Acoustic Localization Based On Wireless Sensor Networks

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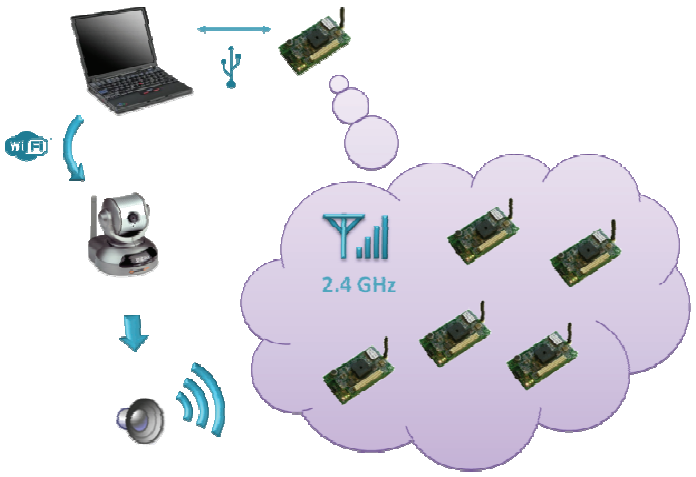
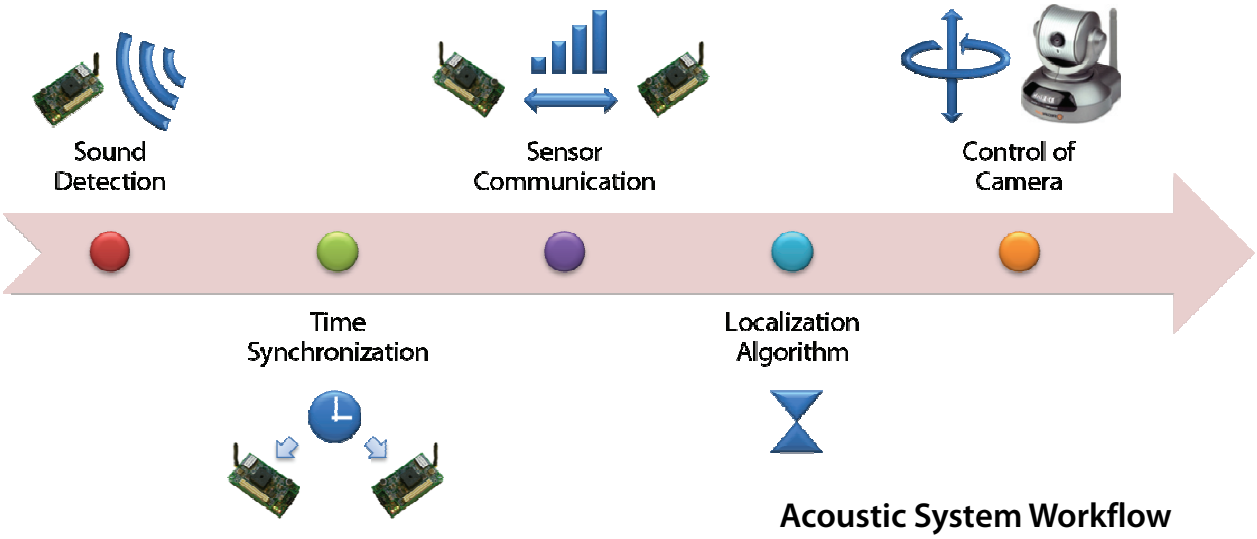
Introduction

Localization is a hot topic which aims to recognize the position of concerned objects. However, most of the current research usually focused on the outdoor environments. As the idea of pervasive computing spreads around the world, we see a growing interest in the indoor application of localization. Being small, easily deployed, wireless and relatively lower-cost, Wireless Sensor Networks (WSNs) shed new light on this area.



In our project, we proposed to use acoustic localization based on wireless sensor networks to build up a system that can be adopted in indoor environments. A camera is also embedded into the acoustic system for video surveillance.

Methodology

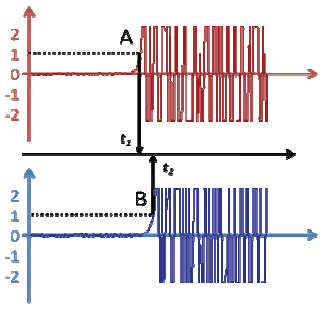


Acoustic System Workflow

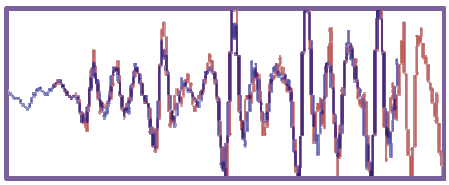
Sound Detection

Given two different sensors, which are in different locations and detecting the same acoustic source, a good sound detection algorithm is said that it is able to find out two different points, which are relating to the same event, from these two waveforms collected by these two sensors in different time series.

