Engineering Project Proposals

(Wireless sensor networks)

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Report Summary

The following report contains four proposals, all of which rely on wireless sensor network technologies.

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OCEAN BASED MONITORING SYSTEM

INTRODUCTION

Underwater monitoring of geological activity along plate faults could allow substantial warning time for evacuation of target areas during the initial generation of a Tsunami wave. Tsunamis are caused by rapid displacement of a body of water on a massive scale. This displacement can be caused by numerous events such as earthquakes, volcanic eruptions, underwater explosions and meteorite impacts and the results can be unnoticeable or devastating. There is no currently known prevention for tsunamis however a quick, efficient warning system can prove to be the best defense.

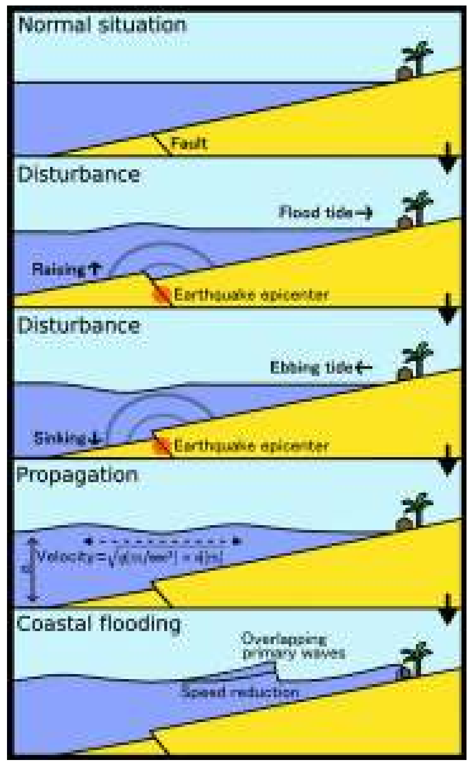

Figure 1

Monitoring an underwater area such as the ocean using a wired network would be costly and time consuming, however the use of wireless sensor network could be strategically deployed. Each device would require a particular set of sensors based on the characteristics of a generating tsunami wave. The formation of a tsunami wave can generally be detected by the following:

- Vibrations indicating an earthquake.
- Large quantities of gas bubbling to the surface.
- Unusually hot water temperatures.
- Presence of hydrogen sulfide.[1]

The sensors required to detect these characteristics include a vibration sensor, temperature sensor and a chemical composition sensor.

The detected characteristics of the wave would be recorded and transmitted through the ad hoc network to all nearby costal links that would alert the proper authorities. This would allow an evacuation or prevention to begin immediately after the detection of the tsunami potentially saving lives.

CURRENT TSUNAMI WARNING SYSTEMS

The systems used currently to detect tsunami waves rely heavily on seismic wave detection. During geological underwater activity seismic waves are generated and propagate through the Earth's crust. This allows for extremely quick detection since seismic waves generally travel with typical speeds of 4km/s (14,400km/h) where the tsunami itself travels at approximately 500km/h to 1000km/h in open water and reduce speeds dramatically as the water depth decreases.[2] This allows for several hours of notice

[1] Wikipedia, <http://en.wikipedia.org/wiki/Tsunami>

[2] Wikipedia, <http://en.wikipedia.org/wiki/Tsunami_warning_system>

before arrival of the tsunami in which an alert may be generated, the entire process requiring a total of 15 minutes.[2]

Since these warning systems rely on seismic waves, characteristics of the tsunami such as energy transfer and propagation may not be detected. Seismic waves allow precise determination of the epicenter however due to the nature of tsunami waves do not predict the probability or progression of actual danger to those at shore.

WIRELESS SENSOR SOLUTION

The use of wireless sensor networks would allow a dynamic ad hoc network to be installed within the large bodies of water to detect and monitor tsunami waves. Monitoring the energy transfer of the tsunami would allow an accurate model to predict the path of propagation giving a better idea of which coastlines to alert.

