SMARbot: Simplifying the Future of Miniature Robotics

Purpose

SMARbot (Stevens Modular Autonomous Robot) is intended as a basic autonomous mobile robot with high modularity and unlimited potential. Designed with swarming and ubiquitous robotics in mind, SMARbot is equipped with a ZigBee wireless module to allow for communication between units, either ad hoc or through a central hub. SMARbot is made to be completely modular, so future robotics projects can build upon each other.

Architecture

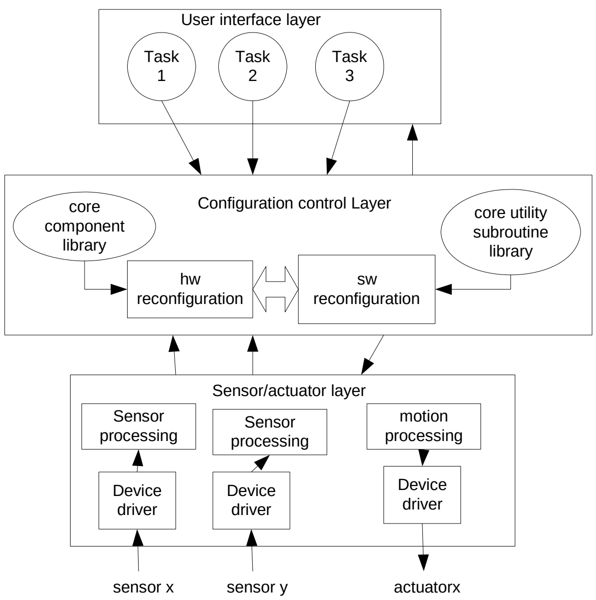


Figure 1. *Architecture of SMARbot.*

Suggested Applications

As an integral part of a pervasive computing environment, SMARbot is designed to improve the daily life of its users. Although it is small, SMARbot is suitable for such tasks as:

- -cleaning
- -pest control
- -laundry
- -small item storage

Features

-7.4V 2-cell Li-Ion Battery
-AT91SAM7S256 ARM processor
(includes UART, PWM, ADC, RTOS)
-Sharp IR range sensors
-Zigbee Wireless Module
-Xilinx Trojan-3A FPGA

CHARLES CREAMER

System and elements

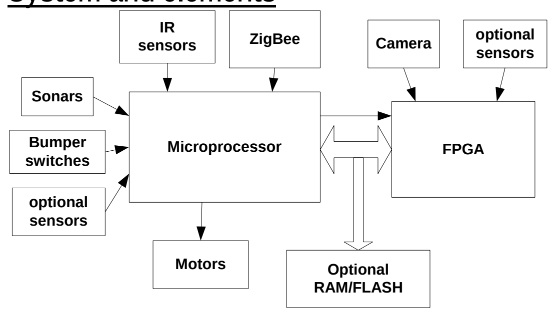


Figure 2. *Hardware Block Diagram.*

Images

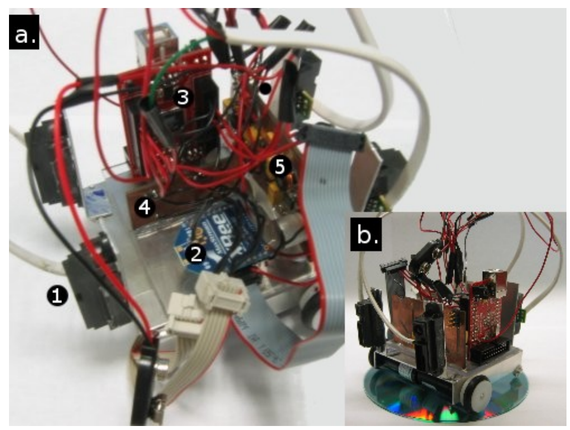


Figure 3. *(a) Top view of prototype assembly:* (1) IR sensor, (2) ZigBee module, (3) Microcontroller, (4) motor driver, (5) power supply. *(b) Side view of SMARbot with a CD shown for scale*

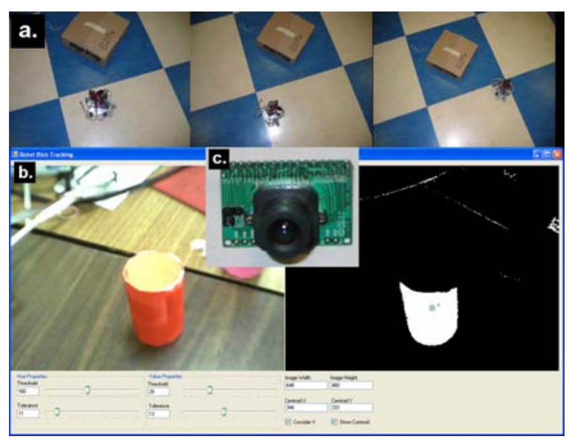


Figure 4. *(a) SMARbot autonomous obstacle avoidance. (b) Color blob tracking program. (c) OmniVision OV7620 CMOS image sensor.*

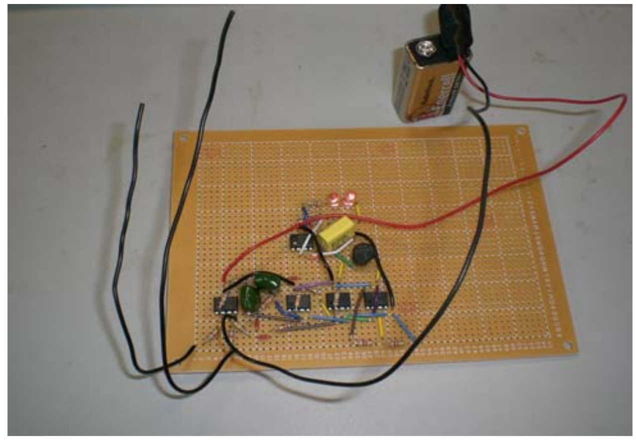
STEVENS Institute of Technology

Advisor: *Dr. Yan Meng*
Research Team: *Kerry Johnson, Brian Simms, Matthew Conforth, Charles Creamer, Christopher Hawley*

NSF

Project Objectives:

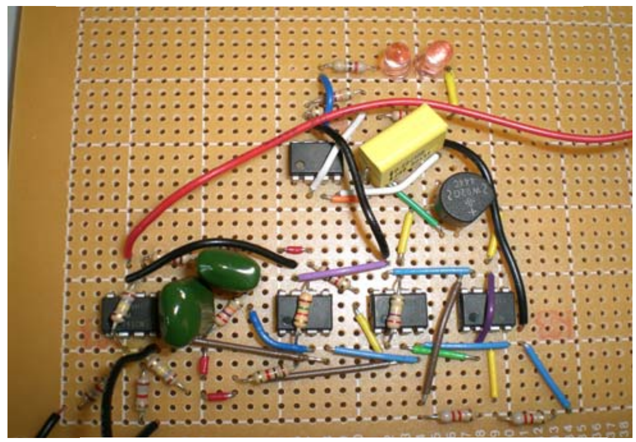
- Design a voltage detector to prevent accidents caused by voltage leakages and electrification of objects at public places. In 2004, this caused the death of an East Village resident who was walking her dogs.
- The voltage detector should be small enough to fit to manhole covers and use a single supply.



The Single Supply Circuit

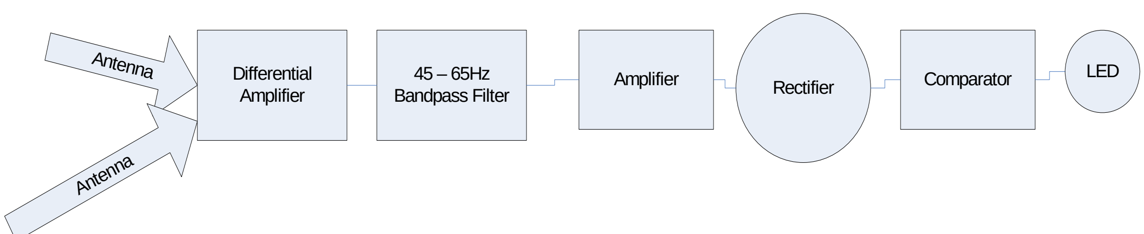
Specifications:

- Acoustic and/or Visual output to display voltage detection.
- A differential amplifier should amplify the voltage difference.
- The output should either be on or off depending on the amplitude of the detected voltage.
- Single battery operated.
- Detect Electrical Fields around 60 Hz and block high frequencies.



Close up of the circuit

Circuit Block Diagram



Research Summary:

- The dual supply circuit was built and tested to be working fine.
- The schematic was updated to get the circuit working with only one 9V Battery.
- The LEDs were incorporated for the visual detection of voltage.
- A comparator was built at the last stage to light the LED only after a certain voltage threshold value.
- It was a success!

Research Team:

- Timothy Garner, ECE department, class of 2008
- Anirudh Agarwal, ECE department, class of 2008

Acknowledgements:

- 2007 Stevens' Scholars' Program.
- Professor Yu-Dong Yao.
- The whole ECE department.

Stevens REU 2007

CDP
Cellular Density Project

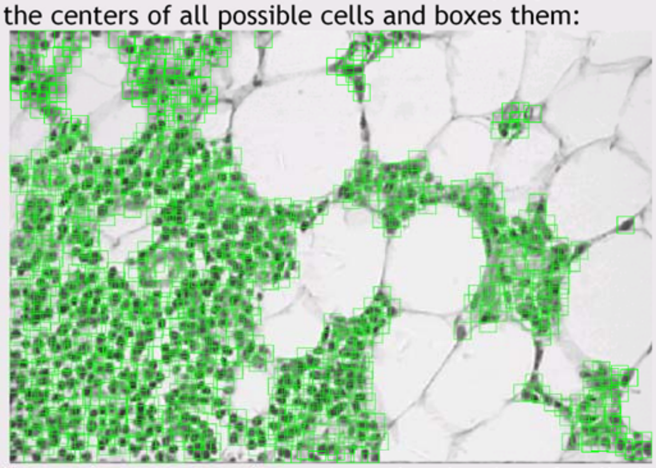
Christopher Mitchell

Introduction

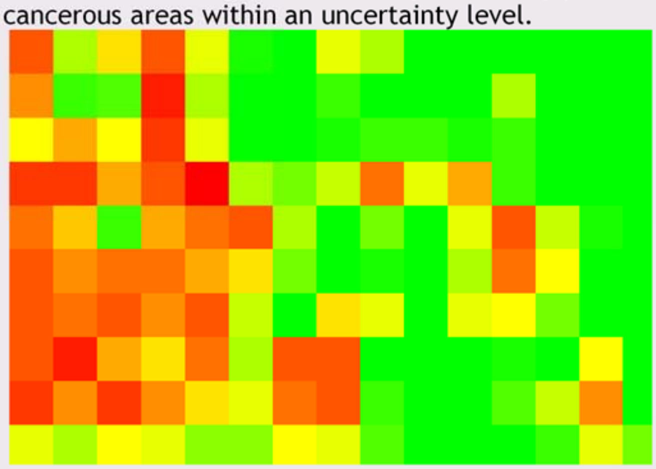
The Cellular Density Project is an attempt to apply computer-based image processing to the detection of cancer in photomicroscopy. One of the primary signs of cancer is unchecked cell growth, leading to abnormally high cellular density within a well-defined area. The CDP uses a Matlab-based program to find each of the cells in a microscope image, then determine density across the image and utilize statistical analysis methods to determine whether or not the image contains possibly cancerous areas.

