Preface

Driven by technological improvements, the noninvasive nature of cameras, affordable prices, security concerns, and federal government grants to aid fighting terrorism, camera utilization has become an integral component of our daily lives. Cameras are pervasively used for surveillance and monitoring applications such as traffic monitoring, monitoring commercial vehicles, and surveillance at schools and parks.

Current video surveillance systems operate in Close-Circuit Television (CCTV), where data collected by camera are analyzed by operator or stored on a central server for further processing. While capabilities of video-processing and communication systems have significantly increased in the recent years due to advances in video sensing technologies, the amount of data being produced by such systems is becoming increasingly difficult to manage. For instance, video sequence of HDTV format (1920×1080 pixels) at 30 frames per second with 24 bits depth per pixel requires 0.5 gigabytes per second in uncompressed form. The department of defense estimates a 5,000 times increase in the amount of sensor data for future assets in Theater and the amount of data produced by development systems like the DARPAs Autonomous Real-Time Ground Ubiquitous Surveillance Imaging System (ARGUS-IS) will be comparable to the 72 gigabytes that the human vision sends to the brain. Current and future systems will not be able to provide the bandwidth required to transport increasingly higher amounts of data. Furthermore, analyzing and understanding terabytes of data in real-time require computer architectures with capability far beyond the currently available systems and processing power of backend servers. Current and future communication systems, even with the most advanced video compression architecture, will not be able to provide the required bandwidth to transport such a datastream.

Smart cameras are capable of analyzing video data in the camera, close to the sensor, thus limiting the amount of data to be transported. Enhancing smart cameras with communication allows for collaborative scene and event analysis, usually in real-time, which further reduces the need for a central server. Events detected in one camera can be transmitted to a surrounding camera for contextual and geographical-related interpretation. Smart cameras can operate in stationary or mobile mode.

The benefit of this approach is illustrated in the following two real-life case studies. In the first example (Fig. 1a) a set of cameras are used for fall detection.

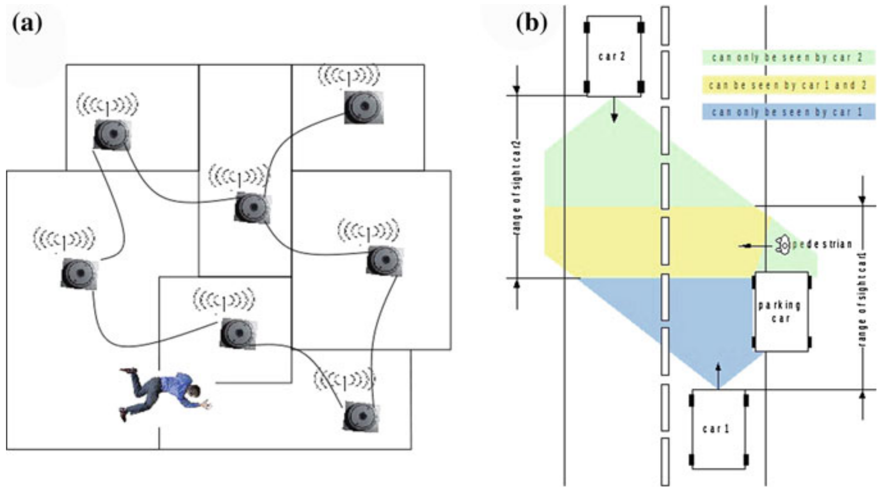

Fig. 1 Efficient visual perception with cooperative cameras **a** Cooperation detection of emergency situations in nursing homes **b** Occluded pedestrian becomes visible through cooperation

Each camera can cover only a partial area of the entire scene. To detect a fall the entire body must be available. In our example, only part of the body can be seen by each camera, none of which can infer a fall with this partial information. The collaboration will allow the camera to exchange partial information, which can be combined to infer the fall.

In the second example, consider cameras mounted on cars, with car-to-car communication capabilities. Figure 1b shows a traffic situation in which a pedestrian crossing the street cannot be seen by the driver of an incoming car. The pedestrian is occluded by a stationary car, which has the pedestrian in its field of view. This information can be sent to surrounding cars, so that their drivers can avoid an accident.

The design and deployment of collaborative smart cameras is a difficult task, which can be tackled only with multidisciplinary expertise. At the lowest level within single camera, VLSI expertise is required for designing optimal and smart CCD that can provide low-level operation on pixels. Computer architects are needed to design dedicated systems that reflect the behavior of most image understanding algorithms. The image processing expert will provide sound image understanding algorithms and machine learning method for information fusion. Communication expertise is required to design better protocols and paradigms for real-time information exchange.

