

Chapter 13

Distributed Visual Surveillance with Resource Constrained Embedded Systems

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ABSTRACT

Wireless Sensor Network (WSN) is a promising technology for distributed sensing and computation. Recently, researchers and engineers started to investigate the use of WSNs to support resource demanding real-time applications, including process control, industrial automation, video surveillance, and multimedia streaming.

Surveillance applications – like traffic monitoring, vehicle parking control, and intrusion detection – involve monitoring of the environment in order to detect and interpret the activities of relevant objects and their behaviour. These applications demand real-time images from the scene in order to collect relevant information. Multimedia Wireless Sensor Network (MWSN) provides a low-cost and flexible solution for distributed video surveillance based on low-power autonomous camera sensor nodes.

MWSN faces the challenge of reliably distributing complex imaging data over low bandwidth and resource constrained computational nodes. To deal with this problem, many researchers have proposed techniques like image compression, in-network processing, distributed statistical correlation and image prediction. However, these techniques still have to store and process huge amount of visual data on energy and resource constrained sensor nodes.

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In this chapter, we present an innovative technique of line sensor based image capturing and processing in order to detect moving objects such as vehicles. Line Sensor techniques, when used in MWSN, may achieve faster processing results with much less storage and bandwidth requirements while conserving node energy. Line Sensor based processing algorithms provide novel ways for object counting, classification and speed measurement. This solution presents itself as an ideal low-cost candidate for Intelligent Transport Systems (ITS) to monitor and control urban traffic.

INTRODUCTION

WSN is a promising technology for distributed sensing and computation. Although constrained by limited computational capabilities, sensor networks are cost-effective and have good scaling virtues. The use of a low-power radio communication protocol such as the IEEE 802.15.4 allows to eliminate the cost of cabling the sensors, and allows more flexibility in the deployment. So far, WSNs have been mainly used in applications with low-frequency sampling and little computational complexity, such as environmental monitoring in agriculture, monitoring and control of the temperature and light in home automation, etc.

Recently, researchers and engineers started to investigate the use of WSNs to support more demanding applications, including process control, industrial automation, video surveillance, and multimedia streaming. Some early attempts have been made to use WSN technology for low-quality video streaming (Kulkarni, Ganesan, Shenoy & Lu, 2005). The success of such attempts have created a new challenging area of research, Multimedia Wireless Sensor Networks (MWSN) (Akyildiz, Melodia & Chowdhury, 2007).

MWSN technology is a good candidate for use in pervasive contexts like info-mobility. The idea is to use a set of inexpensive sensors nodes equipped with low-cost cameras in city streets to monitor traffic flows, number of cars in parking lots, etc.. The information are collected by the sensors and sent through wireless communication to a *concentrator node* that aggregates the incoming data (sensor fusion). The concentrator, which is in charge of collecting data related to a specific city

area, is then connected to a wide area network, and sends aggregated data to higher levels of the information system hierarchy, which monitor and control urban mobility.

The architecture of such a system is shown in Figure 1. The backbone network can be wired (e.g. ADSL or Ethernet) or wireless (e.g. WiFi, WiMax, GPRS or UMTS), depending on the specific needs. In this proposal, we are interested in the lower level of the hierarchy that includes the sensor nodes and the concentrator.

Examples of applications are:

- **Counting the number of cars passing on city streets.** This information can help in estimating the traffic flow entering in (or exiting from) a city area, and take appropriate actions to prevent congestion. While there are other methods to count the number of cars passing in a street (by magnetic sensors, photoelectric cells, etc.), we envision that the one based on WSN cameras will be more flexible, easier to install and more cost-effective.
- **Identifying the occupancy level of a parking lot in an open area.** This information can help to provide appropriate advices to drivers and guide them to the free spots. Also in this case there are many working examples of parking lots equipped with sensor systems. However, these systems are more difficult to be installed in open environments, due to high cabling cost. The use of WSN will help to lower the cost of installation and maintenance.

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