A significant need exists in the open source community to make sensor technology easier for application developers. This will increase the availability of these platforms to more developers, which will in turn improve consumers access to sensor technology and the Internet of Things.

We require an open source device, in the form of a low cost and powerful micro-controller and other components, that enables connectivity to a variety of wired and wireless sensors, utilizing generic RF, Bluetooth and ANT based technologies, on one convenient platform. This device will communicate with a user interface (UI) application residing on an android mobile platform, via Bluetooth or TRRS connections. The system must allow for collection and buffering of sensor data, until the UI consumes the data.

The micro-controller circuit should optionally allow battery charging via solar cells and/or input voltages. The micro-controller circuit should be physically small, similar in size to a key fob, and contain all the required electronic components excluding sensors. Power may be derived from rechargeable lithium ion batteries, or alkaline batteries (precluding the recharging aspects), based on cost.

An API must be developed and reside on the micro-controller to enable the UI to configure and read the data from the sensors, and to permit the micro-controller to purge data, or a subset of the data. As simultaneous sensors will operate together, data storage is an important consideration to optimize. Local data storage should be in the form or a removable SD Card or micro-SD Card, or something similar, and support all major SD Card manufacturers. Cost and complexity considerations apply, so research must be done in this area to determine the best solution.

An Android (and iOS if one is feeling ambitious) based user interface (UI) is required to configure, log, and monitor (real-time) sensor inputs. The UI would initiate data collection and clearing in the micro-controller.

The device must support sensors that will communicate with the device using either Bluetooth, ANT or generic RF technologies or wired, via I2C or TRRS connectors. This must be researched to determine the best possible approach, although at least two wireless (Bluetooth, ANT, or RF) and one wired sensor bus should be in the solution. Power to the wired sensors can be provided, presuming it is kept to within required thresholds. Over a particular threshold, sensors should supply their own power. This maximum power threshold should be stated and known.

Licensing for Bluetooth and ANT+ may be a concern. Research into a technology licensing should be completed before design commences.

Existing sensor technologies, such as Grove, wireless sensors (WPAN) and I2C based devices, and others as research indicates, may be considered.
Project 2: Testbed Development for Geolocation of RF Emitters

**Background:** In recent years, novel sensor networks have been proposed to detect the location of radio signals. These sensors employ novel geometries, multiple platforms, and wireless devices. Various methods for discovering the location of unknown radio signals use unmanned vehicles to place sensors close and remotely relay information. Imagine that you can automatically locate the general direction of the source of a radio transmission, using light-weight, cheap-off-the-shelf technology. Limits on the size and weight of the sensor technology restrict the accuracy of the sensors. However, by employing multiple sensors that are mobile, these sensors need only to provide a rough estimate of the emitter’s location. Combing this information from multiple sensors can determine a more precise location of the emitter (direction and range). In more sophisticated networks, the determination of the origination of signals provides information that could be exploited in order to mitigate interference signals or improve the overall sensing process. Today’s interconnected wireless world has led to a potential spectrum scarcity problem. The Air Force requires real-time radio-frequency situational awareness to support spectrum management protocols and enable cognitive radio networks. These protocols can be improved if the location of signals can be determined. Several algorithms have been proposed that use a cooperative sensor network to locate the source of radio signals. A physical testbed is needed to fully understand and test these algorithms.

**Objectives of the Project:** The objective of this student challenge is to develop a physical testbed simulating a network of RF devices which can be used to evaluate existing localization algorithms [1]. The testbed should be scalable, reconfigurable, and based on Universal Software Radio Peripheral (USRP™), a university and industry standard. The sensors should be capable of mounting on air-based or ground-based mobile platforms. The sensors should be able to communicate with a central node to send data and receive instructions (see Figure 1). A suggested platform for interfacing the USRP and additional sensors is the BeagleBone™ embedded processor ([http://beagleboard.org/Products/BeagleBone](http://beagleboard.org/Products/BeagleBone)).

