Wireless Local Positioning System

- Project Overview
- Functional Description
- Hardware and Software Design
- Components and Interfaces
- Timing
- Extensions
Project Overview

• Wirelessly senses positions of nodes relative to a transmitter array

• Uses ultrasonic signal delay from transmitters to receiver nodes to determine distances.

• Relays captured data to a personal computer.
Functional Description

• Wireless Position Measurement System
  – Highly accurate (>2 cm accuracy)
  – Short range (<3m)
  – Small nodes (<1'X1'X1')
  – Universal Serial Bus interface to transfer data to a computer
Functional Description: Top View

- Computer
- Command
- Transmitter Array
Design: Command Module

- Is combination microcontroller/zigbee node
- Has USB data link to Computer
- Controls the transmitter array and receivers
  - Handles adding nodes to the system
  - Tells transmitter array which transmitter to fire, and when
  - Tells receiver nodes when to start their delay timer
  - Polls receiver nodes for measured delay
- Runs network software for above, as well as drive a serial I/O connection through the USB to the computer.
Design: Transmitter Array

- Controlled by single microcontroller with zigbee.
- Has a set ultrasonic transmitters (as few as 3 but may be up to 8) located in strategic positions for triangulation.
- Software on microcontroller follows command module's directions and sends signal to appropriate transmitter.
Design: Receivers

- Small, simple microcontroller/zigbee setup with ultrasound receiving hardware.
- Software to connect and interface with command module.
- Listens for transmission from transmitter array.
- Records time stamp for transmitter
- Relays this data for each transmitter when asked by Command module.
Design: Computer Software

- Drivers come with USB part or written by us if not.
- Program, or interface to a program, to demonstrate system
- Program Sophistication determined by time
Interfaces

USB Interface
ZigBee Star Network
Transmit Array Node
Zigbee Node
Ultrasonic Signal
Zigbee Data Request
Zigbee Response
Components
Components: Receiver Nodes

- Zigbee Nodes
  - Freescale MC13213 (Transciever/Microcontroller)
  - Freescale 802.15.4 MAC Software
  - 16 Mhz Oscillator Crystal Package
  - RF Antenna
  - Piezoelectric Ultrasound Transducer
  - Op-Amp/Miscellaneous components for signal filtering.
Components: Receiver Nodes
Ultrasonic Receiver Schematic
Components: Transmitter Array

- Transmitter Array Nodes
  - MC13213 (Transceiver/Microcontroller)
  - Oscillator Crystal Package
  - Antenna
  - Piezoelectric Ultrasound Transducers
  - Inverter Packages/Misc. Components
Components: Transmitter Array

Ultrasonic Transmitter Schematic
Components: Command Module

- ZigBee Node (same as Receiver Nodes w/o ultrasound)
- USB Interface
  - USBMULTILINKBDME
    (Microcontroller Programmer/Debugger)
Timing

- Command Module sends out signals which cause Transmitter \( n \) to begin an ultrasonic pulse and all of the Receiver Nodes to start their delay timers.
- Pulse travels through the air at \( \approx 30 \text{ cm/ms} \), reaching Receiver nodes at various times.
- Signal filter takes a few cycles to resonate up to amplitude of predefined threshold.
- Signal triggers input capture, causing each Receiver node to record the current time delay.
Timing

Example Signals
Applications

- **Baseline:**
  - “Wei” style controller used to position/move an object in a 3D application

- **Stretch**
  - 3D brush/pen
  - “Tinker-top” set up of nodes to build physical model to animate characters in a 3D modeling program
  - Full suit of nodes used to control a video game character
Hardware Stretch

- Add additional transmitter array to get better positions
- Add better processor to Command Module to translate data to x,y,z coordinates before sending to computer
- Add accelerometer to nodes, so they can notify Command Module of change instead of having to be polled
- more...
Ideal Final Product

Arrays of Receivers