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Dust Motes for Border Surveillance

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***Abstract*—Prevention of enemy intrusion near the border is an important task. There are many areas that cannot be monitored keenly and continuously by border security forces and satellites. The current monitoring and surveillance systems are expensive in real time. This paper presents a low cost smart wireless network for tactical border surveillance system to detect, classify and track enemy intrusion using vision, acoustic, magnetic, thermal and vibration signatures. Each sensor mote has few on-board sensors, a processor and a wireless connection, to sense and communicate an enemy intrusion across borders and battlefields. These sensor motes are small in size and can be rapidly deployed by few men.**

Keywords—Collection of sensors on a board with processor; Deployed efficiently ; storage ; Vision sensors(camera); Energy Consumed by the motes.

I. INTRODUCTION

Many technologies have been used in border surveillance and the requirement for improvement never ends. Wireless Sensor Networks represent the collection of sensor motes that can be efficiently used for surveillance. Those sensors sense the external environment and send the processed data from one node to other. It has been analyzed that all types are used separately for surveillance. In this project different types of sensors are being used on a single board. The main idea is to disperse these motes within a large geographical area specifically in border and battlefield. The collected data are not only processed and transmitted they are also stored for future reference. The characteristics of each sensor are explained in forthcoming sections of this paper. The energy consumption issue of sensors is to be managed properly. This is because the sensors once deployed cannot be replaced or recharged. All the sensors are connected to a central processor. These sensor motes are placed or dropped in and around the critical areas. Various methods are used for deploying those motes. All sensor motes are placed in such a way that all places are covered.

II. EXISTING SYSTEM

Primarily fencing system was used in Indian borders. Later cameras were added with the system for efficient functioning. Still cameras fail to function efficiently during night and changing weathers. Recent research is going on to improve the efficiency of cameras. In certain marshy lands Laser wall technology is recently implemented to detect the enemy intrusion. In addition to those technologies infrared sensors, thermal sensors and motion sensors are being used separately.These technologies are of high costs and labour intensive.

Fig.1. Laser wall technology in borders

III. PROPOSED SYSTEM

In this section we described in detail about the components used in surveillance. The system contains the tiny motes and they are deployed in a few hours by a few men or even dropped from an airborne helicopter. Each mote consists of a variety of sensors to detect all potential forms of intrusion such as visual, magnetic, acoustic, thermal and vibration signature recognition, a microcontroller for processing these sensor values and a radio transceiver for communication over a wireless network.

Each mote is built with a variety of sensors to detect all types of possible intrusion.The different sensors are

1) **Visual** – A Camera sensor will be used to recognize movement caused by humans or vehicles and the pictures will be stored in a permanent memory for future reference

2) **Magnetic** – A MEMS magnetometer sensor will be used to identify magnetic signature of a large metallic bodies such as a weapon carried by an intruder or a vehicle

3) **Acoustic** – A Microphone sensor will be used to sense the acoustic sound signals of human or vehicle

4) **Thermal** – A PIR sensor will be used to identify movement of humans via the heat emitted from their body.

5) **Vibration** – A MEMS Accelerometer sensor will be used to sense the physical vibration caused by the intruder or a vehicle

Once an intrusion is detected, it will be sent to the coordinator mote and will be classified into vehicles or individuals and groups. The coordinator mote process the sensor readings, classify the targets and the tracking history can be viewed in a Graphics LCD display attached with it. The coordinator mote is able to send an alert SMS to authorities about the intrusion using a GSM unit.

The coordinator mote acts as the base station in a peer to peer wireless network model and will be powered by a larger battery or power mains. Wireless sensor network is constructed based upon IEEE 802.15.4 low power wireless network protocol. A 32-bit ARM Cortex-M3 microcontroller is used as the brain of all these sensor and coordinator motes. Each mote will consume very low power to stay longer and will be powered from a tiny battery. A separate ARM Cortex-M3 microcontroller will be used to interface and process the camera images from the vision sensor.

