Smart Camera for Traffic Surveillance

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1. Introduction

An important application area where smart cameras can potentially and advantageously replace most known cameras, frame grabbers and computer solutions is visual traffic surveillance. CMOS image sensors can overcome problems like large intensity contrasts due to weather conditions or road lights and further blooming, which is an inherent weakness of existing CCD image sensors. Furthermore, noise in the video data is reduced by the capability of video computation “close” to the CMOS sensor. Thus, the smart camera delivers a new video quality and better video analysis results, if it is compared to existing solutions.

2. Requirements

2.1 Requirements of a Smart Camera

In general a smart camera is compromised of a *sensor*, a *processing* and a *communication* unit. In this section we briefly discuss the requirements for each of these units as well as some system wide requirements.

2.1.1 Sensor Requirements

The image sensor is the prime input for a smart camera. An appropriate image quality is, therefore, essential for the performance of the entire system.

- **Dynamic Range**
- **Resolution and Frame Rate**
- **Digital Interface**

2.1.2 Processing Requirements

There are various tasks that must be executed by the processing subsystem including:

- **Video Compression**
- **Video Analysis**
- **Computation of Traffic Statistics**
- **Camera Control and Firmware**

2.1.3 Communication Requirements

The compressed video stream and the output of the video analysis are transferred to the control station via the communication unit. For a flexible and fault tolerant communication different network connections such as Ethernet, wireless-LAN and GSM/GPRS should be possible.

Beside the standard data upload the smart camera must also support data download to enable to change the configuration or firmware of the camera via the network.

2.1.4 System Requirements

Low-Power Power consumption is a major design constraint in recent embedded systems. High power consumption reduces the operation time in battery or solar-powered environments. Another important aspect is heat dissipation which must be low in order to avoid active cooling. Active cooling, e.g., fans, increases size and costs as well as limits the camera's area of application.

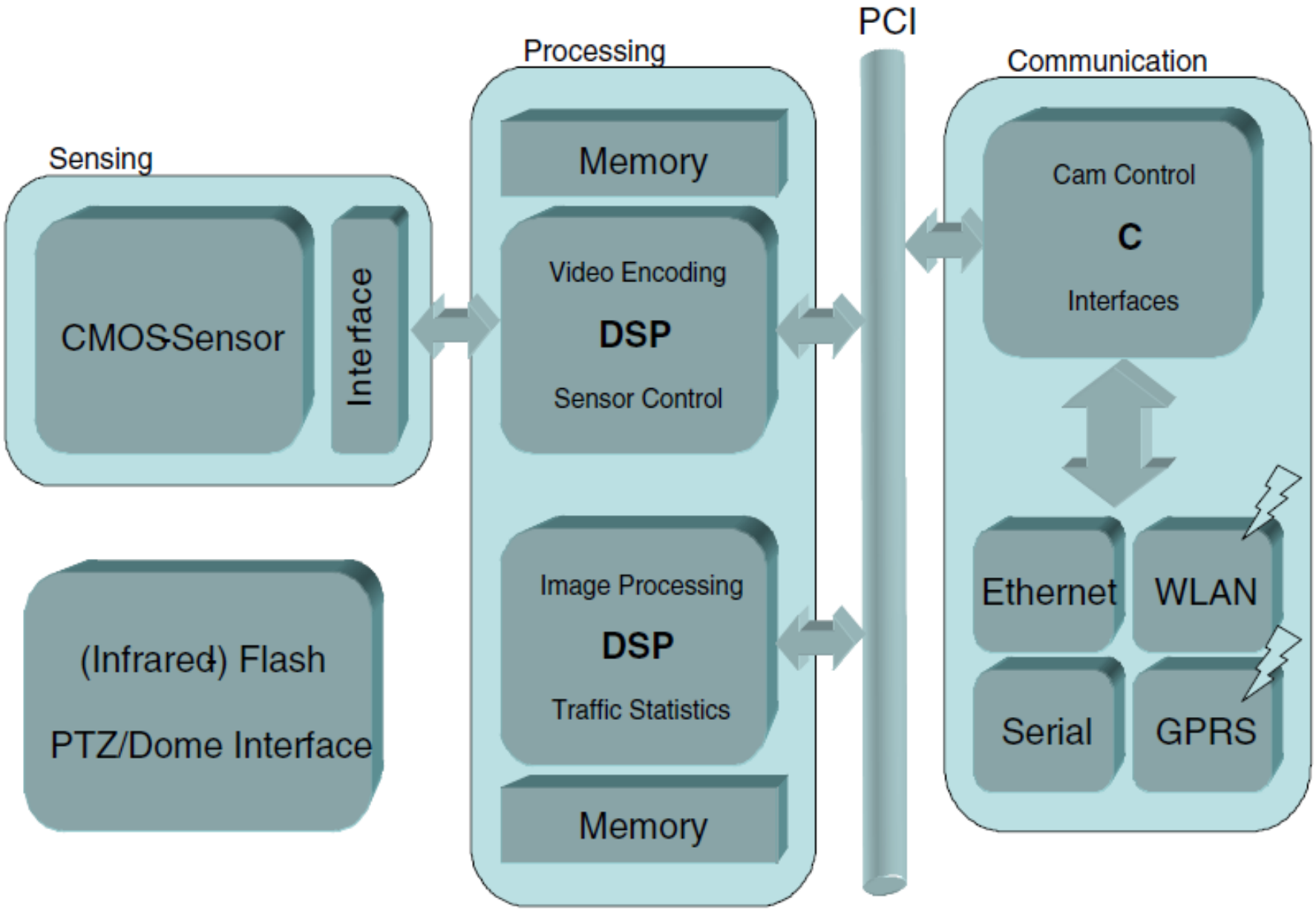
Real-Time The smart camera has various requirements concerning its firm and soft realtime performance. There are several timing constraints concerning the camera control and the peripherals, e.g., the flash trigger. There are also timing constraints for the image analysis algorithms, e.g., a stationary car has to be detected within 6 seconds.

