A Study on Simple Event Detection by Networked Image-Sensing System Using Smart Image Sensors

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Abstract

In this paper, an experimental networked image-sensing system using a group of spatially-variant sampling (SVS) smart image sensors is presented. This system is targeted to reduce the data volume at image acquisition level by utilizing selective spatial/temporal resolution reduction schemes, taking into considerations of the priority of particular regions of the scenes. The main advantage of this system is the pixel-level handling of images on sensor nodes and a host, which contributes to the better efficiency and more flexibility in data management. The recorded images from the spatially-distributed sensors can be used for simple event detection such as movement of some object in the scene during certain period.

1. Introduction

The image sensing with numerous image sensors will provide better coverage than single or small number of cameras do. However, how to transmit and process the vast amount of data is one of the critical issues in practical system. Smart sensors are considered to be one of the feasible solutions to reduce the traffic volume because they can transfer necessary data only at necessary time. The transmitted data can be used to display the real-time scenes and be archived for further off-line analysis to find the spatial or temporal correlation of ROI between the sensors. In this paper, we present a network-based image sensing system consisted of multiple smart image sensors capable of random-accessing. To reduce the data volume, the region determined by local event-extraction rule (e.g., movement) will be selected and transmitted to a host in which the off-line analysis is performed. The pixel-level data management throughout the process provides flexible data handling and efficiency in finding the candidates by similarity measures. The basic principle of complex event detection by histogram matching is introduced.

2. System Overview

We developed a sensor node with networking capability for smart sensors by using general-purpose networking platform [1]. Three FPGAs are used for overall interfacing, ADC and smart sensor control. The system is operated on NetBSD platform and powered by SH-4 RISC CPU(167 MHz). For an image acquisition device, spatially-variant sampling (SVS) smart image sensors [2] are used to give capability of real-time random accessing of any specific region. As the computation logics are not integrated yet with SVS sensors, the external computation resources fabricated on a sensor node is used to determine the region that can be used as simple event. In this paper, the changed region detected by frame difference is selected as local event, which will be used for analysis to find global or more complex event by comparing similarity between them after they are transferred to a host. The system consists of multiple sensor nodes and a host. How they work each other is shown in Figure 1.

No transmission will be made if the frame difference is below the pre-determined threshold level. AR (Active Region: the region detected by frame difference) and IR (Inactive Region: the background region) will be saved separately in a host with header information (sensor ID, resolution, timestamp, etc.) and they will be analyzed later by histogram matching to investigate the temporal relationship of ROI or the objects of interest between the sensor nodes. As a testbed system, nine sensor nodes are installed along the corridor of Aizawa Laboratory of the University of Tokyo as shown in Figure 2. Supportive lighting gears are installed because the dynamic range of the SVS sensors is currently not enough to be operated indoor without proper illumination.

![Figure 1. System Overview](image1.png)

![Figure 2. Installed Sensor Nodes](image2.png)
3. System Overview

The basic diagram of event detection model used in this paper is shown in Figure 3. The image data contains local events are stored in event database of a host then the more complex event can be modeled in response to the query by the user.

With a reference image given, the possible candidates above the threshold level of histogram difference are selected from the archived data and labeled for spatial (the location of the sensor) and temporal (the time detected the possible candidate) information. The example of GUI interface for histogram matching is demonstrated in Figure 4. We confirmed the possibility by this simple simulation and will work on the improvement of this system. Then, the spatio-temporal map of the events will be produced for brief global look of them. The example of spatio-temporal map is shown in Figure 5.

4. Conclusion and Future work

In this paper, the basic work of event an experimental networked image-sensing system using a group of SVS sensors is presented. By using the random accessibility of SVS sensors, only necessary regions can be selected and transmitted at necessary time, which enables the pixel-level handling of images on sensor nodes and a host. Therefore better efficiency and more flexibility in data management can be obtained. In addition, the basic framework is introduced for spatial/temporal event detection by histogram matching to find temporal correlation of ROI based on the data obtained from the spatially distributed sensors. The work described in this paper is considered as a preliminary step towards a large-scale image sensing system by using smart image sensors and therefore there are a lot of works to do to complete the project. For example, this system should be reinforced with more robust algorithms for AR segmentation (in a sensor node) and similarity measure (in a host) for practical application. We will continue to work on this project for site modeling or traffic analysis in regard to the region/object of interest.

References


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