Methodology

The CDP uses the same method as popular image recognition algorithms, namely eigenobjects, to detect cell nuclei in a microscope image. Because the nuclei show up as circles on a contrasting background, a training set of eigencells can be constructed and used to identify new objects as nuclei or non-nuclei. Within a threshold set by the user, the program finds the centers of all possible cells and boxes them:

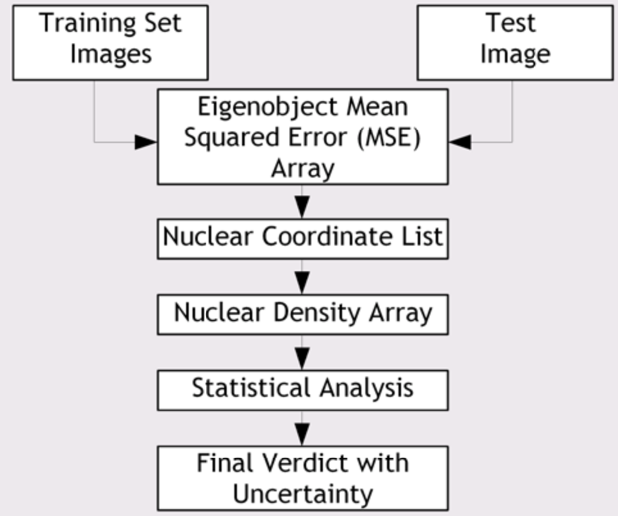


Next, the program determines the density of cells in each area of the image, produces a heatmap, and identifies the image as containing or lacking possible cancerous areas within an uncertainty level.



```
*Based on deviation:* This image contains cancerous
region(s) at uncertainty of 8.518519e+001%.
*Based on mean:* This image contains cancerous region(s)
at uncertainty of 7.2e+001%.
```

Functionality



Conclusions

This project has shown that it is feasible to score the probability a photomicroscopic image contains cancerous regions using image processing techniques. At present it takes five to ten minutes to process each image due to the amount of data that must be processed. In the future, the eigenobject detection routines could be optimized to scan the image in several passes, beginning with a rough scan and getting gradually more precise in areas showing higher probabilities of containing nuclei. In addition, it could be made faster by porting it from Matlab to C or C++. The final program from the CDP of Summer 2007 produces two scores for the probability an image contains cancer based on two statistical aspects; it could be made more precise if additional analysis aspects were found.

Contacts

Research Team: Christopher Mitchell (Cooper Union, EE 2009) – mitche2@cooper.edu
Advisor: Professor Yu-Dong Yao, Stevens Institute of Technology – yyao@stevens.edu

Sponsors & Supporters

National Science Foundation
The Cooper Union for the Advancement of Science and Art
Stevens Institute of Technology
Cemetech

STEVENS INSTITUTE OF TECHNOLOGY

SUMMER RESEARCH 2007

SPECTRUM ANALYZER

SARA JAMES

INTRODUCTION

With the significant advances made in the wireless communication field, the ISM radio bands originally allocated for non-commercial uses have become congested. The dramatic increase in applications associated with these unlicensed bands has necessitated research into optimizing spectrum usage. With the spectrum analyzer developed by Scott Armitage, spectrum occupancy measurements can be collected in the 2.4 GHz ISM band and then analyzed in Matlab.

PROJECT OBJECTIVES

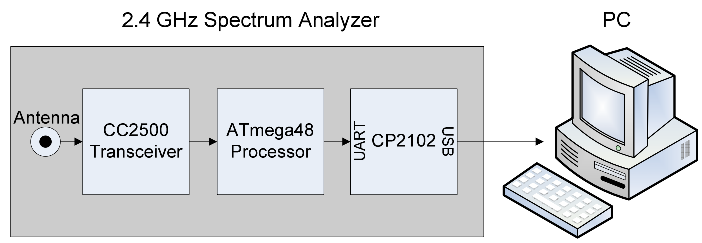
- Development and integration of measurement platform
- Spectrum occupancy measurements and data collection
- Formation of real-time data logging program

SPECTRUM ANALYZER FEATURES

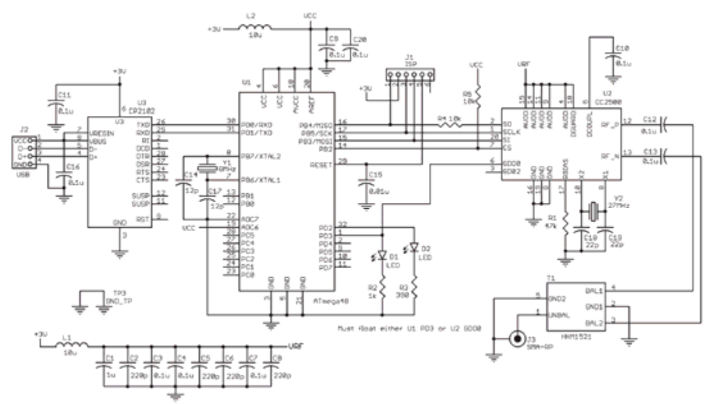
- Developed by Scott Armitage
- Low cost spectrum analyzer with a range of 2.4—2.485 GHz
- Consists primarily of the CC2500 transceiver, the ATmega48 processor, and the CP2102 USB to UART chip
- Sensitive receiver with digital tuning capabilities and digital RSSI
- No external power supplies needed
- Connects to a PC via USB
- Graphical data display software available from Scott Armitage

CIRCUIT AND SYSTEM ARCHITECTURE

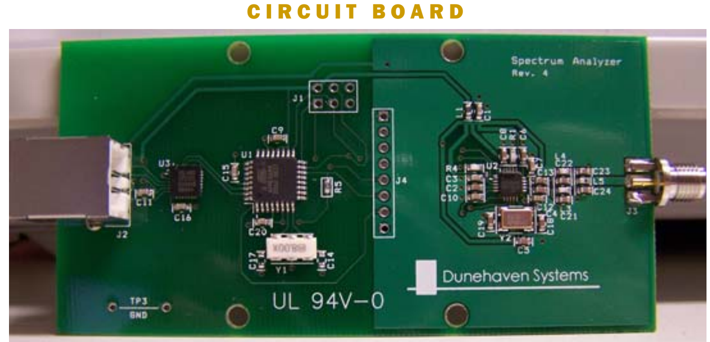
BASIC SYSTEM ARCHITECTURE



SCHEMATIC



CIRCUIT BOARD



CONTACT INFORMATION

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Website: http://personal.stevens.edu/~sjames
Advisor: Prof. Yu-Dong Yao—yyao@stevens.edu

SPONSORS AND SUPPORTERS

- National Science Foundation
- Stevens Scholars Program

Please see www.dunehaven.com for more information regarding the spectrum analyzer.

Modern High Frequency Communication Systems

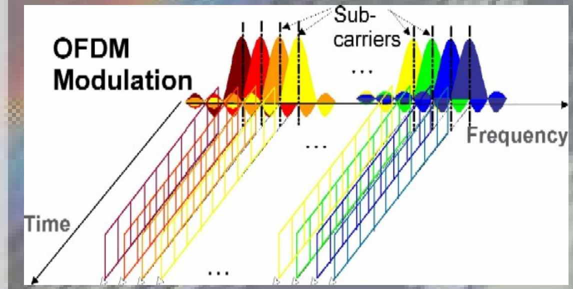
Benefits

- Long range communication
- Reasonable data rates – capable of quality audio signals
- Minimal amounts of special equipment required
- Little infrastructure needed – easy access to remote areas

Challenges

- Transmission medium is constantly changing – daily shifts in ionosphere
- Multipath and selective fading
- Data rate still low by modern standards (near dialup speed)

Making it Happen

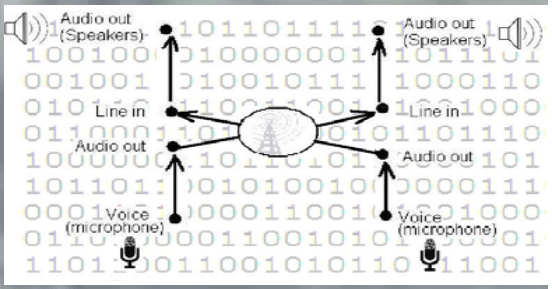


Orthogonal **F**requency **D**ivision **M**ultiplexing

A data modulation scheme that spreads data over whole range of frequencies making it resistant to selective fading

Software **I**mplementation

Most OFDM components can be implemented in software, which help make the system widely accessible.



Research Members:

Christopher Alesandro, Jonathan Chang, Grae Cullen, Joshua Schickling, and Michael Bocchinfuso

Images obtained from the following sources

- http://telephonyonline.com/wireless/technology/mimo_ofdm_091905/index.html
- http://www.arsc.edu/science/ionosphere.html
- http://www.wpclipart.com/music/index.html
- http://www.allaboutjazz.com/newsletter/20040924.htm
- http://techtips.chanduonline.com/2006/08/20/optimizing-bittorrent-transfer-rate/

Fading Characteristics of PC Based OFDM System for Communications Over Narrow-Bandwidth Channels

Michael Bocchinfuso

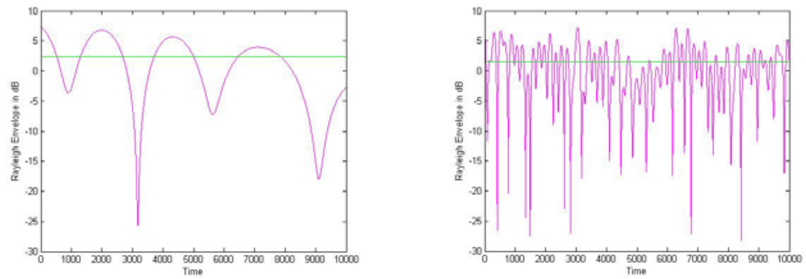
For my section of the project, I looked into the characteristics of signal fading in an OFDM communications system operating in the HF range (3-30 MHz).

A Matlab m-file was found on Mathworks, the Matlab website, which worked on a modified Jakes model of signal fading for OFDM systems.

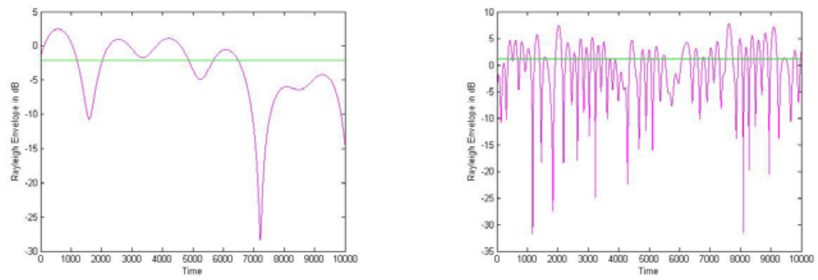
I had to make slight modifications to it, mainly involving the number of oscillators, which allow for more subchannels in an OFDM system.