OBSTACLES / RESEARCH

The use of underwater communication is currently far less advanced than through other mediums (e.g. Air). Water does not transmit radio waves as easily, making the range limited. The use of acoustic waves is the current research interest and most immediately feasible system. Acoustic waves present numerous difficulties for the designer, which are not present in today's wireless communication links using air as the medium of data transfer. The signal propagation speed in underwater acoustic channel is about 1.5×10^3 m/sec; five orders of magnitude lower than the radio propagation speed (3×10^8 m/sec). Most systems today operate below 30kHz and according to current research and development, no commercial system can communicate faster than 40km/kbps as the maximum attainable range/rate product.[3] The bandwidth of underwater acoustic channels operating over several kilometers are about several tens of kbps, while short-range systems over tens of kilometers may reach speeds of hundreds of kbps. In addition to the slow propagation delay, acoustic communication channels are also affected by factors such as path loss, noise, multi-path, and Doppler spread. All of these factors cause high bit-error and delay variance.

POSSIBLE SOLUTIONS

The research of underwater acoustic communication has been vigorously studied and any improvements upon the currently manufactured systems would require further study of transmitting data through that specific medium. The next most obvious improvement solution would be to have a large array of wireless sensor nodes throughout the depths of the body of water and have a buoy that would transmit the information across large distances with current technology using air as the medium. This would allow the data to be collected using the underwater nodes within close distances for the higher bit rate provided the distance between nodes is limited to tens of kilometers. Another solution involves finding the most efficient and cost friendly relation between distance of a wired node close to the shoreline and communicating to the target area via other communication means when the signal arrives to land.

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[3] D. B. Kilfoyle and A. B. Baggeroer. The State of the Art in Under-water Acoustic Telemetry. IEEE Journal of Oceanic Engineering, OE-25(5):4–27, January 2000.

MOTION RECORDING VIA WSN (WIRELESS SENOR NETWORKS)

(Please See "Important Note" Below)

Concept:

In certain environments motion detection / video surveillance can be difficult to implement and manipulate due to logistical limitations. For example, say video documented research is being done for a documentary and the subject of study is a fast moving creature such as a hummingbird in its natural habitat. In order to track and survey its behavior either:

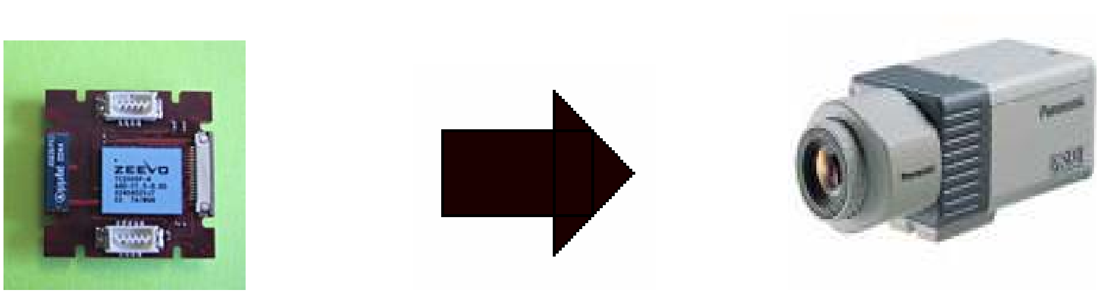
i) A mini network of surveillance equipment will have to be set up in the hummingbird's environ and let recording continuously, or
ii) The network of surveillance would have to individually monitored /controlled by a surveyor to determine what and when should the subject be recorded/tracked

The first method is inefficient in terms of usage of recording media, power consumption and time. The second is overly complex and expensive to implement.