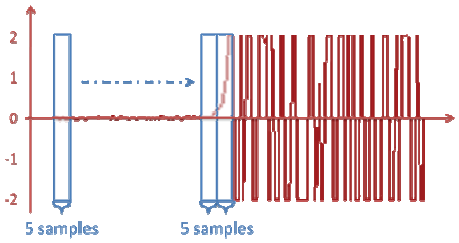
Four approaches are proposed to achieve such a goal in our project.



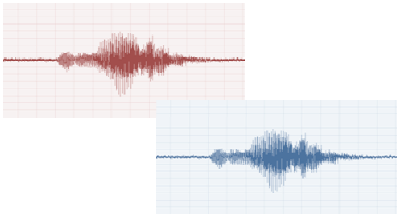
Threshold



Patten Matching



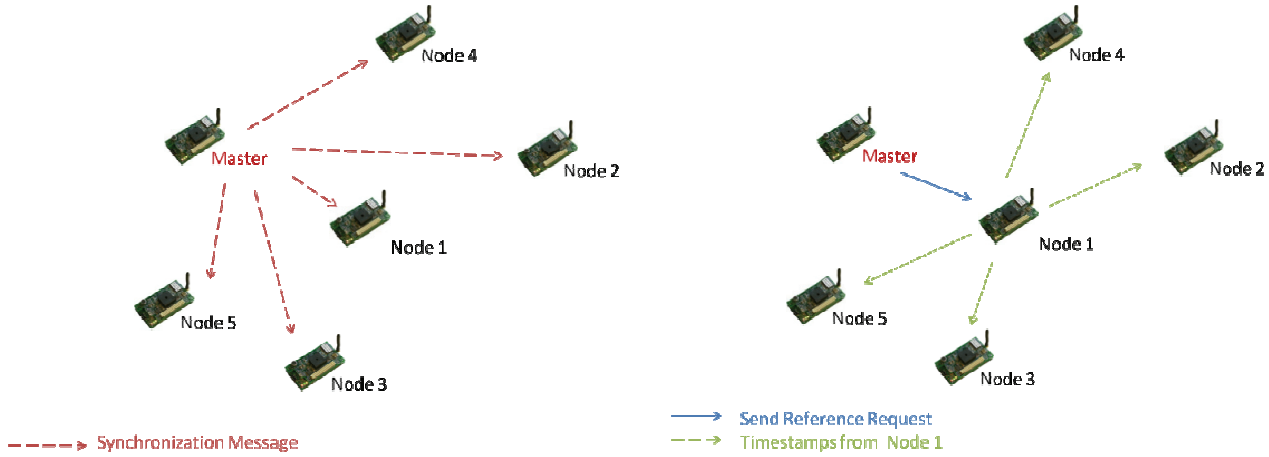
Micro Data Analysis



Marco Data Analysis

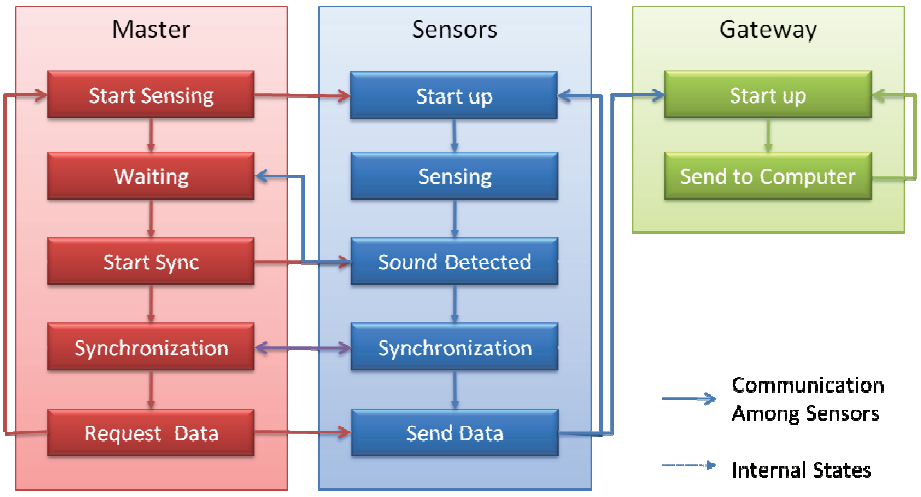
Time Synchronization

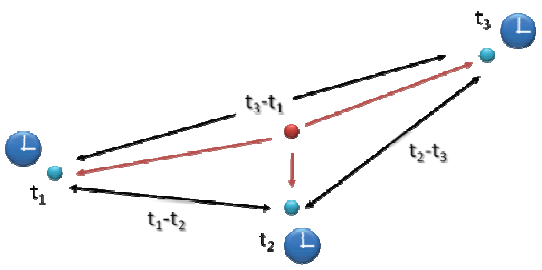
To achieve this effective time synchronization, in our project, we use Reference-Broadcast Synchronization (RBS), a scheme in which nodes send reference beacons to their neighbors using physical-layer broadcasting. A reference broadcast does not contain an explicit timestamp. Instead, receivers use its arrival time as a point of reference for comparing their clocks.



Sensor Communication

Sensor nodes communicate by sending data packet through the built-in 2.4GHz wireless module using amplitude modulation (AM). A protocol is defined for exchanging data between sensor nodes.



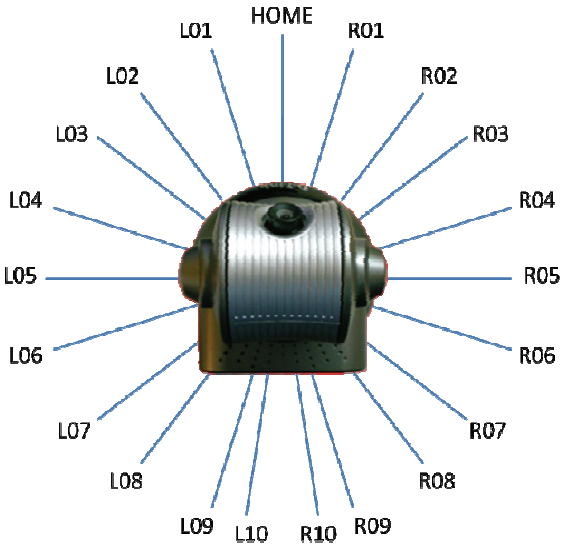