![Figure 1. (left) Cooperative network of mobile sensors for testing geolocation algorithms, (right) Example of a geolocation algorithm simulated with a single emitter.](image-url)
The team will be responsible for integrating hardware and developing software to support a network of 4-6 radio receivers (sensors). The radio receivers should have the capability to measure received signal strength (RSS) and angle of arrival (AOA) with at least 30 degree accuracy. A real-time spectrum sensing of the environment in the 50 MHz - 2.2 GHz band is desired.

**Desired Project Characteristics and Sample Milestones:** It is expected that the team apply systems-level engineering to make and explain appropriate trade-offs and design solutions meeting required milestones, as required in the CAPSTONE course. As the final milestone in the capstone project, the team should strive to demonstrate the operation of the test-bed in an appropriately design field test using any convenient ground based mobile platforms. These could be student cars, bicycles, RC robots, etc. This will bound the technical- and cost-scope of the capstone effort, while affording the maximum flexibility, creativity, and innovation in proposing solutions to the stated problem. A successful project will meet the following milestones:

1. Designate a suitable mobile platform with in the budget-scope;
2. Develop communication protocols for the cooperative wireless network;
3. Complete a systems trade-off study, e.g., trade-off the transmitter power with RSS signal-to-noise ratio and the duration of operation;
4. Incorporate supplied geolocation algorithm(s);
5. Demonstrate, in near real-time, the geolocation of an emitter in a 100 m² area within 3-5 m of the actual location (that is, the Circular Error Probable should be 3-5 meters).

6.

**Skills Needed:**

1. **Innovation and creativity;**
2. Reading and understanding complex academic research;
3. Embedded system operating systems and embedded system development;
4. Communication protocol experience;

**Sponsor:**

Air Force Research Laboratory - Sensors Directorate, WPAFB, OH
Electronic Warfare Techniques Development & Analysis, RYWE
Capt Michael Huffman, Electronic Warfare Research Engineer, (937) 528-8185, Michael.Huffman@wpafb.af.mil
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Project #3

Ballistic Chronometer

The goal of this project is to design and build a low cost ballistic chronograph system. What would be different then most commercial units is the sensing system and the incorporation of additional external inputs used for ballistics calculations. Most common commercial units use some type of IR light and detection system that has problems with sunlight and temperature. Additionally, alignment is critical to get accurate information. A design using a line laser and detector array will be investigated along with a solid structure for permanent detector alignment. To keep cost down the system should use the TI MSP430 launch pad or equivalent TI microcontroller. A touchpad control screen, wireless communications, phone app display and SD card data storage should be investigated. The design day demo would be to measure the speed of a marble shot from a sling shot in a controlled environment.

If the cost and design is easy to replicate the long term idea would be to make the design available as a DIY project on several of the do it yourself web sites.

Introduction to a chronometer

http://www.youtube.com/watch?v=01PbHN1enTM

Ballistic Calculators

http://www.jbmballistics.com/ballistics/calculators/calculators.shtml
Overview of Project:

GM’s climate control system is moving from analog interface actuators/sensors to devices that use LIN (single wire) serial communication. GM has production controllers and production actuator sensors that have been designed to operate using this protocol. The purpose of this project will be to assist GM in developing a rapid prototyping environment for climate controls that will enable the integration of these devices.

Expected Project Tasks/Subtasks:

1. Investigate and Implement general LIN handler in D-space system.
2. Design and Interface LIN handler to device protocol and functional messaging
3. Wire and demonstrate LIN device/sensor function with D-space system.
4. Modify driver design for reusability (if required)
5. Document Design and interface

Expected Potential Deliverables

1. Build/verify D-space LIN actuator driver functions (our models provide actuator % command – need SSW like actuator driver in D-space to support GB and other projects – we have a spec. we actually even have model/code that could be leveraged from S&C → work here is to create a nicely reusable driver library in D-space that is fully verified.
2. Build/verify D-space LIN Active Heater driver (8.X ECC supports the LIN coolant heater but all GB Active heaters → PTC, HEH will use the same LIN protocol per Gilles → again work here is to create a verified reusable driver library in D-space.
3. Build/verify D-space LIN ILSS driver (8.X BCM/ECC supports the LIN ILSS → but there will likely be a need at some point to have this available for rapid proto exercises → again work here is to create a verified reusable driver library in D-space.
4. Build/verify D-space LIN RHS driver (8.X BCM supports the LIN RHS → GB is slated to use same protocol as GA and in GB there is no analogue RHS sensor → again work here is to create a verified reusable driver library in D-space.)
Team 5 Project