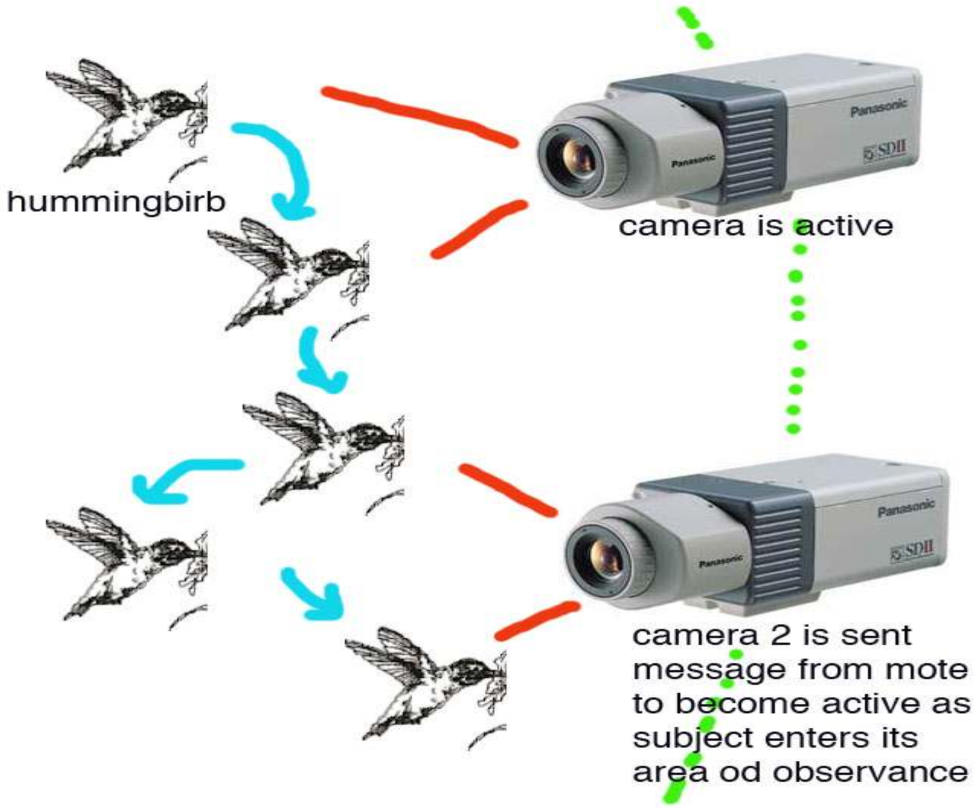
By incorporating the use of a wireless Senor Network (WSN) within the surveillance equipment the efficiency of the time and cost can be drastically improved, as the new network would be virtually autonomous.

Implementation

When the subject (in this case the humming bird) enters a camera's area of surveillance the motion detection activates the recording. Direction and speed information is stored in the resident mote of the camera and is sent to adjacent



camera motes. This information is used to determine which camera in the network is to active and record next, thus creating a motion sensitive video tracking system, which could be set up in remote location. Because the cameras are only active when recording is beneficial, this efficiency allows for battery-powered surveillance. The power will be conserved as there is no continuous recording, given the subject is mobile. Video information can be collected using less personnel and at lower costs.



Important Note:

This is a complex system and the particular application above may not be practical. We would like to stress, however, we find the idea introduced very interesting. In general, it illustrates a system where the nodes are instructed to carry out certain actions by other nodes in the system rather then by some self triggered event.

SOLDIER MONITORING SYSTEM USING WIRELESS SENSOR NETWORKS

Background

Soldier management is one of the key components in military applications. Strategic deployment is vital and contains many variables. One variable that is key to deployment is soldier status. Determination of health and location can provide enough information to determine the number of soldiers to deploy or where a medic might be required.

Objective: To implement a Soldier Monitoring System using wireless sensor networks.

Wireless Sensor Networks (WSN) are networks of low power communication nodes communicating to each other in a peer to peer networking mode transferring data acquired from different sensors back to a base station. The communication of each node is through a radio transceiver that allows each node to communicate to each other in a mesh networking topology. Attached to each node are inputs that monitors different variables. The variables that will be monitored is temperature, pulse and gps information. These input is relayed to neighboring nodes and passed on to a base station. Once acquired, the base station processes the information received. To ensure mobility, the base station will be designed in a mobile robot that will determine best location to ensure connectivity within the mesh networking.