While the m-file was developed for a mobile system, it is still applicable to a stationary one due to the movement of the ionosphere; the velocity of the system just has to be set to a small number.

Digital Radio Mondiale is a European communications system which operates in a similar manner to what we want. It offers four different sub-standards with different numbers of subcarriers, as well as other properties. I modeled the two ends of this spectrum in Matlab.



Graphical analysis of fading in 3 MHz (on left) and 30 MHz (on right) OFDM systems with 88 subcarriers.



Graphical analysis of fading in 3 MHz (on left) and 30 MHz (on right) OFDM systems with 226 subcarriers.

Research Team:
Joshua Schickling, University of Arizona
Grae Cullen, Temple University
Jonathan Chang, University of Maryland, Baltimore County
Christopher Alesandro, Cooper Union
Michael Bocchinfuso, Stevens Institute of Technology

Advisor:
Professor Bruce McNair, bmcnair@stevens.edu

Stevens Institute of Technology
Electrical & Computer Engineering Department, Summer 2007

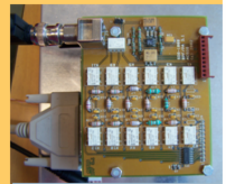
Dynamic Wireless Communication

Project by Jacob Alperin-Sheriff
Advisor: Professor Yu-Dong Yao

STEVENS Institute of Technology

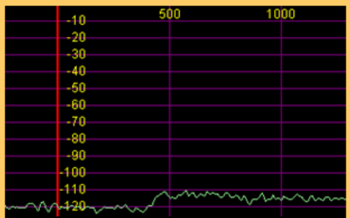
SDR with Antenna

The wireless spectrum is finite, and much of the spectrum is underutilized. With the huge increase in wireless communication, finding ways to use these quiet areas of the spectrum has become practical. This project begins to accomplish this by finding quiet channels of a given bandwidth at or around a given frequency. The underlying software, the PowerSDR 1.6.3, is provided as open-source from Flex-Radio Systems™, as is the minimal hardware, the SDR-1000.

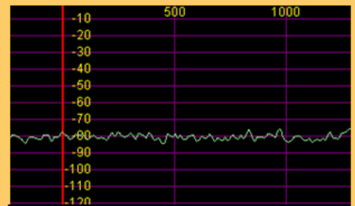


SDR Circuitry

Initial Spectrum at 14.030 MHz; Noisy



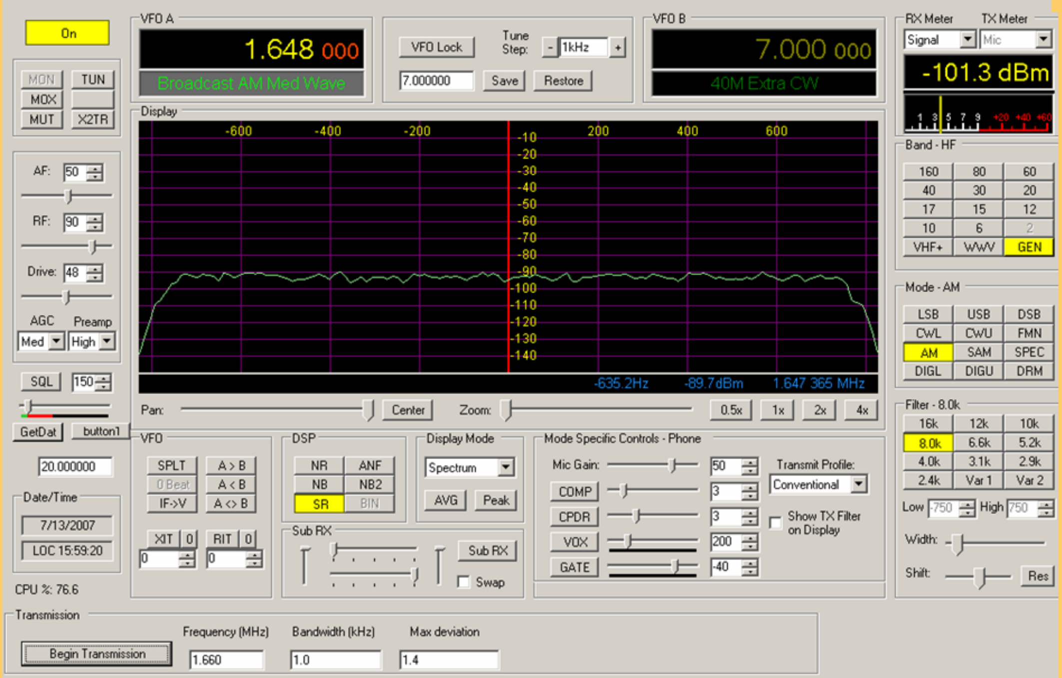
Searching for quiet; at 14.032 MHz



Found quiet; at 14.036 MHz

PowerSDR Software

Found quiet channel at 1.648 MHz



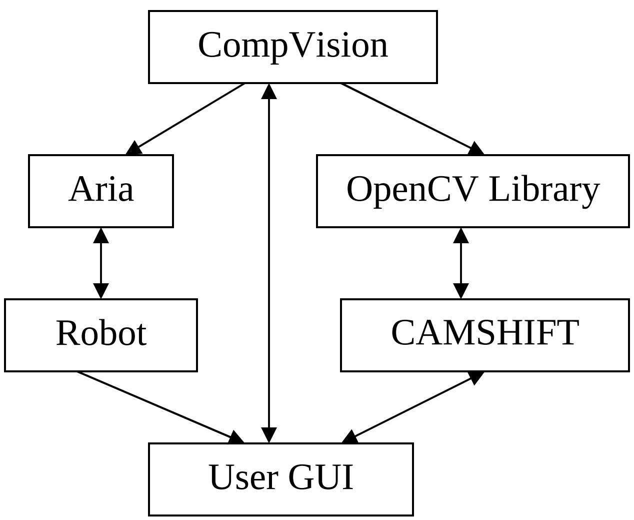
Incorporating CAMSHIFT tracking into P3-AT Robot

Brandon Morton; Asst. Prof. Yan Meng

Purpose

The purpose of our project was to incorporate the object tracking capabilities of the OpenCV library, specifically the continuously adaptive mean shift tracking, into the Aria software package used by the Pioneer 3 All Terrain Robot (P3-AT). Aria, or advanced robotics interface for applications, is responsible for communicating with the robot using a client/server setup while the OpenCV library contains functions that handle image and video processing.

Flow of Control



Components

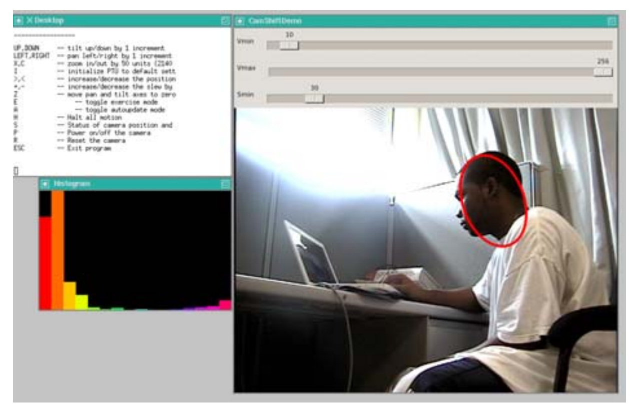
- ARIA software package
- OpenCV Image Processing Libraries
- CAMSHIFT Algorithm
- P3-AT Robot
- Canon VC-C50i PTZ Camera
- CompVision

Code Segment - CompVision

```
int main(int argc, char** argv) {
   Aria::init();
   OpenCVThread openCVThread(argc, argv);
   //Launch the new thread in the background.
   //This thread (of main()) continues
   //immediately.
   ArLog::log(ArLog::Normal,
         "Main thread: Running new example thread ...");
   openCVThread.runAsync();
```

CompVision Program

Using OpenCV's CAMSHIFT algorithm and the Aria's software packages' functions for camera control a new program was created. The program called CompVision allows the user to control the physical movement of the camera while also running the CAMSHIFT tracking algorithm. Control needs to be shared between the two processes, so it was written as a multi-threaded program in which the algorithm is run as a background process and the control of the camera is the main process. Using the tracking box created by the CAMSHIFT algorithm the panning functions of the camera were automated so that the object is always centered in the video image. This method of automation can also be applied to the tilt and zoom functions of the camera which results in a fully automated tracking system.

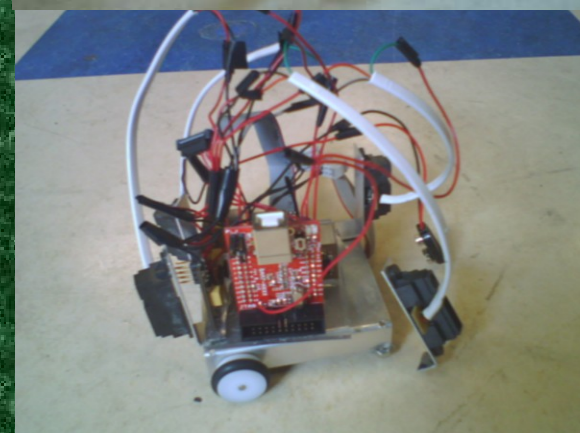


Acknowledgments: Prof. Yan Meng, Yuhua Zeng,, Jeremy Miller, Stevens REU Program, Prof. Yu-Dong Yao, Friends, and Family

Autonomous Miniature Robots:
Swarm-bot Research

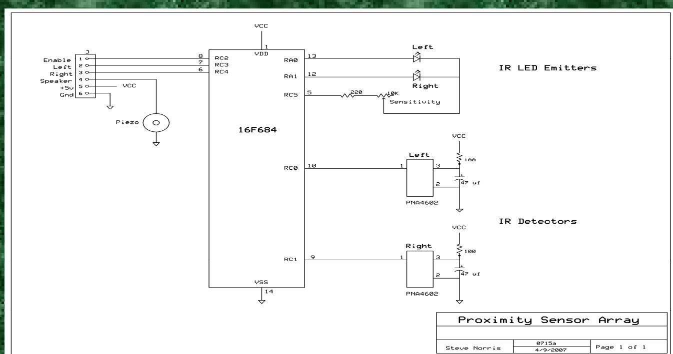
Research and Project Overview

- Programming and building a group of miniature autonomous swarm-bots
- Make them capable of object avoidance with the use of infrared sensors and sonar.
- Autonomous interaction with other swarm-bots as well as autonomous movement.