Synchronization of Sensors Via Timing Lights (SOS Lights)

Richard Van Hook

Air Force Research Labs, Sensors Directorate

Background

Modern military operations are being tasked to detect and identify increasingly difficult targets in a range of situations and environments. It has been shown time and time again that no single sensor is capable of performing these tasks in all instances. As such, the Air Force has turned to layered sensing (LS) as a solution. LS is “characterized by the appropriate sensor or combination of sensors/platforms, infrastructure and exploitation capabilities to generate...situation[al] awareness and directly support delivery of ‘tailored effects’.” In essence, LS can be thought of as putting numerous sensors on target simultaneously.

However, the raw data coming off the sensors is not, in and of itself, the final product. The data can nearly always be processed and fused with other data to generate a much more useful and informative end product. This fusion typically requires that LS sensors have, within some small error margin, a single global clock. This is a pre-requisite to ensure that data from one sensor can be corresponded to data of another sensor. The global clock, in almost every case, is GPS time taken from various GPS receivers.

While this paradigm is adequate for the moment, the Air Force is always looking towards the future. It is unlikely that GPS and other satellite-based geo-location technologies will be uncontested. Rather, it is highly probably that at some point the Air Force will have to operate in a GPS-denied environment. Although there are numerous aspects of that tactical situation to consider, this project is concerned only with the temporal synchronization of sensor data.

Project

The goal of this Senior Design Project (SDP; aka “Capstone Project”) is to design and develop a system to synchronize cameras. One of the easiest methods to solve this problem may be to use light sources on the ground and strobe them towards the sensors. In theory, the airborne sensors would see a “normal” image in one frame, and in the next frame the sensor would see the light source. This transition would serve as a temporal marker.

It is important to note that theory rarely works perfectly in practice. As such, it is expected that sensors will typically not see a binary strobe light (0% luminosity one frame, 100% of the light’s max luminosity the next). It could be the case that the camera’s frame rate is slow enough that the light flashes between images and therefore the camera never detects the light. It may also be the case that the camera’s frame rate is high enough that it sees 0% and, say, 25% luminosity of the first frame and the second frame, respectively. This could potentially be resolved with other light strobes (whether the same or geospatially different lights). Regardless, these and other technical aspects of the problem will have to be carefully
considered in any implementation. Other items the team will have to consider include sensor frame rate, sensor integration time, sensor aperture size, sensor CCD responsiveness to various wavelengths of light, etc.

In addition to coming up with a system to synchronize cameras, the team will need to come up with a system and/or process to determine the accuracy and precision of the temporal registration. This portion should also include a study of sensor clock drift. That is to say, is it sufficient to synchronize the sensors a single time, or will multiple synchronizations need to occur? If multiple synchronization events will be required, how often will those need to occur?

As with any engineering problem, there are multiple solutions to the problem. Though we have presented one possible solution, any proposal which appropriately addresses the problem will be considered.

**Sponsor**

Richard Van Hook  
Associate Computer Engineer  
Air Force Research Labs, Sensors Directorate  
937-528-8589 (Office)  
937-272-7309 (BB)

**AFRL Resources**

AFRL will provide a mentor for the team. In addition, AFRL is willing to provide sensors as requested and as are available.

**Guideline Specifications**

* Temporal Registration Accuracy: +/- 250ms  
* Light Source Setup time: <5 minutes  
* Time to Synchronize Sensors: <10 seconds  
* Synchronization Success Rate: >=90%
ECE 480 Bluetooth Low Energy (BLE) Beacon Design

Introduction
The RCPD has recently discovered a way to make digital signs more accessible to blind users carrying i devices. This same technology can also be used to assist with indoor navigation.

