

## Chapter 2

# Energy Efficiency and Reliability Considerations of a Compressive Sensing Technique in Wireless Visual Sensor Networks

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### **ABSTRACT**

*This chapter focuses on the energy efficiency and reliability issues when applying the novel compressive sensing technique in wireless visual sensor networks. An explanation is given for why compressive sensing is useful for visual sensor networks. The relationships between sparsity control and compression ratio, the effect of block-based sampling on reconstruction quality, complexity consideration of reconstruction process for real-time applications, and compensation for packets missing in network flows are discussed. We analyse the effectiveness of using the 2-dimensional Haar wavelet transform for sparsity control, the difference between compressive sampling in spatial and frequency domains, and the computation of the prime-dual optimisation method and the log barrier algorithm for reconstruction. The effectiveness of the approach on recovered image quality is evaluated using Euclidean distance and variance analysis.*

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## INTRODUCTION

A wireless visual sensor network (WVSN) is a self-organised wireless network widely used for surveillance purposes. The network normally has a large number of sensor nodes to monitor and detects critical events in a broad physical area. The development of image sensors and wireless technologies has greatly increased the surveillance capacity of wireless visual sensor networks. In recent years, the wireless sensor networks have become more and more attractive and have a wide range of applications, such as green-house environment surveillance (Chi, Chen & Gao, 2008), weather monitoring (Chen, Zhong, Chen & Liao, 2006), road traffic surveillance and control (Xie, Zhang & Chen, 2007), health monitoring for aged care (Choi, Choi & Cha, 2008) and broad situational surveillance for defence systems. For different kinds of applications, the networks need to handle diverse sensor data, ranging from scalar data, image data (the generalised meaning of any 2-D array of numbers), and video data (from monitoring and surveillance) to the data from sophisticated medical sensors, e.g. compressed magnetic resonance imaging data (Lustig, Donoho, Santos & Pauly, 2008) for wireless network transmission. Modern image and video sensors are capable of generating a huge amount of data in order to improve the effectiveness of visual information. Therefore, efficient visual data compression techniques are essential to WVSN (Han, Wu and Wu, 2010).

The purpose of this chapter is to examine energy efficiency and reliability issues of employing a compressive sensing (CS) technique in WVSN. These issues are listed below.

1. The methods for image quality measures in human visual based monitoring system.
2. The relationship between compressive ratio and sparsity control.
3. The effectiveness of the 2-dimensional Haar wavelet for image sparsity enhancement.
4. The differences and energy efficient consideration of applying CS in spatial and frequency domains and the corresponding reconstruction techniques.
5. The effectiveness of sampling block size adjustment and network flow control to compensate for lost packets in a wireless network.

The block-based compression method used in JPEG for image and MPEG for video can significantly reduce the data rate for network transmission. However, conventional compression techniques are not completely suitable for wireless visual sensor networks. A wireless sensor network capability is severely constrained by the limited memory, battery life and micro-processing capability of sensor nodes. Conventional image compression techniques with high sampling rates generate a huge amount of data for further processing in visual sensor nodes, and the sensors' battery lives are depleted quickly.

Compressive sensing is a recent development. The CS technique acquires and reconstructs signals at a sampling rate much lower than that required by the Nyquist-Shannon criteria (Ash, 1965). During the CS sampling process, the original visual data is projected to a subspace. The energy to handle the data required by a sensor node using CS will be less than that of conventional compression techniques using a high sampling rate. The heavy sensor node computation load arising from conventional image compression, such as the use of discrete cosine transform (DCT), is not energy efficient. Furthermore, the sensor nodes may not be capable of managing large numbers of data generated by a high sample rate due to their limited memories and micro-processing capability.

Compressive sensing enables high computational tasks to be pushed to the back-end of the wireless sensor network, such as the base station, which offers an effective way for the sensor network to reduce traffic load and prolong battery life. At the back-end, the reconstruction process aims

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