Energy Efficient and Programmable Architecture for Wireless Vision Sensor Node

ABSTRACT

Wireless Vision Sensor Networks (WVSNs) is an emerging field which has attracted a number of potential applications because of smaller per node cost, ease of deployment, scalability and low power stand alone solutions. WVSNs consist of a number of wireless Vision Sensor Nodes (VSNs). Individual VSN has limited resources such as embedded processing platform, power supply, wireless radio and memory. In presence of these limited resources, a VSN is expected to perform complex vision tasks for a long duration of time without battery replacement/recharging. Currently, reduction of processing and communication energy consumptions have been major challenges for battery operated VSNs. Another challenge is to propose generic solutions for a VSN so as to make these solutions suitable for a number of applications.

To meet these challenges, this thesis focuses on energy efficient and programmable VSN architecture for machine vision systems which can classify objects based on binary data. In order to facilitate generic solutions, a taxonomy has been developed together with a complexity model which can be used for systems' classification and comparison without the need for actual implementation. The proposed VSN architecture is based on tasks partitioning between a VSN and a server as well as tasks partitioning locally on the node between software and hardware platforms. In relation to tasks partitioning, the effect on processing, communication energy consumptions, design complexity and lifetime has been investigated.

The investigation shows that the strategy, in which front end tasks up to segmentation accompanied by a bi-level coding are implemented on Field Programmable Platform (FPGA) with small sleep power, offers a generalized low complexity and energy efficient VSN architecture. The implementation of data intensive front end tasks on hardware reconfigurable platform reduces processing energy. However, there is a scope for reducing communication energy, related to output data. This thesis also explores data reduction techniques including image coding, region of interest coding and change coding which reduces output data significantly.

For proof of concept, VSN architecture together with tasks partitioning, bi-level video coding, duty cycling and low complexity background subtraction technique has been implemented on real hardware and functionality has been verified for four applications including particle detection system, remote meter reading, bird detection and people counting. The results based on measured energy values shows that, depending on the application, the energy consumption can be reduced by a factor of approximately 1.5 up to 376 as compared to currently published VSNs. In addition to this, proposed VSN offers generic architecture with smaller design complexity on hardware reconfigurable platform and offers easy adaptation for a number of applications as compared to published systems.

Keywords: Wireless Vision Sensor Node, Smart camera, Wireless Vision Sensor Networks, Architecture, Video coding.

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