Despite its relatively young age, research in multi-camera networks is becoming increasingly popular. The ACM/IEEE international conference on “Distributed Smart Cameras” is established and is the venue for researchers and developers to convene and discuss the most recent advances in the field. A comprehensive survey of the activities in this field has been provided in the book by Aghajan and Cavallero [1].

In this book, emphasis has been placed on embedded architecture for smart cameras and mobility, thus complementing the books by Aghajan et al. [1] and Bhanu et al. [2], whose emphasis has been mostly on fundamentals, algorithm and software, and stationary systems.

This book is organized into three main parts that better categorize the contribution. The first part deals with architecture and design flow, the second part handles smart cameras in the mobile environment, and the last part applications.

Part I consists of four chapters and covers architectures of smart cameras and their design flow. In Chap. 1, Wolf provides an overview of platforms and architectures for embedded smart cameras. The contribution analyzes algorithmic needs at high-level and presents various platforms with their expected performance. In Chap. 2, Ahmadinia and Watson give an overview of System-on-Chip solutions for smart camera. Chip miniaturization and increased density is leading the way to system integration in a single chip with the advantage of performance, robustness, miniaturization, and power saving. Ahmadinia and Watson investigate the landscape and present the recent development in System-on-Chip solution for imaging. Emphasis is put on processors, communication infrastructure, and memory. In Chap. 3 Bobda et al. present the benefit of using reconfigurable devices such as FPGA in embedded smart camera. Their smart camera is presented as prototyping platform, along with the hardware/software partitioning for vision application. A hardware middleware architecture is introduced, which has the capability of reducing communication delay among smart cameras, while reducing design burdens and increasing interoperability. Part I is completed with the contribution of Mefenza et al., which deals with design and verification of embedded smart cameras. An integrated design and verification based on OpenCV and SystemC is presented, which allows entire hardware/software systems to be captured at a high level of abstraction. Subsequent refinements are then performed until the final implementation, with the possibility of prototyping the entire design in the RazorCam, an FPGA-based camera designed at the University of Arkansas.

Part II deals with smart cameras in mobile environment. In Chap. 5, Martinel et al. give an overview of the landscape and recent developments in distributed mobile computer vision. They use case studies (augmented reality and surveillance) to illustrate the advantages of mobile and distributed computer vision. Future challenges on the integration of mobile devices as node in visual sensor networks are discussed. In the seventh chapter, Velipasalar et al. discuss the use of wearable cameras for automatic fall detection and activity classification. Methods for event detection and classification are explained and case studies conducted with the embedded CITRIC platform. In Chap. 6, Almagambetov and Velipasalar use embedded smart cameras mounted on vehicles to detect and track taillights of vehicles in front, recognize common alert signals, and counting the cars passing on both sides of the vehicle. They present the design and implementation of a robust and computationally lightweight algorithm for a real-time mobile vision system. Their emphasis is on low-power, with process scenes entirely on the microprocessor of an embedded smart camera.

Applications of distributed smart cameras are the subject of Part III. In Chap. 8, Wang and Aghajan first review detection and tracking approaches using single camera. Thereafter, they explore methods to combine images from multiple sources to enable tracking in a distributed smart camera network. As application, room occupancy estimation is used. In Chap. 9, Lee et al. discuss a self-organized and scalable multiple-camera system for tracking across cameras with nonoverlapping field of views. Using GPS locations of uncalibrated cameras, detection of camera link relationships is done based on routing information provided by Google Maps. Unsupervised learning is used here to compute network properties such as transition time and brightness transfer function. Self-organization is enforced by unsupervised learning, which allows to improve the scalability of the system. In Chap. 10, Chen et al. discuss the use of soft-biometric features for person identification. Such features, which are invariant to illumination and view changes, are integrated into the feature representation of a target. A reference set is used for track association, instead of the appearance of targets in different cameras. The reference set acts as a basis to represent a target by measuring the similarity between the target and each of the individuals in the reference set. In Chap. 11, Talla et al present a new technique for processing large and complex images, especially SAR images. The method performs computation in parallel and is based on a new modeling of textural parameters of a generic order $n > 1$ equivalent to the classical formulation, but which is no longer based on the co-occurrence matrix of order $n > 1$. While the work at first glance seems not connected to the topic of the book, a closer look shows that the presented parallel approach could be used for distributed processing and fusion of large images taken from different satellites or different UAVs with different perspectives. This extends the applicability field of multi-camera network to distributed remote sensing.

In the last chapter, Banerjee et al. present the use of smart camera as part of a set-up for distracted driver avoidance. The camera is used to analyze the pose and behavior of car occupancy to infer dangerous driving situations.

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