the next ten years these technological advances will continue, improving existing equipment and generating new methods. The next chapter outlines technologies that are currently in their infancy but are expected to be integrated into security systems in the near future.

A video surveillance system design requires making decisions that demand knowledge of basic options and the rationale for selecting from different ones available on the market. One needs to face making the following key decisions:

1. Choosing the best video surveillance companies.
2. Camera types.
3. Camera connection to video management system.
4. Video management system types.
5. Storage type.
6. Video analytics type.
7. Surveillance video display.
8. Integrating video with other systems.

SECTION 7: DEVICES AND APPLICATIONS

The very first element in the video surveillance system is the device that captures the images, which is the camera. “Cameras” is very important chapter in the book as it discusses the concepts of analog and digital cameras, their various designs, and camera specifications. Proper camera choice as well as setting is a very important issue in video surveillance system installation and design.

The next chapter in this section is a summary of IP surveillance systems: basic functions, the advantages of network video, customizing surveillance applications, and possible legal concerns. The most important step one can take before installing an IP surveillance system is to define goals and requirements. Once these are determined, the video system can be set up. The required goals to be determined are the following: definition of the video surveillance system needs (installation plan, area of coverage, camera positioning, illumination conditions determination, camera cabling, the recording server positioning), network camera and/or video encoder selection (image quality, lens selection, network camera selection, Power over Ethernet [PoE], video motion detection, audio, accessories selection, testing), hardware (switches, additional light sources, power supplies, additional server for video management software, hard drives), software (software package selection, licenses, image quality and frame rate requirements, IP address range calculation, hard disk usage calculation, cameras configuration, video motion detection settings, user access definition), and maintenance.

The first five sections represent the foundation and offer various intelligent algorithms that are the basics for motion detectors and their realization. There are two classes of security system alarm triggers: physical motion sensor and visual motion sensors. Both analog motion detectors and digital motion detectors belong to the group of visual motion sensors. Digital motion detector systems should differentiate between activities that are acceptable and those that breach security. When security-breaching acts occur, the system should identify the individuals and instruct security personnel what to do. Motion detectors can surveil, detect, and assess, as well as analyze information and distribute information to security personnel. Motion detector systems drastically reduce the load of footage that guards must watch for a long period of time.

Automated motion detectors are now a standard for serious medium to large security installations; they are necessary for high detection capabilities. All security systems must have an alarming device to signal the guard of irregular motion in a scene, even systems that have a tiny or huge number of cameras.

The fact that video surveillance is such an effective system especially when one thinks of its widespread use attests to its low investment cost. The last chapter contains information about design guidelines, hardware information, specific examples, and necessary parameters to be addressed while designing representative security video surveillance system applications: protection of all assets and personnel, calculation of the overall cost of the video system, surveillance target (assets and/or personnel), surveillance timing schedule, type and number of cameras needed, camera placement, field of view required, console room monitoring equipment, number and types of monitors, number of displays per monitor, number and type of recorders, digital recording technology needed, type of video switchers, type of video printer, if additional lighting is required, if intensified or thermal IR cameras are required, if sensors at doors, windows, and perimeters that are integrated with video signals are needed, digital video motion detectors placement, IP cameras, type of signal and video transmission, type of digital transmission, type of 802.11 protocol, type of compression (MPEG-4 or H.264), and the necessity of encryption or scrambling.

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