With iOS 7, Apple introduced a new interactive positioning interface for their hardware called iBeacons. iBeacons are essentially BLE chips that can be set up to communicate relative location data with each other. Each beacon sends out a signal that will let other BLE devices within range know it’s approximate distance to the beacon. The implementation of such beacons here, on the MSU campus are numerous and they range from indoor navigation to alerts on a blind person’s phone as they approach the interactive signs in the Engineering building and other places on campus. These alerts can direct the user to web sites duplicating information presented in the digital sign.
Since the technology itself is new, the only beacons that can be used right now are apple devices themselves and Arduino boards with BLE shields, both of which are rather expensive to deploy on a large scale such as a University campus.
The aforementioned use cases would only be possible if the beacons themselves can be made inexpensive and in a compact package for easy deployment.

Project description
The goal of this project is to design and create inexpensive BLE beacons that can be used with the iBeacon standard, as well as potentially extended to work with Android and other BLE equipped devices. This project will require understanding the Bluetooth and iBeacon protocols, PCB and circuit design and basic programming skills.

Project contacts
Adi Mathew mathewa6@msu.edu and Stephen Blosser blossers@msu.edu
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Resource Center For Persons with Disabilities (RCPD) 120 Bessey Hall East Lansing, MI 48824-1033
517 884-1914
Project 7  
ECE 480  
Battery Management System  
Michigan State Solar Car Team

The Michigan State Solar Car Team is a student run organization at MSU that builds, tests, and races solar cars. The team is currently working on finishing a car that will race in the 2014 American Solar Challenge.

In the 2012 American Solar Challenge the team used lead acid batteries that weighed 110 kg (242 lb) due to their simplicity in battery management. This upcoming race the team is taking a big step and creating a car with a lithium ion battery pack. The lithium pack will weight a mere 20 kg and contain more energy than the older lead acid battery pack. The challenge is the complexity involved in a lithium ion battery management system.

The MSU Solar Car Team would like to develop a customized battery management solution that will tailor to the needs of the car. The battery management solution must be able to meet the following criteria:

- Detect the following events
  - Over voltage
  - Under voltage
  - Over current
  - Over temperature
- Interface with a GUI that will display the following
  - Individual battery cell voltage
  - Battery pack current and temperature
- Take action to prevent any damage to the battery pack
Accessible Tactile Graphic Printer
January 2, 2014

Introduction
Tactile graphics and Braille are an important part of accessible education for the blind. The RCPD maintains two tactile graphics embossers that produce pictures, charts and drawings that our blind students touch.

Currently tactile graphics are produced in several ways.

The most common method is embossing Braille paper by solenoid activated pins. This method is noisy and it produces a somewhat fragile image that quickly flattens with repeated use. The embossers are very expensive ranging from $10,000 to $50,000 each. www.viewplus.com

Another process uses “swell paper” http://americanthermoform.com/swell-touch-paper/ that is a little more robust but can cost $1 to $2 per sheet. The image is limited in resolution and the edges of lines and dots are often blurred. It is also a two-step process requiring a special machine to swell the image.

Vacuum forming is used to duplicate images from a master. This can produce durable images but is only used when high production is needed. The masters are often made by NC mill or by hand. Similar to the swell paper this method has a limited resolution with rounded edges.

An emerging technology for tactile graphics includes Ink-jet images made by layering a specially designed ink that is cured between layers. This technique is not currently available in a production device.

Another technology that is being used for the blind is 3D printing. http://3dtactilegraphics.com/ This was used last semester at MSU to make several 3D models for our students enrolled in calculus and physics. Many printers are available commercially however the machines are designed to make 3D shapes not tactile maps.

Many kits and parts are available to build your own 3-D printer. http://www.tridprinting.com . Using these resources a specialty printer could be assembled to create tactile graphics with improved features.
Project Goal

ECE480 students will construct a specialty printer that can be used to create tactile graphics and maps for blind users at MSU. Students will investigate the feasibility of using additive manufacturing technology for this printer. The user interface for this device will include voice feedback to enable independent use by blind individuals.

If possible, the deposited material will be elastic http://store.3dprintingsystems.com/3D_Printer_Filament/Experimental?product_id=157 to enable the use of MSU's IV EO touchpad and to provide more flexibility of the paper or plastic substrate.

This project will be documented so that a duplicate device can be assembled for the school for the blind India.

A used pen plotter with X and Y stepper motors is available if needed. Lansing Makers Network\(^1\) has offered to provide the student team with free membership and access to their facility for this project.