Localization Algorithm

Time Difference of Arrival (TDOA) is used to solve the position location problem, similar to Global Positioning System (GPS).

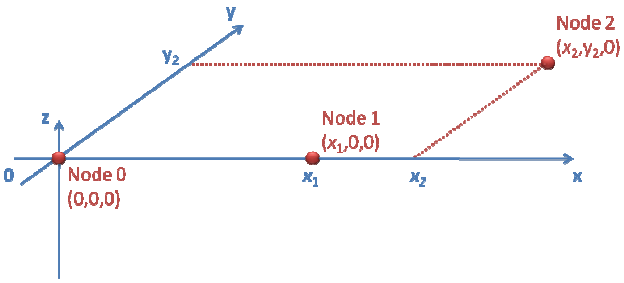
Camera Control

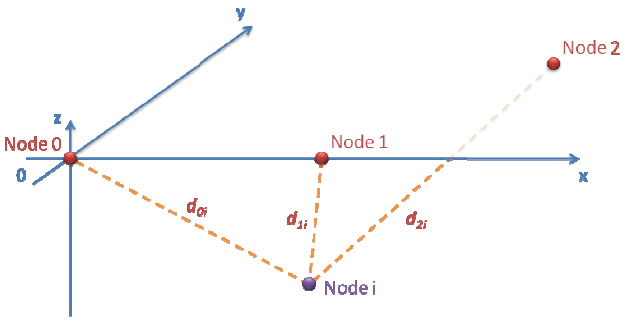
The program sends a serial of HTTP requests to rotate the camera capturing video at one of the predefined positions.



Self Localization

In order to enhance the flexibility of the acoustic system, self localization is proposed within the distributed sensor nodes by making use of the sounder embedded in the sensor board of each sensor. Since the sensor itself is also the acoustic source, by using the time difference of arrival, the distance between them can be calculated. By Knowing all distances between each sensor, a relative coordinate can be built up.





Evaluation

The system performs well subject to knocking sound with the estimating error within 20 cm with an 80% confident and can response in 2 seconds for each cycle using the threshold method.