A Model for Improving Quality of Surveillance with Adaptive Smart Cameras

Presented by: Edwin Amakobe
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Abstract

Currently, Surveillance cameras stay on the alert and will capture as much information as their memory buffers can hold before transmitting it to remote processor. Smart cameras have inbuilt processing capability while standard cameras transmit all of the captured information for processing on a PC running the camera control system. Advancements in technology has led to these cameras being added some form of intelligence to monitor key events thus making them vital for use in various applications requiring real-time image processing. These include industrial inspection, robot vision, photo-copying, traffic control, automotive control, surveillance, security systems and medical imaging. In these applications, the size of the image can be very large, the processing time should often be small and real-time constraints should be met. Starting in the 1980's, many parallel hardware architectures for low-level image processing have been developed. They range from frame-grabbers with attached ***Digital Signal Processors (DSPs)****, to systolic pipelines, square and linear* ***single-instruction multiple-data stream (SIMD) systems, SIMD pyramids, PC-clusters****, and since a number of years, smart cameras as processors are becoming faster, smaller, cheaper, and more efficient, new opportunities arise to integrate them into a wide range of* ***CMOS processor devices****. Since there are so many different applications, there is no single processor that meets all the requirements of all applications. The processing done on a smart camera has very specific characteristics. On one hand, low-level image processing operations such as interpolation, segmentation and edge enhancement are local, regular, and require vast amounts of bandwidth. On the other hand,*

high-level operations like classification, path planning, and control may be irregular, consuming less bandwidth. This paper will focus on how to connect these cameras to an Artificial intelligence knowledge base for video and image processing [1] [2] [3]

Keywords: ***Digital Signal Processor (DSPs), Square and linear single-instruction multiple-data stream (SIMD) systems. Smart Cameras, CMOS processor.***

1 Introduction

A smart camera is one with some processing capability built in. This can take the form of a dedicated **field-programmable gate array (FPGA)**, **a digital signal processor (DSP)**, a fully-fledged CPU or CPU/GPU combination from a processor vendor such as Intel or AMD, or a CPU supported by an FPGA. With increase in usage of surveillance smart cameras, several challenges are posed. The major challenge is how to make this cameras adopt to the environments in which they are installed. For example, how to enable traffic control cameras overlapping and overspending vehicles and report the crime directly without having to process. This paper thus proposes a way of making then more intelligent and specialized for the needs of the users. Since the cameras have limited memory, storage buffers and processing speeds, it is hard to cope with the events happening in the environment and transmit complete meaningful information in real time for further analysis. Network bandwidth constraints also play a major role in determining what is transmitted and at what speed. If transmission is faster than the camera will do less processing and concentrate on vision. If the network is slow, then the camera will have to wait for storage buffers to empty/transmit before capturing more details. By implementing optimized data paths between the ISP and other on-chip multimedia processors (graphics, video encoders and decoder, and display), system designers can minimize memory bandwidth and latency when implementing algorithms for back-end systems used in computational photography. These address the problem of data processing and transmission but the cameras still capture whatever thing that is in their sight. Also in the same spirit, the extensive availability and use of cameras in various application domains calls for the study of new embedded processing systems and algorithms. Many issues relating to surveillance and smart cameras have been discussed in meetings in Vienna (2007), Stanford (2008), Como (2009), Atlanta (2010), and Ghent (2011). The ACM/IEEE International Conference on **Distributed Smart Cameras**, attracted researchers from multiple fields such as computer vision, pervasive computing, embedded systems and sensor networks. This also forms the motivation for writing this paper. The rest of these paper is divided into several sections. Section two covers related work to intelligent cameras, section three deals with the features of these intelligent cameras, section four presents the model for improving surveillance of these intelligent cameras by giving them knowledge to adopt to the environments in which they are to monitor. Section five concludes with a summary of what has been covered in the paper and suggests future research work. The last part then gives the references and electronic sources that have been used to come up with this paper.

