

# Chapter 1

## Visual Sensor Network Technology and its Applications

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### **ABSTRACT**

*The combination of image sensors with wireless sensor network (WSN) technology has resulted in a new network technology called a visual sensor network (VSN). On the one hand, VSNs can be seen as an extension of traditional WSNs where image sensors have replaced scalar sensors. On the other hand, the use of image sensors in VSNs brings with it a different set of practical and research challenges. This is because image sensors generate a very high amount of data that would have to be processed and transmitted within the network. In this chapter, we present an introduction to VSN technology and provide an overview of research issues and trends. Issues related to energy efficient processing, collaborative processing, and hardware technology will be highlighted. This chapter will also give a brief introduction to the other chapters in the book with a focus on showing how the topics covered in each chapter relate to the overall picture of visual information processing in wireless sensor network environments.*

### **INTRODUCTION**

The field of wireless sensor networks (WSNs) has seen much success in diverse applications ranging from environmental monitoring, smart homes, healthcare, to industrial and defence applications. Traditional wireless sensor networks capture scalar

data such as temperature, vibration, pressure, or humidity. Motivated by the success of WSNs and also with the emergence of new technology in the form of low-cost image sensors, researchers have proposed combining image sensors with WSNs to form visual sensor networks (VSNs). The use of image sensors in VSNs increases the range of potential applications because compared to scalar sensors, image sensors are able to provide

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more information which can be used for visual processing tasks such as detection, identification, and tracking. On the one hand, VSNs can be seen as an extension of traditional WSNs where image sensors have replaced scalar sensors. On the other hand, the use of image sensors in VSNs brings with it a different set of practical and research challenges. This is because image sensors generate a very high amount of data that would have to be processed and transmitted within the network. The main issue is that sensor nodes have limited battery power and hardware resources. The energy efficient processing and transmission of the data within the VSN is of primary importance to maximize the lifetime of the overall network. Depending on the application, the network should be active for a duration of time ranging from weeks to years without the need for battery replacement.

Researchers have used several different terms such as camera sensor networks, wireless image sensor networks (WISNs), and wireless visual sensor networks (WVSNs) to describe these image-based sensor networks. When combined with other sensors such as audio sensors, the networks are termed wireless multimedia sensor networks (WMSNs). Throughout this chapter, we will use the term visual sensor networks. A brief description of a VSN can be stated as follows. A VSN comprises of many visual camera nodes (VCNs) working collaboratively to detect useful events in the overall scene data to be conveyed to a base station for higher-level processing. Each VCN is an embedded device which has the capability to perform sensing, processing and communication within the node itself. The VCNs are connected using a wireless sensor network which relays the scene event data from one node of the network to another until it arrives at the base station.

The successful development of VSNs will require research contributions from different disciplines such as visual information processing, wireless networks, hardware and embedded systems, and power engineering. Several survey papers on different issues of VSNs and WMSNs

can be found in the papers by (Akyildiz et al., 2007; Almalkawi, et al., 2010; Soro et al., 2009). The objective of this chapter is to present a brief introduction to VSN technology and to provide an overview of research issues and trends to assist the reader in the journey throughout this book. We will focus our discussions on visual information processing issues for wireless sensor network environments. The end of each section will also draw the reader's attention towards further information and case studies which can be obtained from the later chapters in this book.

## **VSN TECHNOLOGY**

Researchers and authors have used different terms to describe the various components in the VSN. Figure 1 shows a general structure of a VSN consisting of four main components: Visual Camera Node (VCN), Visual Cluster Head (VCH), Network Node, and Base Station. Figure 1 shows that there a decreasing information flow from the VCNs to the base station. The captured scene data are processed and transformed to useful event data. The focus for the upper levels of the network (VCN and VCH) is on visual information processing and the focus for the lower levels of the network (network node) is on wireless network communications. The primary theme for both upper and lower network levels is to achieve energy efficiency within the constraints of the battery powered nodes.

The VCNs form the end points of the network. Each VCN consist of a camera sensor, processing unit, communication unit, and power unit. Each camera sensor has a field of view (FOV) of the scene. A captured scene is called an image frame. The processing unit performs the visual processing to reduce the high amount of scene data. Two approaches can be used. The first approach uses event detectors to identify useful events in the scene data. If an event is not detected, then the image frame is discarded and there is no need to

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