Review on Wireless Visual Sensor Networks

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Abstract- **Due to quick progression of sensor innovation equipping sensors nodes with cameras is possible. sensor nodes can send the captured visual information to give richer sensing and monitoring data, which empowers more applications in territories, for example, wide-life observation and security surveillance. These kinds of camera-prepared sensor systems are known as Wireless Visual Sensor Networks (WVSNs). In this article we are discussing about real design issues, challenges, attributes and applications to meet the QoS requirements for transmitting Visual information and comparing different hardware platforms of WVSN's with the WSN's.**

Keywords: Wireless Visual Sensor Networks, W*VSN's Challenges, Quality of Service, Network Architecture, WVSN's platforms.*

I. INTRODUCTION

The recent advances in micro-electro-mechanical systems (MEMS) technology, wireless communications, and digital electronics of sensors have promoted the development of wireless sensor networks (WSN) [1]. By using low-cost, low-power and multifunctional sensor nodes, the WSN has been deployed in many civil or military applications. Most current deployed WSNs measure scalar physical phenomena like temperature, humidity, pressure, or location of objects, which usually have low bandwidth requirement and usually delay tolerant. However, applications such as environmental monitoring, health-care monitoring, emergency response and security/surveillance, the multimedia information especially video stream is indispensable. Therefore, wireless "multimedia" sensor networks (WMSN) [2], which is capable of delivering multimedia information with high data rate have drawn much attention in research community in recent years.

The availability of inexpensive hardware such as CMOS cameras and microphones has fostered the development of (WMSNs), i.e., networks of wirelessly interconnected devices that are able to ubiquitously retrieve multimedia content such as video and audio streams, still images, and scalar sensor data from the environment. In addition to the ability to retrieve multimedia data, WMSNs will also be able to store, process in real time, correlate and fuse multimedia data originated from heterogeneous sources. Metrics such as latency and jitter have not been primary concerns in mainstream research on sensor networks. In such contexts, when multimedia data is collected exclusively by video based sensors, the resulting networks are referred to as visual sensor networks.

Visual Sensor Networks (VSN) (also referred to as *multimedia sensor networks*, or *video sensor networks* Wireless Visual Sensor Networks (WVSNs) [3] is a category of WSNs in which sensor nodes are equipped with a digital camera. Therefore, they are capable of capturing, processing and communicating multimedia contents in real time. However, in contrast to the limited hardware resources available in WSN motes, video processing applications require more powerful hardware (processing and memory) and communication (bandwidth) resources. Due to these limiting factors, it is an extremely challenging task to realize practical WVSNs. For video communication in WSVNs, video data is often compressed before transmission.

WVSN systems will enhance the ability of private citizens and law enforcement officers to observe and monitor locations and events in an unprecedented way, enabling sophisticated real time scene analysis. author envision that users will be able to gather information about the physical environment by issuing simple textual queries, accessing remote VSNs connected to the Internet through application-level gateways. The characteristics of VSNs diverge considerably from wired network paradigms such as the Internet, and even from traditional sensor networks. With the rapid development of visual sensor networks, numerous applications for these networks have been developed are: Surveillance, Environmental Monitoring, Smart homes, Smart meeting rooms, Telepresence systems [4]. In the following section WVSN's characteristics, challenges, issues, constraints and WVSN's applications are discussed. In section II Related work on WVSN's, in section III WVSN's network and node architectures are discussed. In section IV hardware platforms comparisons are discussed and section V concludes the WVSN's work in this article.

A. *WVSN's Characteristics*

- Resource Requirements.
- Local Processing.
- Real-Time Performance.
- Precise Location and Orientation Information.
- Time Synchronization.
- Data Storage.
- Autonomous Camera Collaboration.

B. *WVSN's Challenges*

WVSNs are capable of collecting large volumes of data about monitored scenes but are constrained with the available node resources and network bandwidth. Designing and implementing VSNs is thus faced with several challenges.

- Robust visual data processing are needed on-board to produce useful data and reduce the amount sent over the network but are typically restricted with the node resources (memory and power).
- Camera locations and modes of operation (active/sleep) should be carefully chosen to enforce continuous monitoring at the least energy cost.
- Reliable and delay-aware communication protocols are necessary to meet QoS requirements without exhausting the network. Other challenges include security, authentication, and privacy issues.

C. *WVSN's Issues*

- Coverage: Most of the visual sensor applications aim at maximum coverage with minimum number of visual sensors to improve lifetime simultaneously.
- Connectivity: Connectivity is part of the coverage problem. It ensures that there is at least one communication path between any pair of active sensors to ensure barrier coverage.
- Network lifetime: Due to the limited capacity of existing batteries, visual sensor nodes do not last as long as desired.
- Network traffic: The more messages are delivered, the more energy is consumed. Therefore, a sensor network should minimize its message traffic.
- Visual data processing, sensor management, Communication etc.

