DEMO: Resource Management with Wireless Sensor Networks and Satellite in Extreme Climates

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ABSTRACT

Advances in the field of sensors, digital cameras and communications can be leveraged for effective remote resource management. The WiSE (Wireless Internet Sensing Environment) project is researching and testing new techniques for monitoring the natural environment that provides essential information for taking informed decisions for sustainability and land management The project uses digital cameras to record high quality imagery - both still images and video content. Advanced video coding methods to detect and compress relevant imagery, which can be retrieved using advanced networking (e.g. satellite or wireless backhaul). This flexible approach represents a new paradigm for collecting environmental data enhancing accuracy and quality, with the potential to revolutionize data collection. The techniques are expected to find application in many arenas allowing future support of a range of applications.

General Terms

Resource management, Wireless sensor networks, Database, Communications.

Keywords

Video processing, Network protocols, Satellite communication.

1.   INTRODUCTION

The developments in sensors enable us to measure phenomena of interest in the physical world. The revolutions in processing power of sensor nodes and communications have removed the barriers of distance and enable us to collect the data and extract the information remotely in near real-time. Resource management of remote assets through cameras and Internet assumes profound significance when the human access to the monitored area is difficult or hazardous. Also, the dynamics of the deployment change significantly as the technology platform becomes exposed to the extreme climate.

The WiSE project (Figure 1) uses a combination of wired and wireless LAN for resource monitoring using night-vision capable cameras. The infrastructure has been designed to cope with extreme weather and also to autonomously take decisions to conserve power and optimize system resources such as satellite bandwidth and data storage.

The system is fully autonomous and can capture useful data by dynamically adjusting parameters for best activation decisions. New methods are used to adapt the volume of captured imagery to save on storage, transmission and simplify analysis.
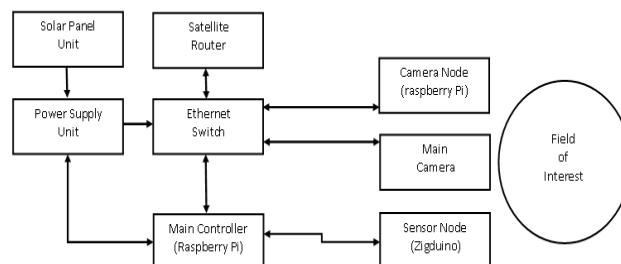

Figure 1: Block diagram of the WiSE System.

The motion detection in the field of interest takes place by combining the signals from infrared and radar sensors. This may be further augmented by incorporating the motion sensing through a camera. The information about the sensors activations and resulting images are stored in an on-site database to enable efficient data collection. The system also logs the temperature and light values in addition to the motion sensors activations which serve as a very useful data repository for analysis.

Remote access to the LAN is provided through a satellite. The satellite link is switched on at a scheduled time for the backhaul of captured imagery and other stored information. The same connection time slot is also used to remotely change system parameters, if required.

2.   DEPLOYMENT SCENARIO

The first application of WiSE in June 2013 is to a remote upland area to assess the impact of changes in a critical aspect of deer management. This supports a new approach for biodiversity management in an extremely remote location.

The demonstration will display the whole start-to-finish process of sensor activation, communication and picture-taking, storage of data to database. Visitors will be able to trigger (or try to avoid triggering) the sensors on display and will be able to explore the captured sensor data and display imagery by accessing a local web server.

3.   TECHNOLOGIES AND INNOVATIVE FEATURES

The platform combines a blend of state-of-the-art technologies and many innovative features to reduce the capture of redundant imagery and to keep an efficient record of system decisions that enable the algorithms used to be further refined.

3.1 Reduction of False Triggering

False triggering occurs when a sensor activates the camera on a false conclusion of having detected a moving object. This is the major nuisance when using conventional camera traps.

The WISE platform reduces false triggering by defining rules that combine the output of different motion sensors and allow intelligent decisions about whether to capture images or video content by interpreting the trigger data. The details of these innovations are as follows:

3.1.1 Motion Detection

Conventional use of Passive Infra-Red sensors (PIR) has been augmented by including low-cost X-Band Doppler radar. The PIR sensor is triggered by presence of moving heat sources in its range but can also be activated by a gust of air of temperature different from the scene in front of the sensor. In contrast the Doppler radar detects motion by sensing a change in the reflected radar frequency, but can be deceived by rain (which absorbs rather than reflects the radar signal). The combined use of both sensors provides a much higher probability of positive detection.

In addition, the project enables a low-resolution camera to run robust motion detection algorithms on the live video stream that can further reduce false triggering.

3.1.2 Exploiting Historical Data

All sensor data and captured imagery is stored in a Triplestore database installed on a Raspberry Pi at the WiSE Gateway. Before a decision is made to activate the main camera, the data stored in the database is analyzed to make a better judgment based on pre-defined rules.

The record of motion sensor activation and resulting images in the data repository are being used to provide evidence to validate correct working of the sensors and related algorithms. This data could also be used to better understand the behavior of animals triggering the camera. Temperature and light sensor data is also logged along with other environmental data. This can be used to monitor the operation of the platform, but could provide data to explore other trends and events.

3.2 Communication

3.2.1 IPv6 Over Low Power Wireless Personal Area Networks (6LoWPAN)

The sensor nodes employ the Contiki, a real-time OS running on the AVR platform. The platform includes a radio interface that is driven using the 6LoWPAN standard. This standard protocol is specifically designed for communication between low power devices and consumes a fraction of the power of an equivalent WiFi connection. It is used by sensor nodes to transmit a wireless trigger signal to the WiSE Gateway.

3.2.2 Satellite Communication

The platform uses a satellite backhaul for Internet connectivity. This makes it possible not only to view the live video and associated state of the system but also to control the platform from any place in the world. We plan to demonstrate remote access to this platform from the demonstration at DF 2013. Visitors are expected to be able to retrieve sensor data and imagery via this satellite link.

3.3 Image and Video Processing

3.3.1 The ROI based image processing

The area monitored by the cameras used in the project is static. It becomes important to utilize region of interest (ROI) based processing techniques to tune the motion detection algorithms.

3.3.2 Scalable Video Streaming

The scalable video system enables selection of various sub-streams of an encoded video sequence according to the processing power and bandwidth of a device.

3.3.3 Video Analysis

The post processing of the captured imagery can tag images and video according to their information.

3.4 Power Management

The battery power is the most valuable resource for the remote system. Its importance increases further during winter months when the charge generated by the solar panels is reduced. This dictates a need to exercise control over the devices' operation and to reduce the amount of image/video being captured. This is made possible through use of effective algorithms to make the optimum utilization of these resources.

4. LESSONS LEARNT

The deployment of the platform to a remote site will take place during Jun 2013 this will give sufficient time before the onset of winters when the system gets tested against the adverse weather conditions.

We expect the lessons learned from this deployment will be useful to explore utilization in other complementary scenarios.

5. TECHNICAL REQUIREMENTS FOR THE DEMO

The following is requested at the venue of DE2013:

- A table to demonstrate the platform components. The allocated table to be preferably located away from other stalls or at least be at an end with a minimum of 5m enable activation of the sensors and camera.
- One 13A mains power strip with 5 power sockets.
- An Internet (Ethernet) connection that is able to support General Routing Encapsulation (GRE) VPNs to allow access to the operational remote camera.
- A poster board to display the project poster and examples of captured images.

6. ACKNOWLEDGEMENTS