IV.BLOCK DIAGRAM

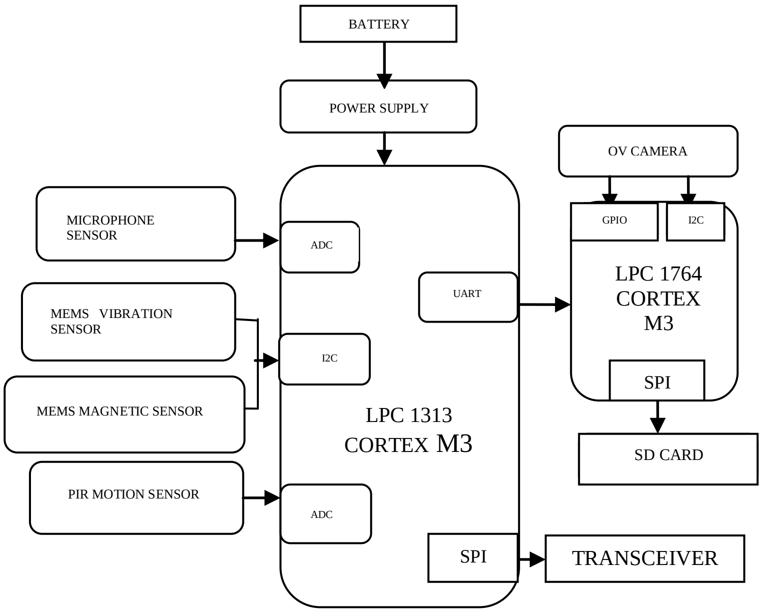

Fig .2. Sensor mote

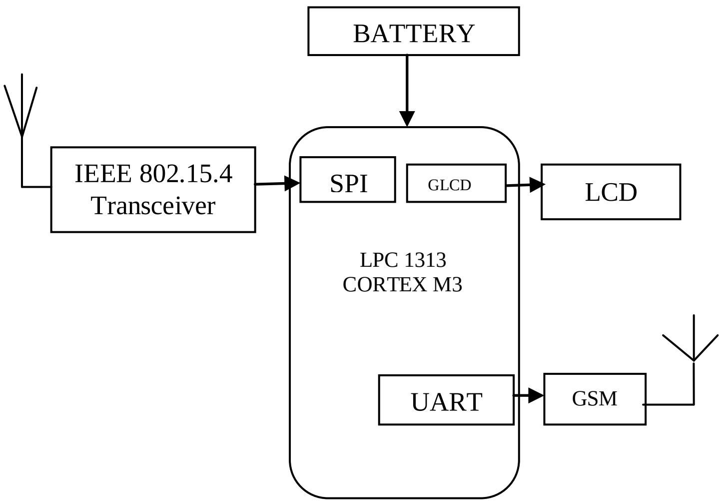

fig.3. Base mote

V. PIR MOTION SENSOR

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out. They are often referred to as PIR, "Passive Infrared", "Pyro electric", or "IR motion" sensors.

PIR can detect levels of infrared radiation. Everything emits some low level radiation, and the hotter something is, the more radiation is emitted. We are looking to detect motion (change) not average IR levels

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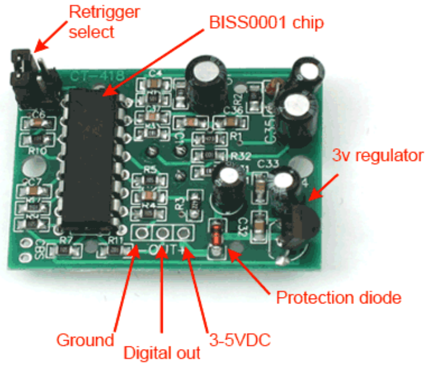

Fig. 4. PIR Sensor

VI. ACCELEROMETER SENSOR

The ultra compact, low-power, digital output 3-axis linear accelerometer can be used. The complete device includes a sensing element and an IC interface able to take the information from the sensing element and to provide a signal to the external world through an I2C/SPI serial interface.

A. *Sensing element*

The technology allows to carry out suspended silicon structures which are attached to the substrate in a few points called anchors and are free to move in the direction of the sensed acceleration. To be compatible with the traditional packaging techniques a cap is placed on top of the sensing element to avoid blocking the moving parts during the moulding phase of the plastic encapsulation.

When an acceleration is applied to the sensor the proof mass displaces from its nominal position, causing an imbalance in the capacitive half-bridge. This imbalance is measured using charge integration in response to a voltage pulse applied to the sense capacitor. At steady state the nominal value of the capacitors are few pF and when an acceleration is applied the maximum variation of the capacitive load is in RF range.

B . IC interface

The complete measurement chain is composed by a low-noise capacitive amplifier which converts into an analog voltage the capacitive unbalancing of the MEMS sensor and by analog-to-digital converters. The acceleration data may be accessed through an I2C/SPI interface thus making the device particularly suitable for direct interfacing with a microcontroller.

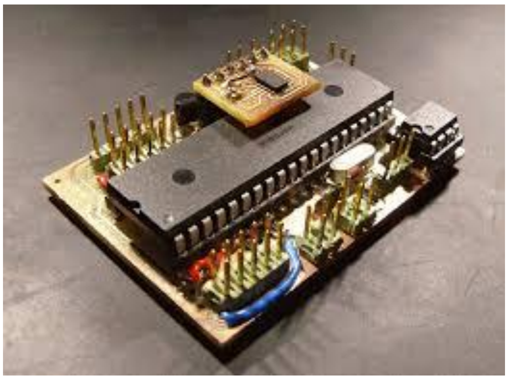

Fig.5. Accelerometer Sensor

VII. MAGNETOMETER SENSOR

A MEMS-based magnetic field sensor is a small-scale micro electromechanical (MEMS) device for detecting and measuring magnetic fields. Many of these operate by detecting effects of the Lorentz force: a change in voltage or resonant frequency may be measured electronically, or a mechanical displacement may be measured optically. Compensation for temperature effects is necessary.