Project Contacts

Participants include the ECE Student team, Jordyn Castor and the RCPD staff. We have also received help from Dr. Mounia Ziat\(^2\) and Dr. Vincent Lévesque\(^3\) who published scholarly papers on tactile graphic devices for the blind.\(^4\)

Stephen Blosser

Assistive Technology Specialist

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\(^1\) http://www.lansingmakersnetwork.org/
\(^2\) http://www.mouniaziat.com/
\(^3\) http://vlevesque.com/
\(^4\) http://myweb.nmu.edu/~mziat/Ziat-LNCS07.pdf
Spring 2014 Electrical and Computer Engineering (ECE480) Capstone Design Project
Sponsored by: Lansing Makers Network, Marathon Oil, Asian Aid School for the Blind in Bobbili India and MSU Resource Center for Persons with Disabilities (RCPD)
Projects 9 and 10 are sponsored by Bosch. They are a continuation of projects from last semester.

See the description on the next couple pages of the overall project. The two projects this semester are:

Project 9:

Continuation of the video capturing tool, i.e. add a record and stop trigger, add a display (for camera adjustment, settings menu, display video filename), add a true DVR feature (buffer the last x sec).

Project 10:

Create an iOS and an Android app that takes a structured speech input and outputs an excel file. The use case would be to capture details of software issues in the car by guiding the driver through a few questions. Several observations can be recorded during one trip separately. At the end of the day, the app creates an excel file (or a file that can be read by excel). The GPS location shall be added as well as the current time.
Requirements specification Application for Sponsorship of a Capstone Design Project

To
Cc
Subject Application for Sponsorship of a Capstone Design Project

1.1 Project Title

Video and Audio recording tool for Car Infotainment and Navigation Systems

1.2 Project Checklist

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>use significant creativity to solve a problem where there are many potential solutions</td>
<td>Yes</td>
</tr>
<tr>
<td>require the design of a system, or subsystem rather than a single part</td>
<td>Yes</td>
</tr>
<tr>
<td>require the use of conventional analytical and computational methods rather than specialized equipment and/or software</td>
<td>Yes &amp; No</td>
</tr>
<tr>
<td>permit our students to display their results at the end-of-semester Design Day, which is attended by the public</td>
<td>Yes</td>
</tr>
<tr>
<td>permit our students to visit to your facilities</td>
<td>Yes</td>
</tr>
</tbody>
</table>

1.3 Impact of this project on your company

At Present Bosch Car Multimedia division at Novi doesn’t have a tool which can do the following

- record audio
- 4 simultaneous videos (Center Stack display, Instrument Cluster, Front view of the road (highway signboards), right side view of the road (road names))
- display the combined video in one screen with timestamp and GPS position logging

This capability would help the testing team to record important and unexpected/unforeseen navigation and infotainment issues during in car tests and road tests.

1.4 Legal Requirement

Bosch will own the intellectual property developed as a result of this project
1.5 Background

It is very important to capture videos of issues/bugs, most prominently unexpected/unforeseen issues in Infotainment & Navigation systems during in-car & road tests besides driver safety.

The video capture tool developed should be an easy to use tool with button press to start and stop the Video recording along with GPS position logging and timestamp. The resulting video file should be stored in the storage device (ex: SD card, USB...)

1.6 Current Status

Bosch currently has a single mount camera lens focusing on the Center Stack display besides logging the vehicle data (MOST, CAN and LIN). This tool/device is very expensive. Consequently Bosch Car Multimedia division is looking for a simple video recording tool for the purpose mentioned in section 1.5.

1.7 Project Scope

Objective:

To develop a tool/device capable of recording audio & videos with GPS data logging and timestamp for Car Infotainment & Navigation System.

The tool’s output should be a cascade of compressed video files and audio shown in one screen along with GPS position logging and timestamp of the recording.