3. System Architecture

3.1 System Overview

For traffic surveillance the entire smart camera is packed into a single cabinet which is typically mounted in tunnels and aside highways. The electrical power is either supplied by a power socket or by solar panels. Thus, our smart camera is exposed to harsh environmental influences such as rapid changes in temperature and humidity as well as wind and rain. It must be implemented as an embedded system with tight operating constraints such as size, power consumption and temperature range.

3.2 Hardware


PCI
Processing
Communication
Sensing
Memory
Cam Control
C
Interfaces
CMOS Sensor
Interface
Video Encoding
DSP
Sensor Control
(Infrared) Flash
PTZ/Dome Interface
Image Processing
DSP
Traffic Statistics
Ethernet
WLAN
Serial
GPRS
Memory

3.3 Software

The software architecture of the smart camera is basically divided into two parts:

DSPs are configured to basically run computation intensive tasks like video compression (MPEG-4 simple profile), image analysis, or traffic parameters calculation. Since reconfigurability and scalability are important issues, the DSPs are running on Texas Instruments' Reference Framework 5 (RF5) in combination with TI's XDAIS algorithm standard, which enables the exchange and reconfiguration of algorithms during runtime. All reconfiguration and control actions are controlled by the system control processor as described below.

XScale processor is primarily used for system control and communication purposes. Therefore a standard operating system eases the development of internal and external communication services like web-services, proprietary control connections, or PCI communications. Hence (Embedded-) Linux has been chosen to be used.

3.3.1 Video Compression

Video transmission at full PAL resolution and at 25 fps requires a bandwidth of approximately 20 MB/s. State-of-the-art video compression reduces the bandwidth needs by factor of 100 down to 1.5 Mb/s.

The advanced simple profile MPEG-4 encoding method is well-suited for traffic surveillance, since the encoded quality, and therefore the required bandwidth can be adapted to different needs. This MPEG-4 compression module is supplied by a DSP- software provider. Performance data reports a required processing power of approximately 4000 MIPS at full PAL resolution running at 25 fps.

3.3.2 Network Connection

Internet connections require the TCP/IP protocol implemented as an IP stack. This software module manages the network traffic with its various protocols like HTTP, FTP, and UDP. The smart camera uses HTTP to provide a flexible and user-friendly user interface for operators to adapt parameters, and to check the camera's vitality and log files. FTP is used to download data stored in files to the camera like firmware updates or new parameter sets. Finally, UDP is used for multicast streaming video transmission.

3.3.3 Firmware

The smart camera’s firmware controls the overall system behavior, and provides interfaces and methods for different tasks like task management, camera control, and control of peripherals.

Four basic runlevels are defined by the firmware:

1) **The normal mode**
2) **the alarm mode**
3) **the full update mode**
4) **the partial update mode**

4. Conclusion

In this lecture, a smart camera that is embedded as a system was presented. Our smart camera integrates a digital CMOS image sensor, a processing unit featuring two high-performance DSPs and a network interface. High-level video analysis algorithms in combination with state-of the-art video compression transform this system from a network camera into a smart camera.

There is a rapidly increasing market for smart cameras. Advances in performance and integration will enable new and more functionality implemented in smart cameras.

5. References

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

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

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

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

[5] 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.

[6] D. R. Magee. Tracking multiple vehicles using foreground, background and motion models. Technical Report 2001.21, Univ. of Leeds, Dec 2001. School of Computer Studies Research Report Series.

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

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

[9] 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.

[10] C. Stauffer and W. E. L. Grimson. Adaptive background mixture models for real-time tracking. In Computer Vision Pattern Recognition, pages 246–252, Ft. Collins, CO, 1999.

Thanks for your attention

Question ?