Swarm-bot Features

- Battery powered. (9V battery power source)
- Front and rear infrared sensors for object avoidance.
- 4 wheels and axels with a click mechanism to measure distance the robot has taken



Team Members: Micah Shears, Shaughn Harris, John Lee, Charles Creamer (Undergrad Summer Research); Matt, Brian, Kerry (Grad Students from Stevens); Prof. Dr. Yan Meng and Prof. Yu-Dong Yao.

Contact Info: Micah Shears(bigmike9283@yahoo.com)or Prof. Yao(yyao@stevens.edu)

Audio Processing Using Audio Daughter Card

Ricky McGruder; Prof. H. Man

Introduction

Digital Signal Processing (DSP) is the study and processing of signals as a digital representation. Subfields of DSP include: audio and speech processing, image processing, audio processing, and speech processing.

Hardware Features

-PCM3003 – Burr Brown® 16-/20-Bit Single-Ended Analog Input/Output Stereo Audio Codec

-Line-in/out stereo mini audio jacks

-2 electret microphones

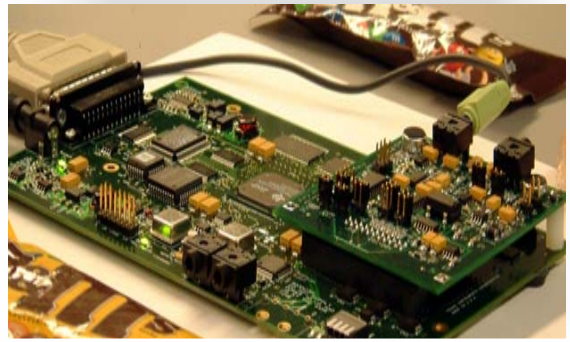
-Sample rate controlled by 12.288 MHz Oscillator or by DSP timer output pin.

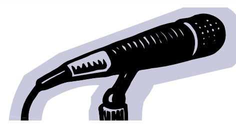
-Clock sample rates

-Jack/Microphone selection

-Separate Analog/Digital power regulators and ground planes for high resolution audio

System Setup





Audio Effects using Daughter Card

Delay and Echo: Using buffers to generate delayed playback.

Alien Voices: Using ring-modulation to produce sum and difference frequencies.

Reverberation: Simulation of echoing room / auditorium using feedback filter

PC - USB Daughter Board Communication

-Communicating with the board from the PC requires code to interface to the USB device driver.

-Lower level details of communicating with the device are handled by the device driver.

-Code running on a built-in micro controller on the USB chip is used to move the data between the USB buffers and external port FIFOs.

Audio Codec: CS4218

-High quality stereo audio input and output.

-Sampling rate of 48 kHz.

-16 bit output (same resolution as audio CD).

-Interface to DSP via serial ports.

Fellow Group Members: Jamar Johnson, Vineeth Paul Tuluri

OFDM – Orthogonal Frequency Division Multiplexing

Student Grae Cullen; Advisor Bruce McNair

Project Overview:

OFDM is used to help transmit signals through interference. It digitalizes the data, and rearranges it a manner that allows natural signal loss to be spread and minimized, trying to avoid complete signal loss.

OFDM is currently reaching wide acceptance, and usage in broad band, wireless, digital audio broadcasting, and many other applications.

Our on going project is trying to take the step of developing an OFDM system for short wave radio users, which does not require special hardware.

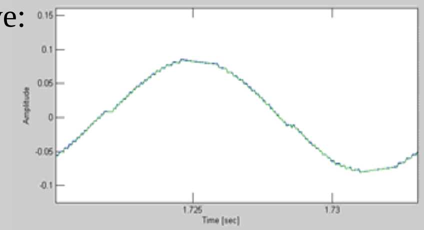
System requirements:

Requires Windows 2k, or XP installed on the computer, and one Full Duplex Sound Card

For synchronous send and receive:
2 "Wave In" and 2 "Wave Out" Devices

Note: Most sound cards are now full duplex.

Sine Wave:



Design approaches:

Our group broke into to sections, a simulation and design section, and a hardware interface section.

The simulation and design section worked on simulating and researching details of an OFDM system.

The hardware interface section wrote several programs for operating on sound data, including a buffered program that can process data from the microphone and send it to the speakers. This sound data could then in theory be transmitted.

Results:

Sound data is read into 88200 bytes chucks, which look similar to the sine wave above. (88200 bytes is 1 second of 16 bit Pulse Code Modulation data.)

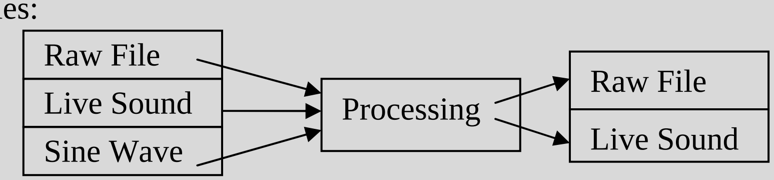
A raw PCM file, live sound, or sine wave generators can act as different source options.

The data can be sent to different modules determined at compile time. These destination options include live sound, and raw file.

The system allows more modules to be added for source, processing or destination.

In addition, to the modular processing program, we found a MATLAB program which displays a wav file, made raw to wav file converter and function speed tester, and have several simulations of OFDM signals.

Modules:



Summary:

The next group has most of the tools, and a jump on the research which may allow them to finish the project next time.

The OFDM project is very complex, but at least the next group will have more of foundation for designing and coding the OFDM project.

Acknowledgment: Thank You; Bruce McNair and the rest of the OFDM group.

Wireless Drifter

Wireless Drifter - is used to detect ocean currents and other trends of the sea by being tossed into the ocean and dragged by currents.

Wireless Drifter Components:

- GPS unit
- Microcontrollers
- Wireless transceiver
- Charging circuit
- Power regulators
- Solar panels
- Battery

ES Series Master Development System Transmitter/ Receiver kit – allows user to integrate module into a specific design

Kit Components:

- Transmitter
- Receiver
- Antennas

Additional Features

- Pic Microcontroller (16F877A)
- Resistors
- Light Emitting Diodes
- Light Sensor
- Salinity Sensor
- Water Sensor

Photos

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Sponsors:
Dr. Yao; Yu-Dong.Yao@stevens.edu
Stevens Institute of Technology REU
Summer Research 2007

Wireless LED System

By: Zamon Granger

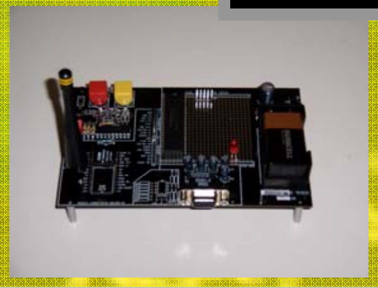
Objective

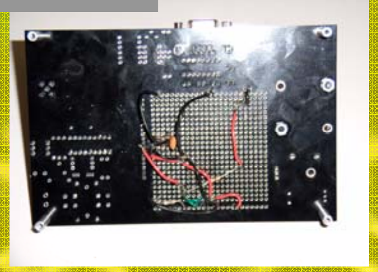
The objective of the project was to create a water proof LED system that would be placed on the top of the drifter so it can be seen in poor light conditions.

System Description

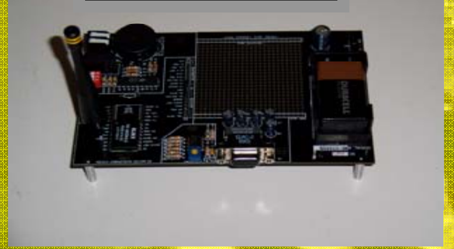
This system is essentially a blank pallet that allows you to incorporate your designs into an functional transmitter receiver system. Even though the system provides software, I opted to install a PIC microcontroller to enable communication between the system's transmitter and receiver. The PIC microcontroller allows the transmitter and receiver to be autonomous from a pc once it is installed. After being programmed they can work independently once they have been activated.

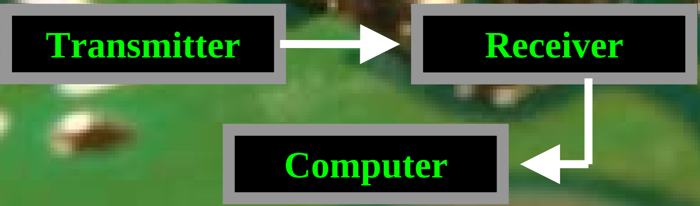
Transmitter





Receiver





Components Used

- **Transmitter**
  (*Linx Technologies Evaluation Kit/ Master Development System)*
- **Receiver**
  (*Linx Technologies Evaluation Kit/ Master Development System)*
- **LEDs**
  (5mm, 1.8 volt, 20 mA, 120mcd)
- **Nine Volt Battery**
- **Ceramic Resonator**
- **PIC Programmer**
- **PIC Microcontroller**
  (PIC 16K877A-l/P)
- **Resistors**
  (*540 ohm/ 51 ohm)*

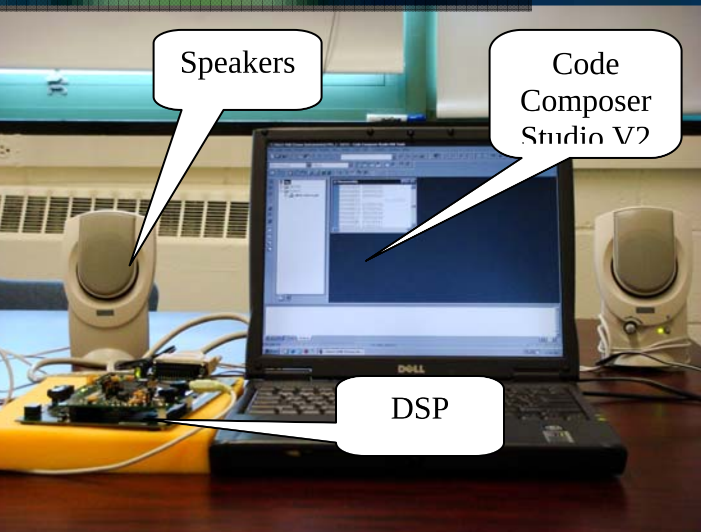
Acknowledgements

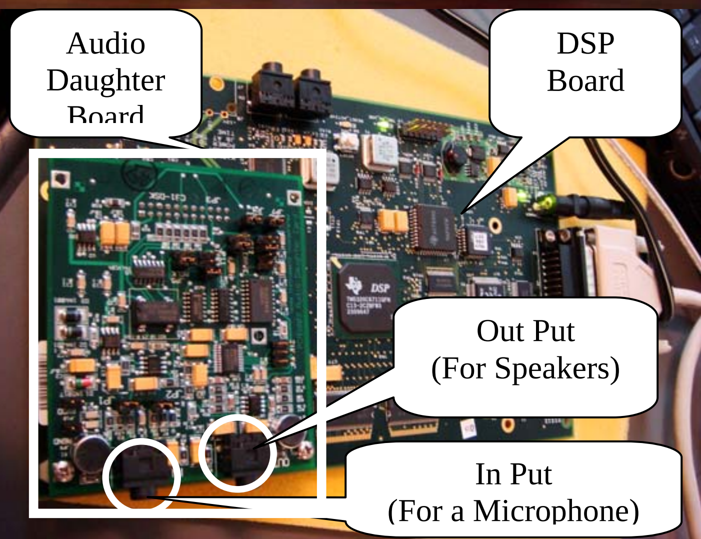
REU-2007 at Stevens Institute of Technology
Dr. Yao
Edward Tolza
Fred Windham
Cameron Abt

The Modification of Sounds

By: *Jamar Johnson*

Photos of Setup:





Objective:

The objective of this project is to use the equipment listed to modify sounds. Such sounds will come from music, voices, and many other sounds. The sounds will be modified by changing the speed, the pitch, the frequency, and also giving the sounds echoes.