Description:

Components list (free choice):

- Use 4 lenses to record views of Center Stack display, Instrument Cluster, Front view of the road (to capture highway signboards), right side view of the road (to capture road names)
- Use GPS for position data logging corresponding to the recorded video
- Storage device(SDHC Card/USB)
- Microphone for Audio recording
- Any choice of Digital Signal Processor or ARM evaluation hardware (e.g. Raspberry Pi, OMAP, BlackFin,...). No complex PCB development is required
Requirements specification
Application for Sponsorship of a Capstone Design Project

➢ Video can be streamed analog, digital or via USB
➢ Free choice of Operating System and programming language (though common languages are appreciated)

![Diagram of Video Recording Tool]

**Fig 1: Video Recording tool**

**Features**
➢ Start recording the video and audio on push of a button from \((t-2)\) minutes, where \(t\) is time at which the button is pressed
➢ Stop recording on push of the button
➢ Log the GPS position details corresponding to the video
➢ Display a cascaded video of the complete event in one single file
➢ Possibility to compress the file
➢ Store the compressed file in the storage device (>16GB)
➢ Name the files with timestamp (start time of recording of the event)
➢ Simple and Low cost device

**Nice to have features**
➢ Display the remaining capacity of the storage device
➢ Display the event/trigger number
➢ Display the current local time (HH:MM:SS) and date
➢ Display the current file name
Team 11 Project
Project Title: Electronic Parachute Deployment System
Project Sponsor: Texas Instruments-Precision Analog
TI Contact: Pete Semig, Analog Applications Engineer

The purpose of this project is to design, simulate, fabricate, test, and demonstrate a TI-based electronic parachute deployment system for large model rockets. Individuals with a passion for any or all of the following are desirable: analog circuit design/simulation, printed circuit board (PCB) layout & fabrication, microcontroller coding, and hardware debugging.

There will be two phases of the project:

Phase 1: Develop a BoosterPack for the MSP430 LaunchPad. Examples can be found here:


The BoosterPack will have one or more sensors (e.g. accelerometer and/or altimeter) to detect acceleration/velocity/altitude. It will also have an LCD display that reports real-time data. You will design, simulate, and fabricate a PCB with the analog signal conditioning circuit to interface the sensor(s) with the MSP430 ADC. Testing for this phase likely includes emulating the sensor(s) with their voltage profile from a typical rocket launch.

Phase 2: Integrate design with rocket. You may need to integrate the BoosterPack and LaunchPad into one PCB due to weigh/space constraints. Testing for this phase likely includes collaborating with a local rocket club (previous team has contacts that you can leverage).

This project will utilize a variety of components from Texas Instruments’ broad portfolio. This will qualify the project for participation in Texas Instruments’ Analog Design Contest.

Team members will have the opportunity to develop and/or strengthen the following skills:

- Analog circuit design with op-amps, instrumentation amplifiers, and power devices.
- SPICE simulation (TINA-TI)
- PCB layout, fabrication, and testing
- Rocketry fundamentals
- Documentation

These skills will prepare group members well for post-graduation positions such as applications & design engineering.
Project #12: Diamond Optical Properties Measurement System

Sponsor: Fraunhofer Center for Coatings and Laser Applications

This project was done in Spring 2013. The sponsor wants several improvements to improve the accuracy and sensitivity of the system.

Diamond is a material with extreme properties including highest hardness, very chemically inert, highest thermal conductivity, wide spectral window for transmission of light and biocompatible. These properties suggest many engineering applications for diamond. Did you know that some of the highest quality diamond is grown here on MSU campus? The group on campus that grows diamond wants to improve its ability to measure the optical quality of diamond.

One of the more sensitive measurements of the quality of diamond is the birefringence. Birefringence is an optical quality where linearly polarized light shining through a flat diamond piece is made non-polarized by imperfections in the diamond. This project is to develop a birefringence measurement system. One possible system could be a linearly polarized laser beam shining through a diamond flat sample with the light exiting the diamond being filtered by a linear polarizing filter that transmits only the light polarized 90 degrees with respect to the input light. The presence of defects and stress in the diamond causes the polarized light to exit the diamond partially non-polarized and it is the strength of the non-polarized light that is to be measured. Typical single crystal diamonds grown in the MSU labs are 4 mm by 4mm in size. The system should interface to a computer and display the data on the computer in a 2-D image. The measurement should be noise immune to the background light in the room. It is desired to incorporate multiply colors of LED as the light source in this system this semester.