D. *WVSN's Constraints*

Constraints associated with Visual Sensor Nodes are: Limited angle of view, Single working direction out of multiple working directions is active during sensing, Line of sight plays a key role, fixed sensing radius, Motility allows adjustment of working direction, and Mobility of nodes removes coverage holes.

E. *WVSN's Applications*

WSN's capturing, processing, and communication capabilities enable a wide range of vision-based applications. In table 1 shows the various applications of WVSN's.

General application	Specific application
Surveillance	Public places, Traffic Parking lots, Remote areas
Environmental monitoring	Hazardous areas Animal habitats Building monitoring
Smart homes	Elderly care, Kindergarden
Smart meeting rooms	Teleconferencing Virtual studios
Virtual reality	Telepresence systems Telereality systems

Table 1: shows WVSN's Applications.

VSNs are useful for surveillance, smart rooms, and many others. Some of these applications are summarized below:

- Public and commercial surveillance: VSNs may be used for monitoring public places such as parks, department stores, transport systems, and production sites for infrastructure malfunctioning, accident detection, and crime prevention.
- Environmental and building monitoring: VSNs are perfect solutions for early detection of landslides, fires, or damages in mountain coasts, historical and archaeological sites and hence preservation of these areas.
- Military surveillance: Such networks can be employed in patrolling national borders, measuring flow of refugees, and assisting battlefield command and control .
- Smart homes and meeting rooms: VSNs can provide continuous monitoring of kindergarten, patients, or elderly requiring special care. This helps measure the effectiveness of medical treatments as well as detect early alarms.

VSNs are also used for teleconferencing and remote meetings.

- Telepresence systems: In VSN-based telepresence systems, the user can view any point from the remote location as if he or she was actually physically present at that location.

II. RELATED WORK

Developments in image technology lead to the emergence of a new class of distributed sensor-based networks, WVSN's. WVSN's consist of tiny, battery-operated, visual sensor nodes that integrate the image sensor, embedded processor, and wireless transceiver. WVSN's are able to capture, process, and transmit visual data collectively over the network to a central station for further processing. The difference between WVSN's and WSNs lies in the type of data collected and processed. Sensors in WSNs capture scalar measurements such as temperature readings, sounds, vibration, or pressure [5] all of which are somehow limited compared to WVSN data [6]. WVSN's thus produce much richer description of a situation of interest. Local processing extracts important information about the scene so the node transmits only intelligent data to the central station. These capturing, processing, and communication capabilities enable a wide range of vision-based applications. WVSN's are useful for surveillance, smart rooms, and many others.

The conventional video coding architecture has been challenged by the emergence of WVSN's. Traditional state-of-the-art video coding standards such as H.264 [7], MPEGx are pertinent to the broader class of applications that support encoders with complexity of at least 5–10 times greater than that of the decoder [8]. These video coding architectures suit applications such as streaming video-on-demand (VoD), video broadcasting, digital home systems, and multimedia collaboration that requires video to be encoded once and decoded several times by consumers [9]

Conventional video coding architectures are primarily based on hybrid discrete cosine transformation (DCT) and interframe predictive video coding (PVC) frameworks. These frameworks allocate codec functionalities such that most of the high complexity operations that involve exploiting spatial and temporal correlation, e.g. motion estimation and compensation, are executed at the encoder, while the decoder performs lower complexity operations such as entropy decoding, frame prediction, inverse quantization, and DCT on the bit stream received from encoder [10].

DVC is an emerging video coding paradigm for applications with limited resources available at encoder. It reverses the conventional video coding paradigm by shifting the encoder's complexity entirely or partially to the decoder, which is assumed to be more resourceful than the encoder. Therefore, DVC based encoders are much simpler, and a number of different DVC architectures have been proposed in literature [11].

III. VISUAL SENSOR NETWORKS ARCHITECTURE

A. *Network Architecture*

The VSN's network generally consists of the cameras themselves, which have some local image processing, communication and storage capabilities, and possibly one or more central computers, where image data from multiple cameras is further processed and fused (this processing may, however, simply take place in a distributed fashion across the cameras and their local controllers). Visual sensor networks also provide some high-level services to the user so that the large amount of data can be distilled into information of interest using specific queries.