Equipment:

- **DSP Board (Digital Signal Processing)**
  - ***TMS320C6711GFNC13***
- **Audio Daughter Board**
  - ***PCM3003***
- **Code Composer Studio 'V2'**
  - ***Software Package***
- **Speakers**
  - ***Use to hear output***
- **Microphone**
  - ***Use for input of sounds***

Project Programs:

(The programs were use to modify sounds)

- **Alien Voice**
  - **Use to make the voice sound like an alien's voice**

(http://youtube.com/watch?v=w4bztpdaAjQ)

- **Record and Playback**
  - **Use to record sounds and play it back.**

(http://youtube.com/watch?v=kNCbaXuHGZ0)

- **Half Speed (Record and Playback)**
- **Use to record sound and play it back in half the speed**

(http://youtube.com/watch?v=7YIKR-4SVuU)

- **Double Speed (Record and Playback)**
- **Use to record sound and play it back in double the speed.**

(http://youtube.com/watch?v=m7FpPStwSE0)

Team Members:

Vineeth Paul Tuluri, Ricky McGruder, Prof. H. Man (Advisor)

INTERACTIVE EVALUATION OF FUTURE-GENERATION WIRELESS SYSTEMS

[A Slotted Aloha Design Tool]

Megan Propts
Stevens Institute of Technology

STEVENS Institute of Technology

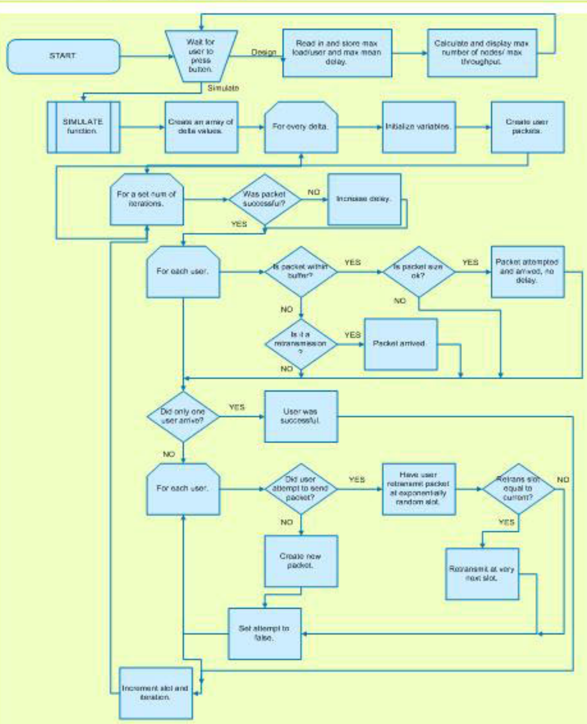
Project Objectives

The purpose of this project is to provide a GUI Design Tool for developers designing a network using the Slotted Aloha protocol. It will read in requirements specified by the user and return optimized conditions, as well as simulate the implementation of these results.

System Requirements

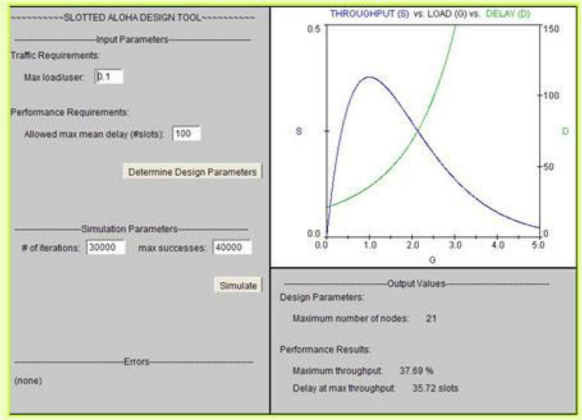
- user parameters for maximum load per user and mean delay
- simulation parameters for maximum iterations and successes
- a simulation with multiple points plotted
- displayed results for max number of nodes and maximum throughput
- error checking
- user friendly
- works in all browsers through Java applet

Design Approach

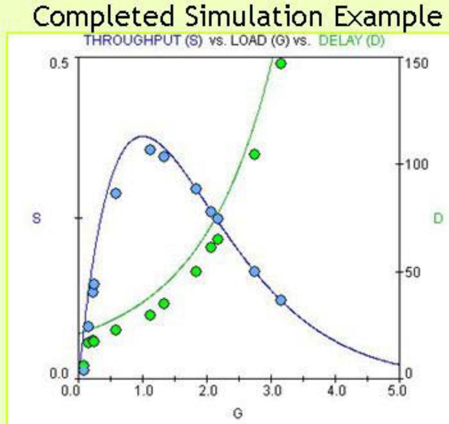


Final Product

Design Tool GUI



Completed Simulation Example



Research Team

- Megan Propts: Undergraduate Scholar
- Di Zheng: Graduate RA
- Prof. Yu-Dong Yao: Associate Professor, Stevens ECE Department

Sponsors

- Stevens' Scholars Program (Summer '07)
- CCOMM

SIT Contact Info

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VSafe

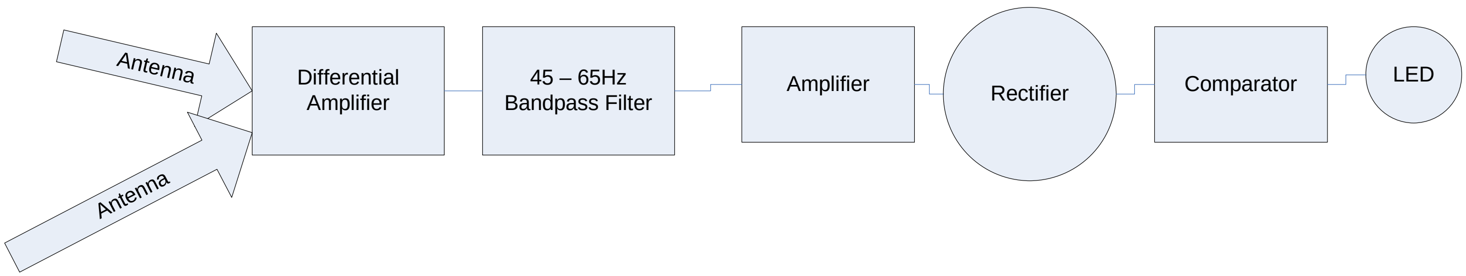
Timothy Garner

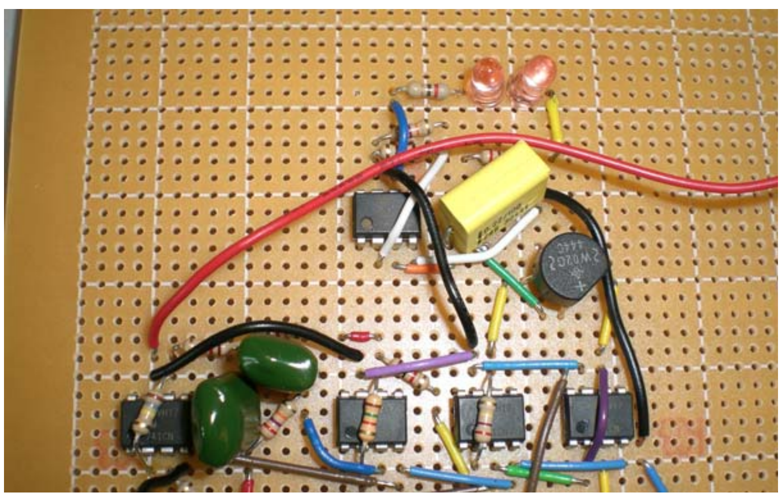
The purpose of the VSafe project is to design a voltage detector that can be attached to manhole covers and other metal objects on the sidewalk. Conductive manhole covers and sidewalk grates can sometimes become electrified in cities with aging electrical infrastructures. In 2004, this resulted in the death of an East Village resident who was walking her dogs.

System Requirements

Battery Operated
Detect Electric Fields around 60 Hz
Block High Frequency Noise
Use LED's to Indicate Voltage

- A dual supply detector was built powered by two 9V batteries.
- The design was updated to require only one battery.
- The single supply design was modified to turn on LED only when field strength crosses a threshold value.





Summary

A 60Hz detector was built operates on one 9V Battery. The circuit is currently being tested in various enclosures and miniature manholes.
A printed circuit board design is designed but not fabricated in case changes to the circuit are necessary.

Acknowledgment Prof. Yu-Dong Yao, Advisor, Prof. McNair

Audio Signal Processing with TMS320C6711 DSP chip

Vineeth Paul Tuluri; Prof. H. Man (Advisor)

Introduction

The Texas Instrument (TI) TMS320C6711 is a floating-point DSP chip in the TMS320C6000 DSP platform family. It is based on the high-performance, advanced very-long-instruction-word (VLIW) architecture developed by TI. It is an excellent choice for multi-channel and multifunction applications. It also has application-specific hardware logic, on-chip memory, and additional on-chip peripherals.

Applications

Alien Voices - Changing voices using ring modulation.
Delays and Echo - Using buffers to delay a signal up to 4 seconds to simulate echo from a valley / cavern.
Reverberation - Simulation of reflections from walls to make a small room sound like an auditorium.

Project Hardware Specs

The Texas Instrument 6711DSK is a DSP starter kit for the TMS320C6711 DSP chip.
The kit contains:
An emulator board which contains:

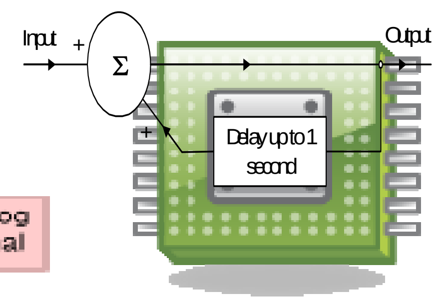
- DSP chip, memory and control circuitry.
- Input/output capabilities in the form of
- An audio codec (ADC and DAC) which provides 1 input and 1 output channel sampled at 8 kHz.
- Digital inputs and outputs
- A connector for adding external evaluation modules, like the PCM3003 Audio daughter card, which has 2 analog in and 2 analog out, sampled at 48 kHz.
- A parallel port for interface to a host computer used for program development, program download and debugging.