2 Related Work

The model for improving quality of surveillance with adaptive smart cameras presented in this paper is a critical step towards a high-performance embedded surveillance system. In [9], Wolf et al. presented a PC-based smart camera system using analog cameras. Although smart cameras are already commercially available [4], the possibilities of embedded systems are not exploited there. High-level image analysis algorithms require processing power that current systems are not able to deliver. Some commercial and scientific systems have been proposed for traffic surveillance in the past. These systems extract quantitative information, e.g. speed, volume, and qualitative information such as unusual events like stationary vehicles, from the image data. All these systems use either a background/foreground segmentation in combination with object tracking or analyze long-term background changes in a statistical background model [13]. Background/foreground segmentation can be done by frame differencing which is simple and surprisingly robust to illumination changes, e.g. car lights. As this method has problems within the objects due to small illumination changes, more sophisticated, adaptive methods like adaptive background models [10] or pixel-wise background estimation techniques are used [10][11]. This paper proposes a model that incorporates an expert system to make decisions after image processing.

3 Analysis Of Smart Cameras

Image processing and adoption of smart cameras for surveillance in cities and business environments has become a common trend. These is in relation to the capabilities and features that these cameras have. It presents a potentially enormous opportunity both for businesses and consumers.

3.1 The Future Of Smart Cameras

According to BCC Research report, the global machine vision systems market is expected to reach $17 billion in 2015 and about $26.9 billion in 2020 and, according to Yole Development, the CMOS image sensor market will reach $13 billion dollar by 2018 according to Yole Development Report. Companies that adopt and fuel these innovations early will become the leaders in their sector. These acts as a main motivation for conducting research in these knowledge area. Some of the research done and still ongoing focuses on the topics such as Distributed problem solving and decision making Intelligent applications in e-business/e-commerce, e-learning, e-health, e-science, e-government, crisis management, smart grid Modelling, simulation and development of intelligent distributed systems Simulation of groups and crowds Intelligent data processing Intelligent robots Intelligent environments.

3.2 Features of Smart Cameras

Before we think of adding intelligence to this already smart cameras, it is appropriate to fast look at the features that the cameras already have and how to take advantage of those features to add intelligence and focus on what is necessary. The XCI-SXI can capture and process pictures and even control peripheral devices.

3.2.1 High Image Quality

The **XCI-SXI (SXGA)** has a progressive scan CCD of 1,450,000 pixels. These produce high resolution images. The pixels are squared thus images can be processed using the original aspect ratio without necessarily having to convert. **Charge-coupled device (CCD)** is a device for the movement of electrical charge, usually from within the device to an area where the charge can be manipulated, for example conversion into a digital value.

3.2.2 Various Mode Settings

The smart camera has the following mode setting that can be taken advantage of. Gain, Read Mode, High rate Scan, Shutter and LUT. It allows switching between these modes at a high speed and adopts to the next mode immediately.

3.2.3 High Rate Scan

The camera module can limit the effective video output area to achieve high frame rates, enabling high speed image processing and transmitting.

3.2.4 Binning

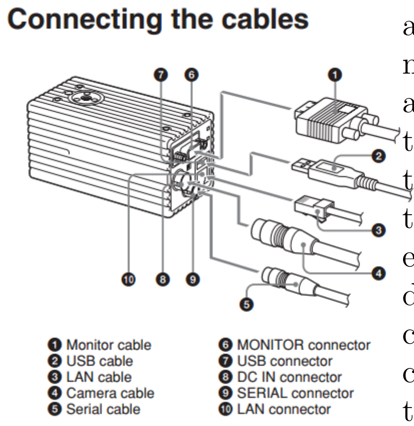
By Binning two pixels that align vertically or horizontally, you can acquire a frame rate twice that of the normal mode vertically and a sensitivity twice that of normal mode horizontally.

3.2.5 Built-in Processor

The camera has a built in processor with the following specifications. X86 CPU, 128MB **DDR-SDRAM** and 128 MB compact Flash.

3.2.6 PC standard input output interface

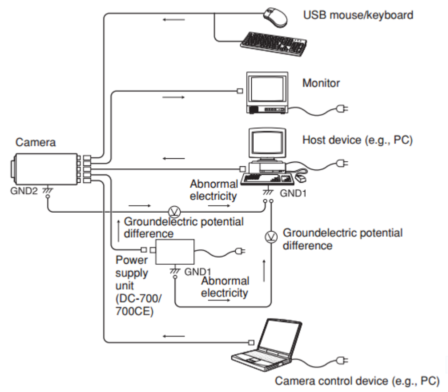
The camera has a built in processor with the following specifications. X86 CPU, 128MB **DDR-SDRAM** and 128 MB compact Flash.