The primary difference between visual sensor networks and other types of sensor networks is the nature and volume of information the individual sensors acquire: unlike, cameras are directional in their field of view, and they capture a large amount of visual information which may be partially processed independently of data from other cameras in the network. Alternatively, one may say that while most sensors measure some value such as temperature or pressure, visual sensors measure patterns. In light of this, communication in visual sensor networks differs substantially from traditional sensor networks. Fig 1 shows the visual sensor network scenario.

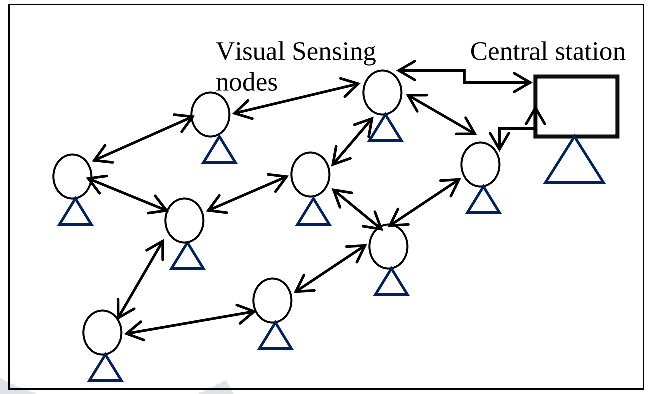

Fig 1: Visual Sensor Network Scenarios

Visual sensor nodes are defined as small, battery-operated nodes with image sensor, embedded processor, and wireless transceiver. This allows them to perform the following operations: capture images or videos from the scene, process them locally to extract relevant information, and transmit this data rather than raw images to a base station for activity analysis. The main blocks in a typical node are shown in Fig. 2. They include: a sensing module, processing module, storage module, communication module, and power or energy module.

B. *Node Architecture*

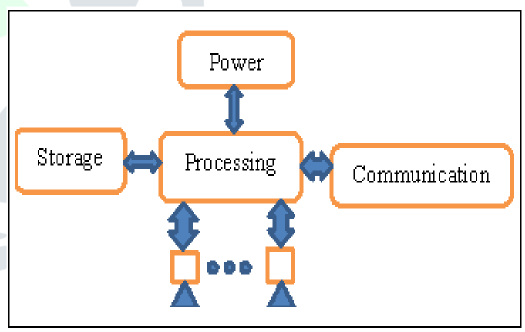

Fig 2: Visual Sensor Nodes Architecture

Underlying blocks and the way they are connected differs from one platform to another. The *sensing module* consists of one or more imaging sensors to capture image and video sequences. *Processing and storage modules* are responsible for handling all visual data operations including image processing tasks and buffering data during processing. The *communication module* or wireless transceiver is responsible for communication with the central station and collaborating with others nodes in the network the energy module is responsible for powering the node. Visual nodes are usually and mostly battery-operated. Renewable and solar energy was recently researched as a potential alternative to prolong the lifetime of these networks. The idea is to use energy harvesting and convert different forms of ambient energy (e.g. solar power, thermal energy, wind energy, salinity gradients, and kinetic energy) into electricity to power the nodes. However, harvesting solutions proposed so far can produce limited amounts of energy and power nodes interruptedly. Energy saving approaches (in terms of sensing, communication, and data processing) is mostly needed to reduce the nodes energy dissipation.

C. Information Processing in VSN's

In VSN's Information processing can be performed in various stages, here we proposed a simple algorithm which shows the various stages of information Processing.

Algorithm *Information Processing* (Visual sensor nodes (cameras))
Begin
Step 1: Sensor (Camera) Deployment & Initialization.
Step 2: Object (Event) Detection.
If (object is detected)
Collect the features of object.
Else
Go to Step 2;
Step 3: Perform Analysis of Features collected.
Step 4: Performs In-network processing.
Step 5: Send Information to the base (sink) station.
End

The first phase of our algorithm is sensor deployment & initialization of sensor nodes. VSNs consist of several spatially distributed nodes to provide a wide and efficient coverage of the monitored scene. Sensor management is important to maintain the most coverage at the least energy cost even when certain visual sensors fail. To meet these requirements, several design issues must be considered. First, the location, orientation, and mode of operation of each camera node need to be carefully chosen to ensure a well-covered scene. After successful deployment and initialization of camera nodes, an object or event is captured from the environment. Object detection and tracking identify interesting objects in the scene, their distinguishing features, and trajectories. Once object are detected and matched, high-resolution images are triggered to take snapshots of regions of interest. When matching objects, simple features such as position, velocity, and bounding box were extracted. In the next context performs the in-network processing which includes multimedia coding techniques for compression of captured multimedia data before transmitting, which helps further reduce the size of the data sent to the central station, and in the next step it transmits the data to the base station or sink.