Hardware

TI's 6711 DSP connected to the PCM3003 Audio daughter card

Design Implementation for Reverberation:

Configuration for Reverberation



Software Development

The Code Composer Studio (CCS) software is an integrated development environment (IDE) for editing programs, compiling, linking, download to target (i.e., to the DSK board) and debugging. The CCS also includes the DSP/BIOS real-time operating system. The DSP/BIOS code considerably simplifies the code development for real-time applications, which include interrupt driven and time scheduled tasks.

Summary

During the course of my research I have been able to implement various applications on the TMS320C6711 DSP chip. Applications such as reverberation, record and playback have various functionalities due to the 6711's high performance architecture. The board was also able to behave differently when its binary value was changed from 0-7.

Team Members:

Jamar Johnson & Ricky McGruder.

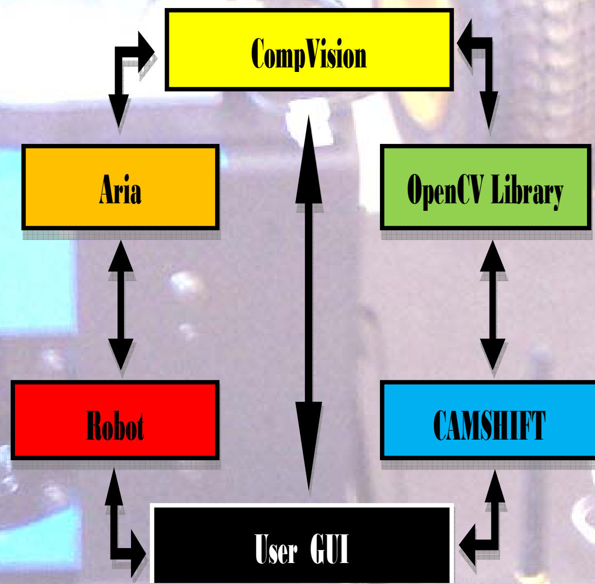
Incorporating Object Tracking Into the P3-AT Mobile Robot

Jeremy Miller; Advisor: Prof. Yan Meng

Project Overview

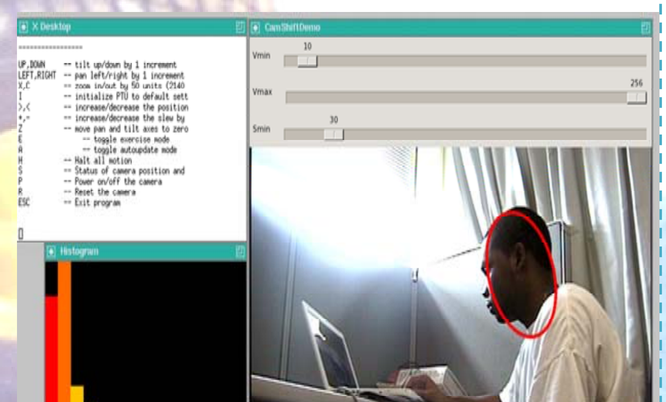
The mobile robot, the Pioneer 3-All-Terrain (P3-AT), that our team has been doing research on is surely a magnificent creation of the MobileRobots Incorporation. Equipped with a sturdy aluminum body, four-wheel drive system, reversible DC motors, and high-resolution motion encoders, this intelligent machine can easily sense and navigate itself around in a real-world environment. The main feature that our research team is adding on to its wonderful platform is real-life, motorized object tracking. Although the P3-AT can detect many objects with its onboard

System and Elements



The CompVision Program

During this research experience, our team has been working towards developing and incorporating the OpenCV library to enable an object-tracking feature onboard the P3-AT mobile robot. With the help of the OpenCV library's CAMSHIFT object-tracking algorithm, we were able to get the camera onboard the P3-AT to detect human faces and various other objects inside the output window display. In addition, a productive software called ARIA (Advanced Robotics Interface for Applications), made it useful for our program to control camera movements while we were searching for objects to track. This software was already installed on the P3-AT's server. Our multi-threaded CompVision source code was developed on the robot's Linux-based operating system. A picture of the CompVision program is shown below. As you can see in the CAMSHIFT DEMO display window, a red circle is placed around the human object that we were trying to track. The Histogram box is simply used to display all the different color variations of the object tracked.



Research Team:

Yuhua Zheng (Graduate RA)
Jeremy Miller (Undergraduate Intern)
Brandon Morton (Undergraduate Intern)
Prof. Yan Meng (Research mentor)

Contact info:

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Brandon Morton; bmorton1@umbc.edu

Sponsors and Acknowledgment

- Stevens Institute of Technology
- The National Science Foundation (NSF)
- Office of Navy Research (ONR)
- www.mobilerobots.com

Team websites: www.freewebs.com/jrmymiller ; www.freewebs.com/bmorton1

Study of Electroencephalography

Signal Properties:

- $|\mathbf{V}| \leq 100\mu V$
- $0.5Hz \leq f_V \leq 70Hz$

Detecting Signals:

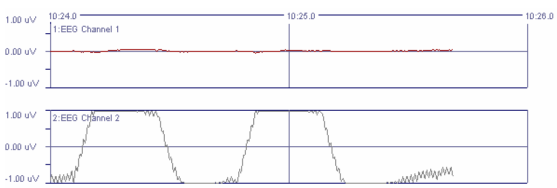
- Passive AgCl electrodes
- High-impedance instrumental (differential) OpAmps
- Low-pass filters

Engineering Difficulties:

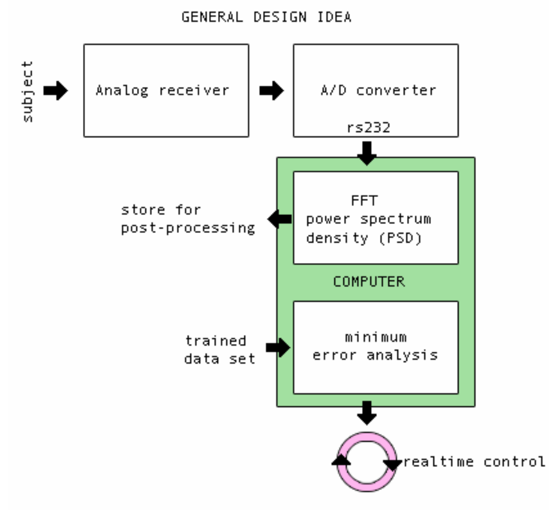
- High noise levels
- Very low amplitude (microVolt) waves
- Biological response create artifacts in detected signals

Results:

Channel 2 shows the result of horizontal eye movement:



Channel 2 shows the result of blinking:



Design Prototype:

Analog[1] - Boards- Digital[1]

Testing:

Research team; Contact info:

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Deian Stefan (Secondary Advr.); stefan@cooper.edu
James Miraglia (Patient); jamesmiraglia@gmail.com
Prof. Yu-Dong Yao (Advisor); yyao@stevens.edu

References:
1. http://www.olimex.com/gadgets/index.html

Sponsors:

Stevens Institute of Tech.

National Science Foundation

Stevens REU 2007 Chong-Oak Lee

Tree Communication Protocol for Swarm Robots

Problem

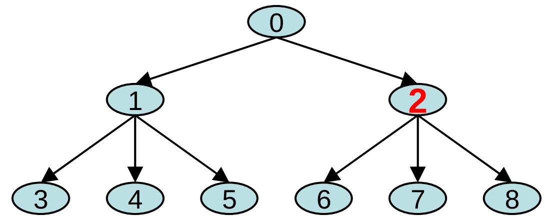
In the current research of swarm robotics, one of the most important topics to consider is the communication protocol. The protocol needs to be as simple as possible, yet account for efficiency, energy consumption, and reliability. In a dynamic system such as the swarm robots, the number of transmissions can grow at a factorial rate if unchecked. Note that if there are n nodes (robots), then the number of edges (wireless transmissions) is O(n!).

Solution

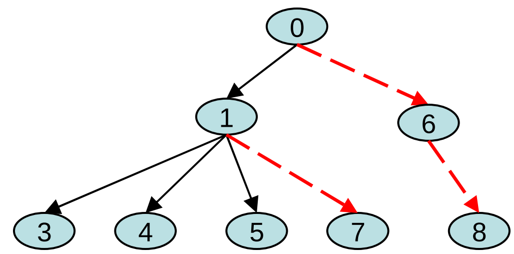
To account for the possible flooding of the wireless broadcast communication, the following protocol can be implemented. Let each swarm robot be a node and each edge represent a communication link where if a robot receives a transmission from a robot which there exists an edge between, then the robot will broadcast the information. The initial protocol is set up as a tree where one robot will be the root without a parent and the rest of the nodes will have one parent. This guarantees that there will be no loops in the protocol as a tree is a loop-less graph. When a node's parent goes out of range, it founds another node to be its parent. This maintains the tree structures and the forest of nodes (robots) ensure loop-less communication.

One downside of the tree protocol is that reliability may become an issue as the redundancy decreases. However, this can be fixed by implementing multiple tree protocol on top of each other. This can give the user a linear factor in the redundancy vs. reliability issue as the number of edges in a tree is linear to the number of nodes.

Algorithm Demonstration

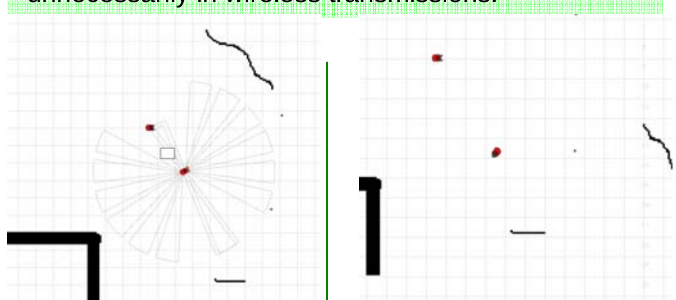


After failure in node 2, the children nodes 6, 7, 8 find another parent to link to.



Implementation

This algorithm implementation is done in the player/stage simulator. Player/Stage is a sophisticated software that can accurately simulate real robots and allows programming that's parallel to both the simulation and the actual hardware. The robots are equipped with a blob-tracking camera, a sonar, and a gripper to bring back targets of interest. The robots must effectively communicate in order to find the sights of interest and the algorithm allows this without clogging the network or wasting energy unnecessarily in wireless transmissions.



Player/Stage Simulation

Contacts:

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Matthew Confort mconfort@stevens.edu
Professor Yan Meng Yan.Meng@stevens.edu

Sponsors:

STEVENS Institute of Technology

National Science Foundation WHERE DISCOVERIES BEGIN

Short Wave Orthogonal Frequency Division Multiplexing

Applications

Utilizing the High-Frequency band, this kind of system is the next step in worldwide communication

Working with multipath fading, global radios can become a reality

Disaster sites or underdeveloped areas will be able to communicate easily.

Utilizes one of the overshadowed areas of the frequency spectrum

Features

Orthogonal Subcarriers: high efficiency of the frequency band.