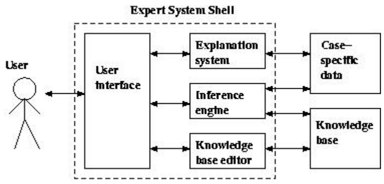


ports.PNG

3.3 The Proposed Working Model

parts.PNG widthwidth The model that this paper presents is that intelligent cameras can be made more intelligent by linking them to an expert system so that the cameras consult the knowledge base of the expert system for events to focus on depending on the environment in which the camera is installed. Since this cameras have a high scan rate and can capture images at an amazingly fast speed. Then linking them to an expert system and a reporting unit can make them adaptive to suit the needs of the users in their respective environments. Some examples of these specialized environments that these paper focuses on are: banking hall, traffic control, aircraft control, and city security surveillance. A case scenario of how surveillance can be improved with integrated expert system and reporting system has also been included in these paper. Since several cameras can be connected to a central processing system, it also makes sense for these cameras to have a centralized expert system to be able to interpret the events happening in their installation environments in real time with each having its installation environment characteristics already defined. Once the camera captures a certain event, image, object or other climatic factors of the environment, the cameras consult their case specific data in central knowledge base of the expert system for an interpretation. The expert system gives interpretation if found and if not requests for more information from the vision processing system which receives information from the cameras. Also the Reporting system is categorized according to the type of alarm to be raised in the event of an unusual event being realized. The diagram below shows how the camera is connected to a PC that is to run the expert system. The system shell of the expert system consists of a user interface, explanation system, interface engine, knowledge base editor, case specific data and the knowledge base as shown in figure 3.





3.4 A Case Scenario Of Improved Air Surveillance Case of Missing Malaysia Plane MH370

This paper makes assumptions to suit the situation of the missing Malaysia plane MH370 and shows how integrating an expert system and an aircraft notification or reporting system could have helped to mitigate the situation. First, assume that the plane had a smart camera with installed and configured to check the expert system for characteristics of an aircraft environment. Such characteristics as altitude, motion projection, radar route position and source and destination for the flight. Second, Assume the radar control had an expert system with these characteristics already stored in its knowledge base and a reporting system integrated to it. Third, assume that there was a military plane for rescue missions that is dedicated once a flight is launched.

The radar system is only capable of monitoring objects that are on its path. so for the case of MH370 the plane could have gone of radar as usual. The pilot has now lost communication with the team at the radar and the plane is off radar. the smart camera capture/records events just like the Black box records voice and send them to the vision processing system which then compares these factors with those in its knowledge base. The expert system determines that there is a variation outside the allowed degree of variation. These raises suspicion. The expert system thus notifies the alerting system which is interrupted from sleep mode. The alerting system then raises the alarm and the rescue team is launched at a fast speed following the new characteristics that are received by the expert system. The rescue team could actually have located the plane off radar and the effects of the missing plane could have been minimized. The integrated expert system and reporting systems could have played a major role to enable firing of the rescue plane in time.

3.5 A Case Scenario of Improved Surveillance in a Bank

A smart camera is installed in a bank to monitor money leaving the bank. Assume there is an untrustworthy employee who wants to hide cash in his/her bag and wait until the end of the day to leave with the cash. One characteristic stored in case specific data for all cameras in banks is to observe cash. The smart camera observes the teller putting aside some money. It captures the image and sends it to the vision processing system. The system determines that the teller instead of putting the cash in the bank's cash drawer, puts the cash in their pocket or bag. The vision processing system then asks the expert system what keeping cash in a pocket means. The expert system checks in its bank case specific data and determines that, that is a theft case. The information is sent back to the vision processing system with an instruction to alert the manager/sound an alarm. You can see clearly, that an alarm is raised just as cash is being stolen instead of having to wait for the daily balance sheet to have errors to start tracking the events that happened during the day to find the missing cash. The same can be applied in traffic control systems to report overlapping and over speeding vehicles just when they are in the act. It can also be used by police on night patrol in cities so that they can catch criminals before they cause damage and escape.