A. *Advantages of MEMS-based sensors*

A MEMS-based magnetic field sensor is small in size, and so it can be placed close to the measurement location and thereby achieves higher spatial resolution. Additionally, constructing a MEMS magnetic field sensor does not involve the micro fabrication of magnetic material. Therefore, the cost of the sensor can be greatly reduced. Integration of MEMS sensor and microelectronics can further reduce the size of the entire magnetic field sensing system.

The sensor consists of micro-machined structures on a silicon wafer. There are structures designed to measure magnetic fields in the X, Y and Z axis. These structures are suspended by poly silicon springs and are etched with microscopic coils,which allow them to deflect when subject to magnetic field in the X, Y and/or Z axis. An excitation current is passed through the coils, and the Lorentz Force due to the magnetic field causes the structure to deflect. Once again the deflection is converted to an output voltage proportional to the strength of the magnetic field in that axis.

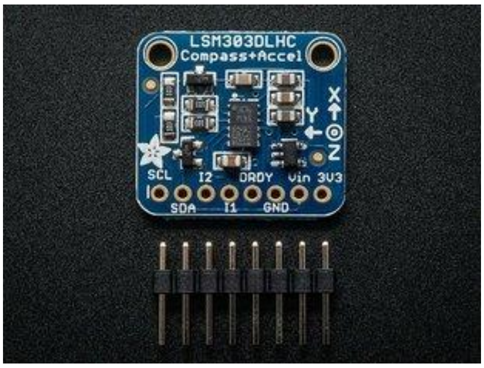

Fig .5. Magnetometer Sensor

VIII. OMNI VISION CAMERA

The OV7670 employs Omni Vision's proprietary Omni Pixel sensor architecture, which significantly increases signal-to-noise ratio and delivers exceptional low-light performance. The OV7670 comes in a lead-free package and is available now in volume production quantities. It has a resolution of 1.3 mega pixel.

The low-voltage OV7670 image sensor provides the full functionality of a single-chip VGA camera and image processor in a small footprint package (3.8mm x 4.2mm), which allows for a camera module size as small as 6mm x 6mm x 4.5mm. It provides full-frame, sub-sampled or windowed 8-bit images in a wide range of formats controlled through a serial camera control bus (SCCB) interface.

All required image processing functions including exposure control, gamma, white balance, color saturation, hue control, white pixel canceling and noise canceling are programmable. This product has an image array capable of operating at up to 30 frames per second (fps) in VGA with complete user control over image quality, formatting and output data transfer. All required image processing functions, including.

In addition, Omni Vision sensors use proprietary sensor technology to improve image quality by reducing or eliminating common lighting/electrical sources of image contamination, such as fixed pattern noise (FPN), smearing, blooming, etc., to produce a clean, fully stable color image .

Fig .6.Omni Vision Camera

IX. ACOUSTIC SENSOR

In Acoustic wave sensors , detection mechanism is a mechanical. As the acoustic wave propagates through or on the surface of the material, any changes to the characteristics of the propagation path affect the velocity and/or amplitude of the wave. Changes in velocity can be monitored by measuring the frequency or phase characteristics of the sensor and can then be correlated to the corresponding physical quantity being measured.

The range of those devices can be detected by expansion of coating materials of the devices that undergo changes in their mass, elasticity, or conductivity upon exposure to some physical or chemical stimulus. These sensors become pressure, torque, shock, and force detectors under an applied stress that changes the dynamics of the propagating medium. They become mass, or gravimetric, sensors when particles are allowed to contact the propagation medium, changing the stress on it.

Fig.7. Acoustic Sensor

X. SOFTWARE TOOLS

NXP's low-cost development platform for LPC families. LPC Xpresso IDE will provide software engineers a quick and easy way to develop their applications. It supports NXP's ARM-based LPC microcontrollers. Highly - integrated software development environment for NXP's LPC microcontrollers.

Fig.8. NXP Logo

Fig..9. Software Tool Logo

XI. FUTURE DEVELOPMENT

- The battery of the sensor mote would drain in mean time and this battery can be supported with mini solar panel which in-turn can increase the life time of the motes.
- The data captured and processed by the sensors are stored in SD cards. In future those images and information can be live streamed with suitable technologies.
- The resolution of the cameras can be increased or it can be replaced by one which is efficient in all climatic conditions possibly with a small size.

XII CONCLUSION

Next generation intelligent ultra small dust like wireless sensor motes which has multiple on -board sensors and a processor was designed. It has the ability to detect an enemy intrusion across borders and battlefields. If thousands of these smart dust motes are deployed within a large area, they will detect the intrusion and classify it into vehicles or individuals and groups. On-board hardware include a variety of sensors for vibration/seismic, magnetic, acoustic and thermal signature recognition, a microcontroller for processing these sensor values and a radio transceiver for communication over a wireless network. The system process the sensor readings, classify the targets and the tracking history can be viewed in the Graphics LCD display attached in the central monitoring unit

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