Cyclic Prefix: combats multipath fading

Interleaving/Encoding: minimizes loss in imperfect channel conditions

QAM modulation: efficient use of the complex plain for transmission

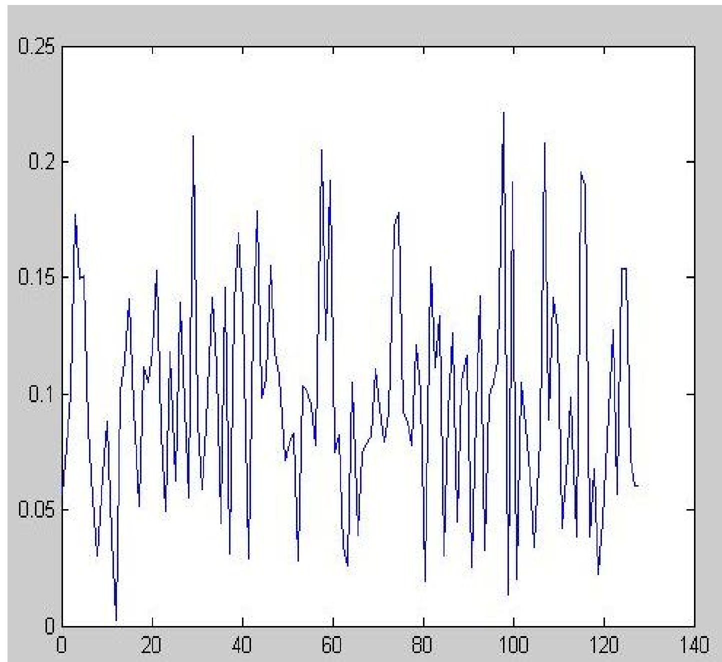
Pilot Symbols: for adapting to worsening channel conditions

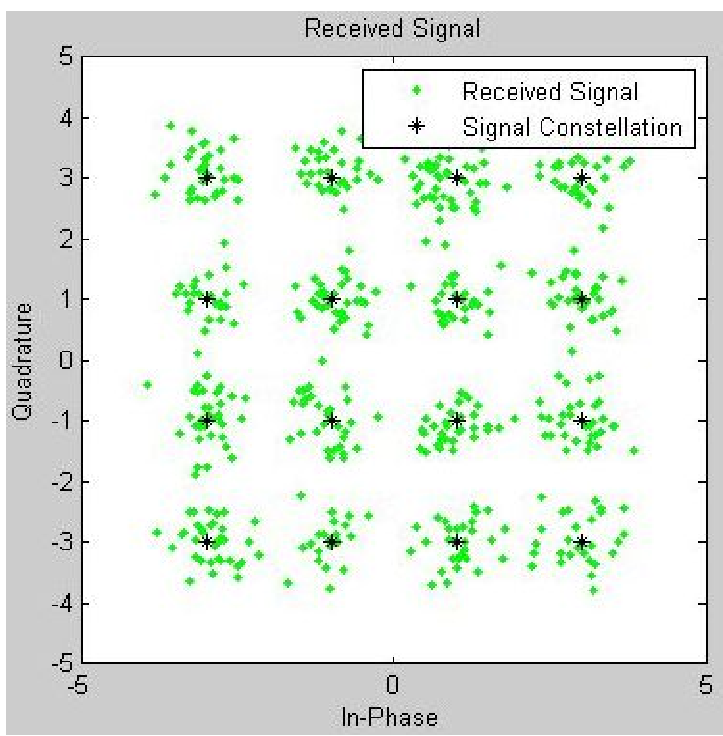
Christopher Alesandro, Cooper
Jonathan Chang, UMBC
Grae Cullen, Temple
Joshua Schickling, Arizona
Michael Bocchinfuso, Stevens

Professor Bruce McNair

The System

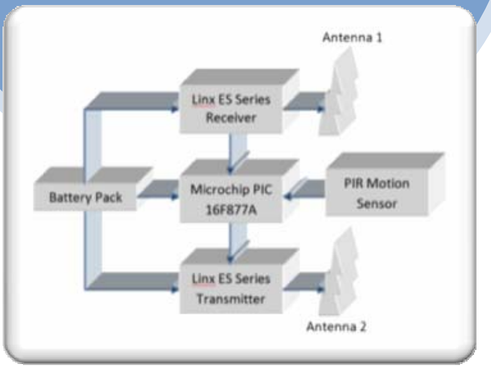
data -> split into sub carriers -> encoding -> interleaving -> modulation -> pilot symbols -> time domain conversion -> cyclic prefix -> channel conditions -> decoding





Wireless Sensor Array Network (WSAN)

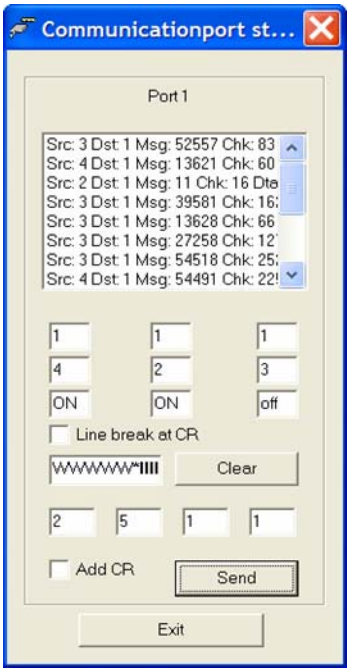
Wireless Node Block Diagram



System Overview:

WSAN is a multipoint wireless sensor array for military or commercial use with ad-hoc or star-network topology. The system consists of 2 types of items: the "base station" which is the central hub for the network, and the "wireless nodes" which can communicate with each other as well as the base station. The base station can be connected to a PC through a serial port to monitor, receive, or send network traffic using the WSAN protocol created exclusively for this system. Additionally, the base station can display up to 3 Boolean values using on-board LEDs making remote monitoring of the system without a PC possible. All system components run on individual 9V batteries. The

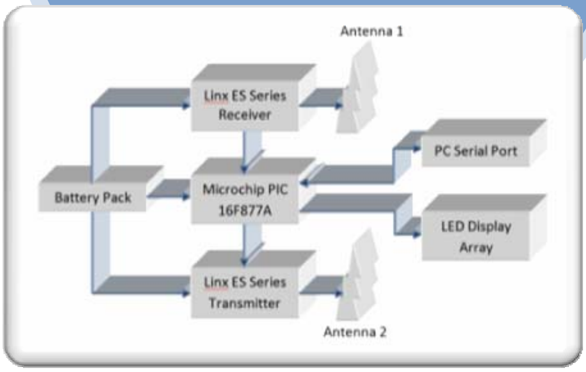
PC Program



Future Enhancements:

- *8 x faster data rate*
- *Ad-hoc network message routing with node-hopping*
- *Boost transmission range through increased power*
- *Two-byte addressing for up to 65535 nodes and bases*

Base Station Block Diagram



System Features:

- *Wireless up to 1000 feet*
- *Scalable with multipoint-to-point network topology*
- *Compatible with digital or analog sensors*
- *Completely mobile*
- *Long battery life*

Technical Features:

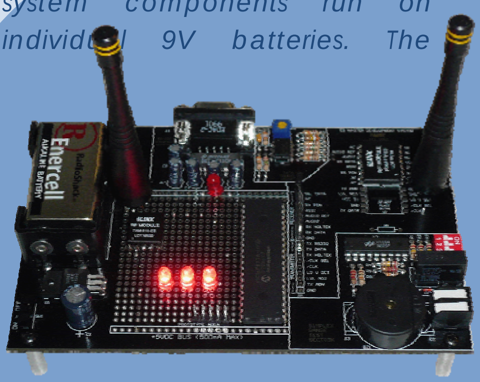
Microcontroller:

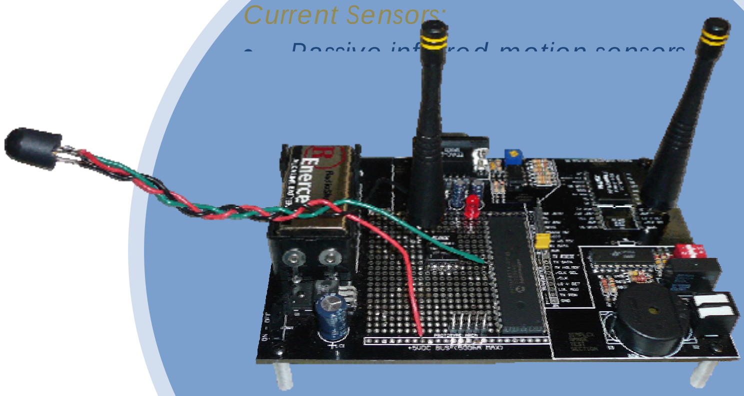
- *20 MHz microprocessor*
- *7 analog inputs with 10-bit resolution*
- *12 digital IO pins available*
- *14 KB flash with 368 bytes RAM*

RF Modules:

- *900 MHz ISM band for unlicensed usage*
- *Two pin "data-in, data-out" usage*
- *FSM for immunity to noise*
- *2400 bps for quick yet robust transmission*

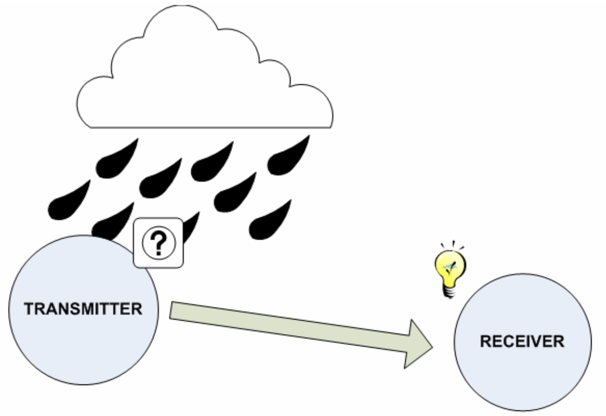
Current Sensors:



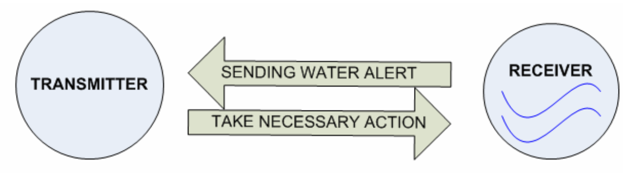


WIRELESS LED SYSTEM (CONCEPT/PROTOTYPE)

APPLICATION SCENARIO A



APPLICATION SCENARIO B



SYSTEM FEATURES

- **Sensors (Flood/Light) *CONCEPT***
- **PIC (16F877A)**
  - 2 PWM 10-bit
  - 256 Bytes EEPROM data memory
  - ICD
  - 25mA sink/source per I/O
  - Self Programming
  - Parallel Slave Port
- **Development System (LINX)**
  - On-board decoder/encoder and relay outputs
  - Prototyping area with breakout headers
  - Regulated power supply
  - On-board RS-232