3.6 Limitations of the Proposed Working Model

1) The case specific data might not contain all the characteristic that can be observed by the cameras. These can be addressed by having the characteristic stored in the knowledge base and monitoring similar occurrences. 2) The speed of processing and transmitting information by the Vision processing system and the expert system might slow down action. This is addressed by letting cameras store and refer to case specific data about the environment they are installed. It also reduces the time taken to try all rules before making a conclusion. 3) The cost of implementing, expert system and integrating it with a reporting system might be high and thus users may want to shy away from using these model. These can be addressed by having the model first adopted by government agencies for public security and the knowledge base shared by private users.

4 Conclusion and Future Work

This paper has presented a model for improving the quality of surveillance with adaptive intelligent smart cameras by using an expert system that bases its decision making on a knowledge base that is defined for a particular operating environment for the camera. Smart cameras have similarities in number of features they support and some are even similar in structure but the environments in which they are used are different. These environments have different needs to be accomplished hence need to support the intelligence of these cameras with a knowledge base and a decision support system to interpret the knowledge and control the focusing of these cameras. The decisions to be made involve, the events to be captured, the zooming and what activities to concentrate on most in a particular environment. Future research can to be conducted to determine how to optimize decision making for systems guiding the cameras and priorities on the information to be stored in the knowledge base about a particular environment.

References

[1] 'Integrating Consumer Smart Cameras into Camera Networks: Opportunities and Obstacles', Computer, vol. 47, no. 5, pp. 45-51, 2014.

[2] J. Miseikis and P. Borges, 'Joint Human Detection From Static and Mobile Cameras', IEEE Trans. Intell. Transport. Syst., pp. 1-12, 2014.

[3] L. Calderoni, D. Maio and S. Rovis, 'Deploying a network of smart cameras for traffic monitoring on a âœcity kernelâ', Expert Systems with Applications, vol. 41, no. 2, pp. 502-507, 2014.

[4] 'Surveillance systems need sustained support - FAO', Veterinary Record, vol. 175, no. 8, pp. 186-186, 2014.

[5] 'US banks attacked, but by whom?', Network Security, vol. 2013, no. 1, p. 2, 2013.

[6] D. Jeon, Y. Eun and H. Kim, 'Estimation fusion with radar and ADS-B for air traffic surveillance', International Journal of Control, Automation and Systems, vol. 13, no. 2, pp. 336-345, 2015.

[7] K. Borras. In life you must have vision. Traffic Technology International, pages 36–39, Oct/Nov 2002.

[8] C. S. Regazzoni, V. Ramesh, and G. L. Foresti. Introduction of the special issue. Proceedings of the IEEE, 89(10), Oct 2001.

[9] W. Wolf, B. Ozer, and T. Lv. Smart cameras as embedded systems. IEEE Computer, pages 48–53, 2002.

[10] Vision Components Germany. http://www.vision-comp.com, 2002.

[11] D. Beymer, P. McLauchlan, B. Coifman, and J. Malik. A real-time computer vision system for measuring traffic parameters. In Computer Vision Pattern Recognition, 1997.

[12] R. P. Pflugfelder. Visual traffic surveillance using real-time tracking. Master's thesis, Vienna University of Technology, Vienna, Austria, 2002.

[13] D. Gibbins, G. N. Newsam, and M. J. Brooks. Detecting suspicious background changes in video surveillance of busy scenes. In Proceedings 3rd IEEE Workshop on Applications of Computer Vision, pages 22–26, Sarasota, FL, USA, Dec 1996.

[14] S. Huwer and H. Niemann. Adaptive change detection for real-time surveillance applications. In Third IEEE International Workshop on Visual Surveillance, pages 37–45, Dublin, 2000. IEEE Computer Society, Los Alamitos.

[15] L. Benini, A. Bogliolo, and G. De Micheli. A survey of design techniques for system-level dynamic power management. IEEE Transactions on VLSI Systems, 8:299–316, Jun 2000.

[16] R. Lyons. Understanding Digital Signal Processing. Addison-Wesley, 1997.

[17] R. P. Pflugfelder and H. Bischof. Learning spatiotemporal traffic behaviour and traffic patterns for unusual event detection. In 26th Workshop of the Austrian Association for Pattern Recognition, pages 125–133.

[18] G. L. Foresti, P. Mah onen, and C. S. Regazzoni, editors. Multimedia video-based surveillance systems. Kluwer Academic Publishers, Boston, 2000.