Architecture Exploration Based on Tasks Partitioning Between Hardware, Software and Locality for a Wireless Vision Sensor Node

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ABSTRACT

Wireless Vision Sensor Networks (WVSNs) is an emerging field which consists of a number of Visual Sensor Nodes (VSNs). Compared to traditional sensor networks, WVSNs operates on two dimensional data, which requires high bandwidth and high energy consumption. In order to minimize the energy consumption, the focus is on finding energy efficient and programmable architectures for the VSN by partitioning the vision tasks among hardware (FPGA), software (Micro-controller) and locality (sensor node or server). The energy consumption, cost and design time of different processing strategies is analyzed for the implementation of VSN. Moreover, the processing energy and communication energy consumption of VSN is investigated in order to maximize the lifetime. Results show that by introducing a reconfigurable platform such as FPGA with small static power consumption and by transmitting the compressed images after pixel based tasks from the VSN results in longer battery lifetime for the VSN.

Keywords: Hardware/Software Partitioning, Image Processing, Reconfigurable Architecture, Vision Sensor Node, Wireless Vision Sensor Networks

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INTRODUCTION

WVSNs have found its uses in many applications including industrial control and monitoring, surveillance, environmental monitoring, personal care and virtual world. Traditional imaging systems used for monitoring include a wired link, centralized network, wall power supply, high processing capabilities and unlimited storage. Such networks are difficult to deploy for many applications where there is limited availability of power, limited access to the location of interest and it is not convenient to modify the locations of the node or to frequently recharge the batteries. The wired solution usually results in high installation and maintenance costs. The wired network systems would require the cable to be isolated from factors such as humidity, magnetic field and the vibration associated with environment. In addition, it is necessary to have redundant wire for critical operations (Low, Win, & Er, 2006). Due to the advances made in the relevant technologies such as image sensors, sensor networking, distributed processing, power supplies and embedded systems, complex vision tasks can be performed using smart camera network usually referred as WVSN which consist of many nodes referred as VSN. Each VSN consists of an image sensor for acquiring images of the area of interest, a processor for local image processing, a transceiver for communicating the results to the server and a battery or alternative energy source for power.

The energy consumption and bandwidth are major constraints in WVSN. Therefore researchers are focused on minimizing the energy consumption of a VSN in order to prolong the lifetime of the visual sensor network (Akyildiz, Melodia, & Chouwdhry, 2007). On board processing and communication influence the energy consumption of the sensor node. Also, more on board processing reduces the energy consumption due to communication and vice versa (Ferrigno, Marano, Piaciello, & Pietrosanto, 2005). Visual sensor systems are very application specific and it is hard to generalize an implementation to take advantage of the low power characteristics of a custom made design. Thus, to achieve some volume for these systems, the target architecture needs to be programmable.

Our research is focused on providing energy efficient reconfigurable architectures for VSN by partitioning the vision tasks between VSN and server and between software and hardware platforms. This paper is extended work of the (Khursheed, Imran, O’Nils, Malik, O’Nils, Lawal, & Thornberg, 2011). Here, we have implemented all vision tasks of our application such as image capturing, subtraction, segmentation, morphology, bubble remover, labeling, features extraction and TIFF Group4 compression, on hardware, software platform and the server. It may be noted that by hardware we mean FPGA implementation and by software we mean Micro-controller implementation. Main objective of this work is to study the energy consumption, cost and design complexity of VSN when functionality is moved from one platform to another. This study can be used to determine which general programmable and low energy architecture is suitable for VSN. Moreover, the energy consumed by different VSN modules is investigated in order to maximize the lifetime of the node.

Following this, next sections are related work, experimental system, results, discussion and then conclusion of the paper.

RELATED WORK

WVSNs have been designed and implemented on software and on hardware platform. Often software solutions have small design time as many mature vision processing libraries are available for implementation.

In literature, different approaches have been proposed to implement VSN on software platform in order to minimize the energy consumption. FireFly Mosaic (Rowe, Goel, & Rajkumar, 2007) wireless camera consists of a collision free TDMA based communication protocol. FireFly is a low-cost, low power sensor
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