# Networked Energy-Aware Visual Analysis

1. Optimize visual features extraction algorithms and propose novel coding solutions for visual features in resource constrained networks.
2. Define energy-rate-efficiency models for specific (and generic) image analysis tasks.
3. Propose algorithms for distributed computation and coding of visual features.
4. Design distributed algorithms to coordinate computation and coding among the nodes.


| Main Project Team | |
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**Two Main Publications**

N. Monteiro, F. Pereira, J. Ascenso, **Multi-View Distributed Source Coding of Binary Features for Visual Sensor Networks**, IEEE International Conference on Acoustics, Speech, and Signal Processing - ICASSP, Shanghai, China, March, 2016

L. Baroffio, J. Ascenso, M. Cesana, M. Tagliasacchi, **Coding Binary Local Features Extracted From Video Sequences**, IEEE International Conference on Image Processing - ICIP, Paris, France, October, 2014

PROJECT WEBPAGE URL
http://www.greeneyesproject.eu/


**Fig. 1** GreenEyes Application Scenarios.

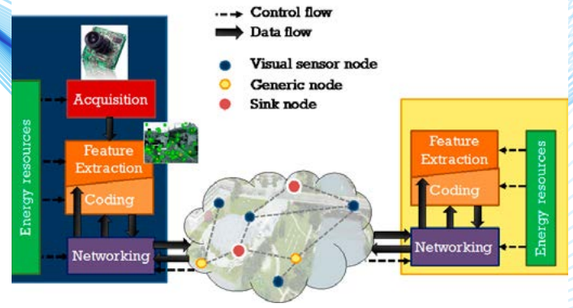


**Fig. 2** GreenEyes Vision: cooperation among nodes.

## GENERAL MOTIVATION AND OBJECTIVES

Every day, humans analyse and ultimately convert visual stimuli into high level semantic concepts, which form the basis for efficient communication between individuals. Digital cameras have been developed mimicking a simplified model of the human visual system. Images are acquired in digital format by sampling and quantizing the light-field on a discrete lattice of pixels. Images, or image sequences, are then compressed in order to be stored and/or transmitted. In many scenarios, image analysis comes at last and it is decoupled from the acquisition and compression phases. Therefore, image analysis is often based on a compressed and hence lossy representation of the original image, which might significantly impair its efficiency. In addition, a pixel-level representation of the image data is usually stored and transmitted, although it might ultimately matter only its semantics. Second, energy-efficiency is often neglected, since most of the processing burden associated to image analysis tasks is to be carried out at a centralized, power-eager, node.

Such a compress-then-analyse paradigm is being successfully employed in a number of application scenarios, e.g. video surveillance, where energy constraints are not overwhelming. However, the potential of the Internet of Things is leading to a paradigm shift with an ambitious long-term vision, in which battery-operated sensing nodes are empowered with sight and are capable of complex visual analysis tasks (e.g. object recognition, event detection, localization, tracking, etc.). Figure 2 provides an illustrative representation of the high level system architecture addressed by the GreenEyes project, highlighting the functional modules and their dependencies. Nodes are equipped with low-power microprocessors and radio chips on board, so that they can communicate among each other and, whenever available, with a power-eager sink node. GreenEyes envisages a scenario in which sensing nodes might perform local processing to extract and encode visual features, rather than compressing and transmitting the sensed images in the pixel domain, a limited representation of the visual content.

## CHALLENGE

Enabling visual analysis in energy-constrained sensor networks requires departing from traditional solutions and pursuing a paradigm shift that affects the way visual data is sensed, processed and transmitted. To this end, GreenEyes is developing a comprehensive set of new methodologies, practical algorithms and protocols, to empower sensor networks with vision capabilities. The key tenet is that most visual analysis tasks can be carried out based on a succinct representation of the image, which entails both global and local features, while it disregards the underlying pixel-level representation.

## WORK DESCRIPTION AND ACHIEVEMENTS

GreenEyes aims to optimize the computation, coding and communication of the visual features, and approaches the problem by proposing a novel analyse-and-compress paradigm. The following contributions were made:

· Energy-constrained extraction of visual features. To reverse the compress-then-analyze paradigm, visual features need to be computed at the sensing nodes, thus avoiding the need for encoding and transmitting redundant pixel-level representations. Thus, energy-aware visual feature extraction methods suitable for resource-constrained hardware platforms were proposed.

· Rate-efficiency modelling and coding of visual features. Visual features need to be efficiently encoded to be transmitted in resource constrained sensor networks. GreenEyes has proposed a wide range of coding solutions with different complexity-efficiency tradeoffs, such as inter-node predictive coding schemes and distributed source coding of visual features.

· Networking streams of visual features. GreenEyes has designed new visual sensor network protocols to coordinate the distributed computation and the coding of visual features performed in the sensing nodes which is essential to deliver the coded information to the destination node(s).