IV. PLATFORM COMPARISON

In this section various wsn platforms are discussed and compared along with the WVSN's platforms. Table 1 presents the features of several WSN platforms. Lightweight platforms (e.g., Mica2, Mica2Dot, MicaZ, and Telos) are highly resource-constrained; thus, they are only suitable for simple sensing and detection tasks. The Yale XYZ platform, which is a typical example of intermediate platforms, has more memory and processing resources than the lightweight platforms. At the higher performance set, there is PDA-class platforms (e.g., Stargates) which are more powerful than the intermediate platforms but also consume more power.

Mote	Micro controller	Data, Memory	Storage, Memory	Radio	Data Rate
Mica2	ATmega1 28l (8-bit)	4 KB	512 KB	CC1000	38.4 Kbps
Mica2 Dot	ATmega1 28l (8-bit)	4 KB	512 KB	CC1000	38.4 Kbps
MicaZ	ATmega1 28l (8-bit)	4 KB	128 KB	CC2420	250 Kbps
Tmote SKY	MSP430F (16-bit)	10 KB	1,024 KB	CC2420	250 Kbps
Imote	ARM7 (32-bit)	11 KB	–	Zeevo TC2001	723.2 Kbps
XYZ	OKI ML67Q50 02(32-bit)	32 KB + 2 MB RAM	256 KB	CC2420	250 Kbps
Stargat e	Intel XScale (32-bit)	64 MB	32 MB	IEEE 802.11 bCC24 0	1–11 Mbps250 Kbps

Table 2: Wireless Sensor Networks Platforms

In table 2 we present an overview of nine available WVSN platforms. Depending upon some criteria criteria we use to select the WVSN platforms, with respect to that all platforms has local processing capabilities. They do not transmit visual data in raw form. And they all operate with battery not with power adapters. A typical WVSN platform consists of at least four building blocks; a microcontroller, a memory (on-board and/or external), imager(s) and wireless transceiver (built-in or integrated) and is powered with a limited battery resource. In this section, we aim to present all WVSN platforms which have the aforementioned physical attributes.

Platform	MCU	Memory	Radio
Cyclops	ATMELATmega128L (8-bit) processor on both imaging board (IM) & networking board (NB)	512 KB FLASH 64 KB SRAM on IB,4 KB SRAM 128 KB FLASH on NB	CC1000 (38.4 Kbps)
MeshEye	ARM7TDMI based ATMEL AT91SAM7S (32-bit)	64 KB SRAM 256 KB FLASH Internalmemory, 256 MB external on-board FLASH memory	CC2420 (250 Kbps)
Panoptes	StrongARM (32-bit)	64 MB	IEEE802 .11
Meerkats	XScale PXA255 (32-bit)	32 MB FLASH 64 MB DRAM	IEEE802 .11b(1–11 Mbps
FireFly Mosaic	LPC2106 ARM7TDMI (32-bit) processor on IB, ATMELAtmega1281 (8-bit) processor on NB	64 KB RAM 128 KB FLASH on IB, 8 KB RAM 128 KB FLASH on NB	CC2420 (250 Kbps)
MicrelEye	ATMEL FPSLIC SoC, with an AT40K MCU (8-bit)	36 KB onboard SRAM 1 MB external SRAM	LMX98 20A Bluetoot h (230.4 Kbps)
XYZALO HA	ARM7TDMI-based (32-bit) OKI ML67Q5002 on NB	32 KB RAM 256 KB FLASH onboard, 2 MB external RAM on NB	CC2420 (250 Kbps)
CITRIC	PXA270 (32-bit) on IB TI MSP430 (16-bit) on NB	64 MB SDRAM and 16 MB FLASH on IB, 10 KB RAM and 1 MB FLASH on NB	CC2420 (250 Kbps)
Vision Mote	ATMEL 9261 ARM 9 (32-bit)	128 MB FLASH 64 MB DRAM	CC2430 (250 Kbps)

Table 3: WVSN's hardware platforms

V. CONCLUSION

WVSN's are a valuable resource for many surveillance, tracking and general-purpose monitoring applications. Camera-enabled sensors will retrieve visual information that can be exploited for public security, military surveillance, industrial automation, weather monitoring, rescue operations, traffic management uses, among many others. In this way, sensor nodes can send the captured visual data to provide richer sensing and monitoring information. For some of those applications; tremendous challenges and research opportunities are present. In terms of Quality of Service (QoS) aware visual sensory data processing, coverage optimization, improved Communication protocols, intelligent data coding and compression methods, or localized information analysis and task distribution. And also in this article we have provided an overview of current platforms developed for WVSN's.

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