Chapter 12
Using Line Cameras for Monitoring and Surveillance Sensor Networks

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ABSTRACT

The innovative combination of wireless sensor network (WSN) technology with visual monitoring and surveillance technology in computer vision has been emerging as an important new paradigm. This emerging technology will play a crucial role in visual monitoring and surveillance for automatic object detection and tracking in applications such as real-time traffic monitoring and control, vehicle parking control, intrusion detection, security surveillance, military battlefield monitoring, and so on. Compared to traditional WSNs with scalar sensing data, the development of WVSNs presents much greater challenges in terms of node's computation power, storage, wireless bandwidth capacity and energy conservation due to the processing and transmission of the huge amount of two-dimensional (2D) image data. We introduce the use of linear CCD sensors for wireless sensor network here. It reads temporal data from a CCD array continuously and stores them to form a 2D image profile. Compared to most of the sensors in the current sensor networks that output temporal signals, it delivers more information such as color, shape, and event of a flowing scene. On the other hand, it abstracts passing objects in the profile without heavy computation and transmits much less data than a video from normal cameras. This paper focus on several unsolved issues of line sensors in capturing targets in the 3D space such as sensor setting, shape analysis, robust object extraction, and real time background adapting to ensure long-term sensing and visual data collection via networks. All the developed algorithms are executed in constant complexity for reducing the sensor and network burden. A sustainable visual sensor network can thus be established in a large area to monitor passing objects and people for surveillance, traffic assessment, invasion alarming, etc.

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INTRODUCTION

Many works of sensor network have focused on low-power sensors and reliable data transmission. Most sensor receptors obtain a temporal signal and send data to a centralized server for analysis and visualization via wireless sensor networks (WSN). For visual information, however, the temporal two-dimensional data from a camera to transmit are tremendous. Different from broadcasting and multicasting of a video via the Internet that can eventually use the peer-to-peer strategy to reduce overall data transmission on the network, transmitting different videos to a server simultaneously in a unicast style is more constrained by the network bandwidth and the server capacity.

To diminish the data sent in a sensor network, one alternative way is to reconsider linear CCD sensors, which were used in the early stage of digital imaging (Zheng & Tsuji, 1989, 1990; Taniguchi & Seki, 1994) and are still widely used in scanners and terrain data acquisition (Gupta & Hartley, 1997). In sports areas, static line cameras are used for the time puncture of racing cars, boats, and athletes at destinations, capturing the time of arrival from the line sensor image. Similar use is in traffic monitoring (Zhu, Xu, Yang, Shi & Lin, 2000) with a static line sensor mounted at some high position above the road. A vehicle-borne line sensors have also been used in scanning environments for panoramic views and route panoramas (Zheng, 2003; Chitnes, Liang, Zheng, Pagano & Lipari, 2009; Zheng & Shi, 2006) where the line sensor is rotated or translated so that the accumulated sets of line data form long images representing surrounding scenes or side scenes along a street. A handheld line sensor further sweeps objects or environments to obtain texture map for graphics models (Rademacher & Bishop, 1998). However, they have not been explored in the frame of sensor network applied to broader areas. In many applications such as counting passing people in an entertainment park, station, store or exhibition site (MacDorman, Nabuta, Koizumi & Ishiguro, 2007), alarming invasion across a border or a critical facility and monitoring a traffic flow, the detailed moving directions, speeds and trajectories of passing objects are already obvious or less interested. Rather than processing normal video, we use line sensors for counting passing targets for saving computation cost and extend the area of monitoring via networks, which is new in sensor network distributed in a large 3D space. To achieve more general sensing tasks and a variety of dynamic environments in a sensor network, we need to explore the sensor setting conditions such as the viewing angle, distance, alignment, and sampling rate, and discover the properties of the sensed images. How to locate sensors and how to analyze sensor data to obtain meaningful information are essential topics to be investigated.

Degrading from 2D images, the 1D temporal data are captured continuously by a CCD array to form a 2D image temporally. The sensor delivers visual information to a server in real time and requires much less bandwidth than a closed-circuit television (CCTV) system. If penetrating objects are pursuing a simple movement, the resulting 2D profile contains information on shape, time, and identities (Zheng & Tsuji, 1989, 1990; Nakanixhi & Ishii, 1992; Taniguchi & Seki, 1995; Yoshioka, Nakaue & Uemura, 1999), but requires less redundant processing than normal video (Gupte & Papanikolopoulos, 2002; Li, Huang, Gu & Tian, 2003). It is also more intuitive to examine the history of passing entities in the line sensor produced image than a sequential signal and a video sequence, which serves the purpose of indexing of surveillance data.

This chapter focuses on algorithms and sensing modes of a line sensor network in the aspect of computer vision for counting object flows through spatial channels or guard lines. We discuss how to use the line camera in the sensor network and what effects or information can obtained from a set of line sensors. We propose efficient algorithms in constant complexity for data processing over time such that the sensors can send long archives

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