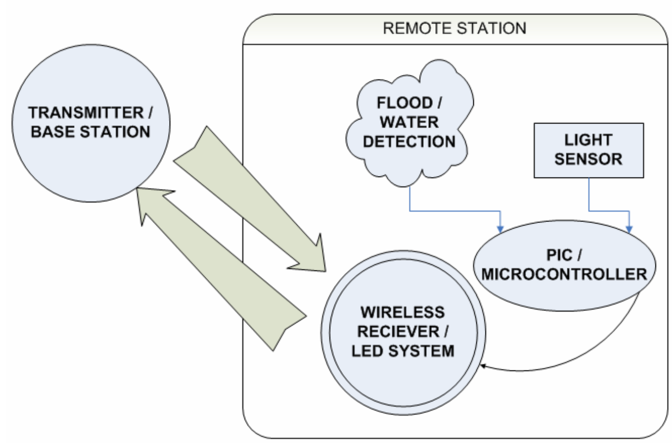
RESEARCH TEAM

Edward Toloza – Stevens Institute of Technology

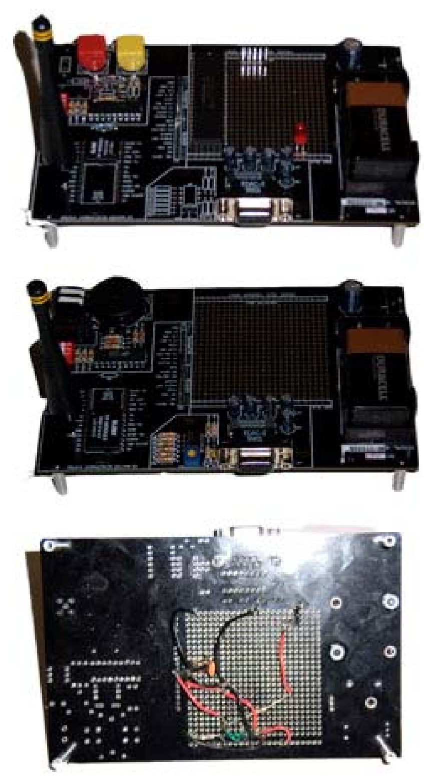
Zamon Granger – Jackson State University

Frederick Windham – Jackson State University

SYSTEM AND ELEMENTS



CONCEPT / PROTOTYPE



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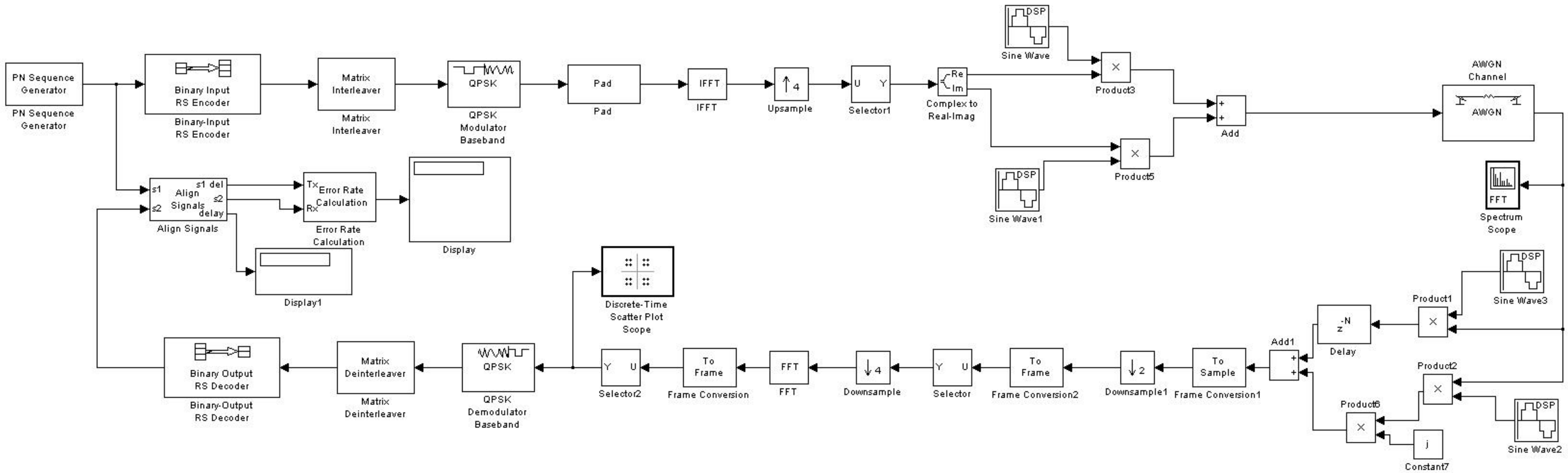
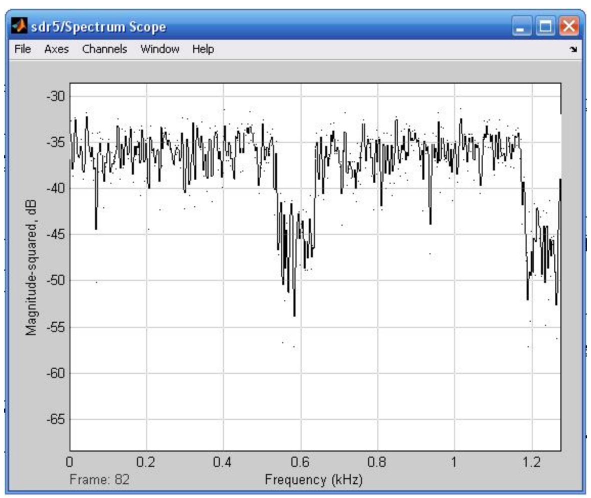
High Speed Data Transmission over High Frequency Radio using Orthogonal Frequency Division Multiplexing (OFDM)

Chris Alesandro; Advisor: Prof. McNair



Overview

A software based system for transmitting and receiving high speed digital data over long distances using HF radio signals.



Transmitted Signal

Simulink Simulation Specifications

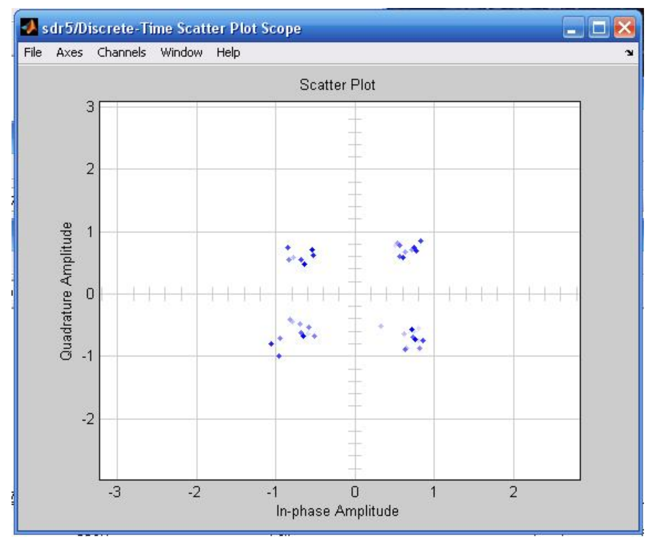
-Reed-Solomon Encoding and Matrix Interleaving
-Quadrature Amplitude Modulation
-Zero Padding
-OFDM
-1024-Point FFTs
-Cyclic Prefix Extension
-Quadrature Signal Generation

Project Team

Chris Alesandro
Jonathan Chang
Grae Cullen
Joshua Schickling
Michael Bocchinfuso
Advisor: Prof. Bruce McNair

Acknowledgements

Advisor Professor Bruce McNair
Program Director Prof. Yu-Dong Yao
Stevens Institute of Technology



Visible Quadrature Amplitude Modulation

Miniature Autonomous Swarming Robots

Swarm bot: artifact composed of a number of simpler, insect-like, robots (*s-bots*), built out of relatively cheap components, capable of self-assembling and self-organizing to adapt to its environment.

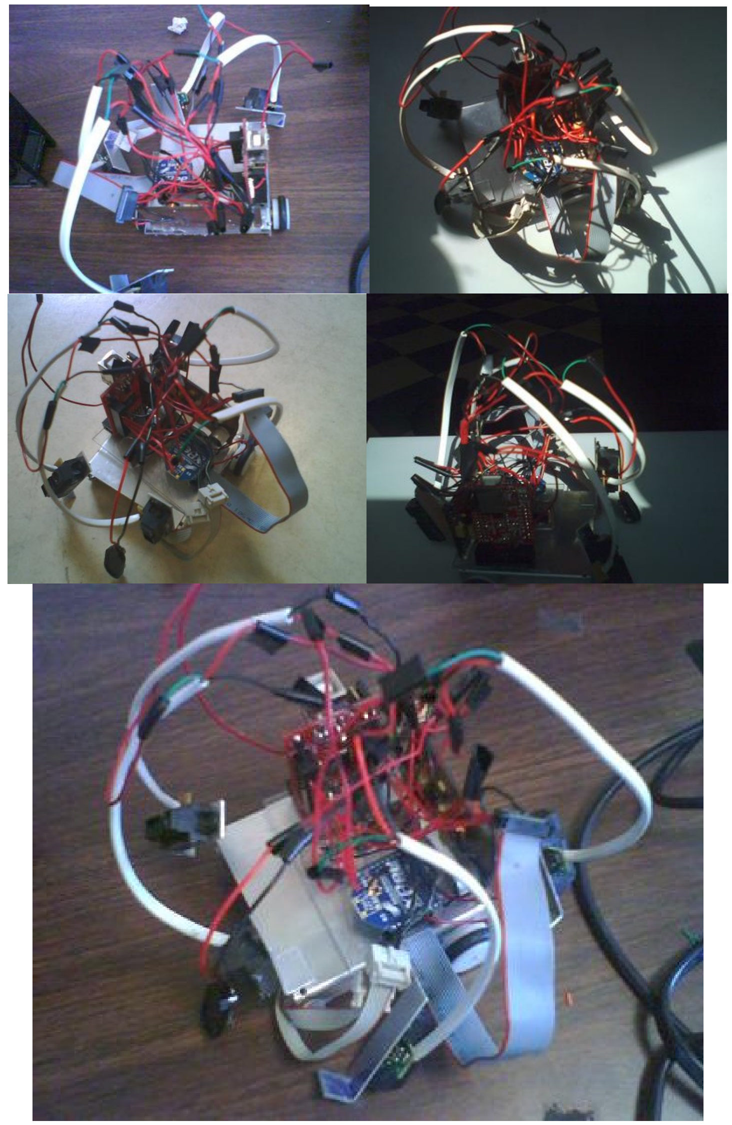
Current capabilities:

- Sensor (object, temperature, light)
- Linux graphical interface
- Radio transceiver range of 50ft.

Work in progress:

- CMOS camera
- Solar power
- Web graphical interface
- Remote control
- GPS

Prototype



Swarm Bot features:

- Map rooms and hallways for blueprint creation and analysis
- Work together to move large objects and even people
- Clean up hazardous material in dangerous situations with no human input required

Research team: Dr. Yan Meng, Matthew Conforth, Kerry Johnson, Brian Simms, Charles Creamer, John Lee, Shaughn Harris, Micah Shears

Contact info: Dr. Yan Meng, Yan.Meng@stevens.edu

Sponsored by Stevens' Department of ECE