Video Surveillance Using Wireless Sensors

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Abstract: Research in wireless sensor networks is continuously growing in recent years. However, despite the theoretical advances, practical applications are still in prototyping stages. In this paper, we will use concepts of wireless sensor networks for video surveillance application. Video surveillance is usually done with big cameras which have the capability of moving and zooming in and out. We will use small video cameras, which are low-cost and tiny tools, to implement video surveillance. Using a number of these cameras instead of a big camera will lower the cost of implementation. Coding concepts such as multi-terminal coding in sensor networks are applied to make the system efficient. The demonstration includes taking images with two cameras, and see how efficiently they can be transmitted to the base station. Then we will apply some coding strategies, to reduce the rate-distortion of our overall system.

1. INTRODUCTION

In a video surveillance system, one of the biggest problems is minimizing the rate of communication between video sensors and the base station, where the images are aggregated and decisions are made. Information theory provides compression bounds that can be achieved. The motivation behind the proposed research work is that video sensors observing the same area of interest have lot of common information to send to the base station. Such sources can be modeled as correlated random processes. The correlation among the sources can be exploited to compress the images generated by the sources or sensors.

2. THEORETICAL MODEL

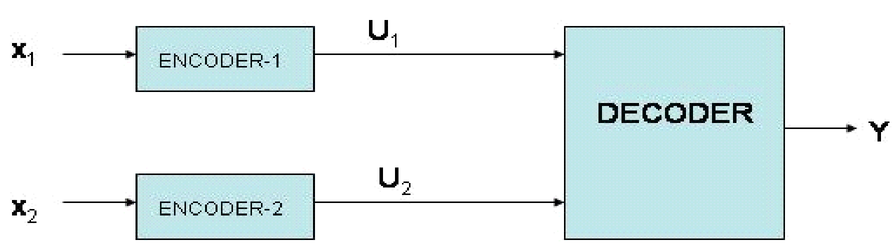

Figure 1: Two sensors sending correlated information to a common destination

Figure 1 illustrates two sources modeled as two random variables X_1 and X_2 sending data to a common destination. The source information is encoded (U_1 and U_2) in such a way as to minimize the overall rate (bits) spent in transmitting the input data to the destination. If we encode the sources in such a way that U1 - X_1 - X_2 - U_2 form a Markov chain, our goal is achieved. In a Markov chain only consecutive elements are directly correlated to each other, the other elements are correlated via the elements in between. For example, U_1 and X_1 are directly correlated, but U_1 and X_2 are only correlated via X_1. In other words, if the information content of X_1 is removed from at least one of U1 or X_2 they become uncorrelated. The above Markov chain implies that U_1 does not have any information about X_2 which is not present in X_1, and U_2 does not have any information about X_1 which is not present at X_2. It is previously shown that when we apply the above Markov chain to our system at hand, we get rid of the excessive rate, and we end up with the least possible sum rate [1].

The figure shows only two sources to illustrate the theoretical concept behind the problem being addressed. The general problem consists of n number of correlated sources each producing a sequence of symbols. For simplicity sake, in the literature, only spatial correlation is considered ignoring temporal correlation in the source samples.

3. PRACTICAL SETUP

Cyclops[5] Camera is a small low power color camera designed jointly by Agilent Laboratories and the Center for Embedded Network Sensing at UCLA. This camera can be connected to the wireless motes such as those developed by Crossbow Technology [2].Crossbow's motes (example, MICA2) are small wireless sensor boards that can be connected to sensors capable of sensing environmental parameters such as temperature, light, humidity, etc and transmitting the measured data to other motes or a base stations which are located within their radio transmission range. The motes run the code developed in NesC language [4] on TinyOS operating system [6]. This combination can be used to develop several applications over wireless sensor network.

Connecting the Cyclops cameras to the wireless motes allows the sensor network to acquire images at regular intervals and transmit them to the desktop/laptop over a wireless channel [5] and can be used to infer meaningful information that can be used for object detection, recognition, motion detection, video surveillance and monitoring applications. Due to the limited size of the memory buffer available in the Cyclops camera, it is possible to obtain images of resolution 64x64 pixels as opposed very high resolution images that can be obtained by high-end cameras.

a) MICA2 Mote b) MTS400CA Multi-Functional Sensor Unit

c) MIB510 Programming Board d) Cyclops Camera

Figure 2. Crossbow Technology's Sensor Platform [Crossbow]

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