Design

The system has three facets of design: Sensor design/interface, Network implementation and Base station design.

Sensor Design and/or Interface

This facet will entail the design of the sensors that will be used to interface with the wireless sensor nodes. Designing the different sensors can be time consuming, but can eliminate a lot of the cost entailed in the project. Once the sensors are designed, each sensor must be able to interface with each node. This entails decoding the signals acquired from the nodes to information that can be transmitted within the sensor network. Therefore, each node must be programmed with necessary information to translate signals transmitted from the different sensors.

Network Implementation

This is one of the most difficult facet to implement. Since communication will be peer to peer, an optimal way of communicating within nodes must be developed to ensure maximum bandwidth. Different algorithms can be tested to ensure that data is efficiently acquired and transferred within the mesh of networks. This includes ensuring minimum hops taken to communicate from node to base station. A routing algorithm must be developed to ensure if one of the nodes is disconnected, there are alternative routes that can be taken that is optimal.

Base Station Design

To ensure mobility, the base station will be installed in mobile robot. There are two components that must be implemented in the design of the base station: data processing and localization. Data processing will entail updating the necessary user interface from the acquired data from the sensor nodes. To ensure that the mobile robot is within communicating distance of the mote, after every data acquisition, the mobile robot must calculate its optimal location and move to that location. This will entail determining specific patterns of movements on the sensor nodes and applying a probabilistic function to determine its next location. If communication is lost to all nodes, an algorithm must be determined to move the mobile robot to the highest probable location that will allow connectivity.

AIRPORT BAGGAGE MONITORING SYSTEM

System Overview

We propose a system which will be used to replace the existing baggage systems implemented in airports. The downside of the current system lies with the lack of redundancy and the difficulty in locating baggage if it is misplaced or shipped to the wrong destination. For customers of different airlines, one of the most common complaints is late or lost baggage. Our system should:

1) Never have a bag misplaced or lost permanently
2) If a bag is misplaced guarantee that its location is known and the time it will take to retrieve the bag is made clear to the client

To implement such a system we intend on placing wireless nodes along the path of the baggage system. These nodes communicate with other nodes along the path using a peer to peer protocol. The nodes themselves each have a RFID tag reader.

System Details

To ensure the general location of the bag is known at any time we must ensure that we can record when a particular bag passes through the RFID tag reader of a node. Once the tag is read, the node sends a message back to the base station (Relying on a peer-to-peer protocol) informing it to update a database. This database will contain entries for every bag currently in the system. They will be added to the database once the RFID tag is placed on the bag. Each entry will contain the unique ID code of the bag as well as its current location. In other words, once a bag passes through a node it will update the database by changing the current position to that of the node the bag just passed through.

With this system we will know a bag's general location at all times. Many features can be implemented on top of this such as (It is very extendible and only a few possible ideas are illustrated below):

1) A timer which monitors the duration between the location updates of the bag, if too much time passes we know the bag could have fallen off.

2) An entry of all the valid locations the bag may pass through. If a location other then these is sent back some sort of alarm can be triggered.

More information about the bag such as its weight and destination can be included. Once a bag arrives at an airport it will need to be added to the new airport's baggage system (The bag can be taken off the system once the bag is collected by the passenger, this can be done by having the passenger pass through a gateway with a node which signals the system to remove the entry), it can check whether the destination matches the current airport. The weight feature can be used for security to guarantee no extra content was added during the time when the bag was in the previous airports baggage system as well as the airplane it self.

They key concept of the system is a centralized database which contains entries for all bags currently in the system. This database is updated via the nodes along the path the bags travel. Wireless sensor networks allow this system to be very versatile and easy to set up.