Critical Sign Tracking

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Website: http://seniord.ece.iastate.edu/may1418/index.html

Goal

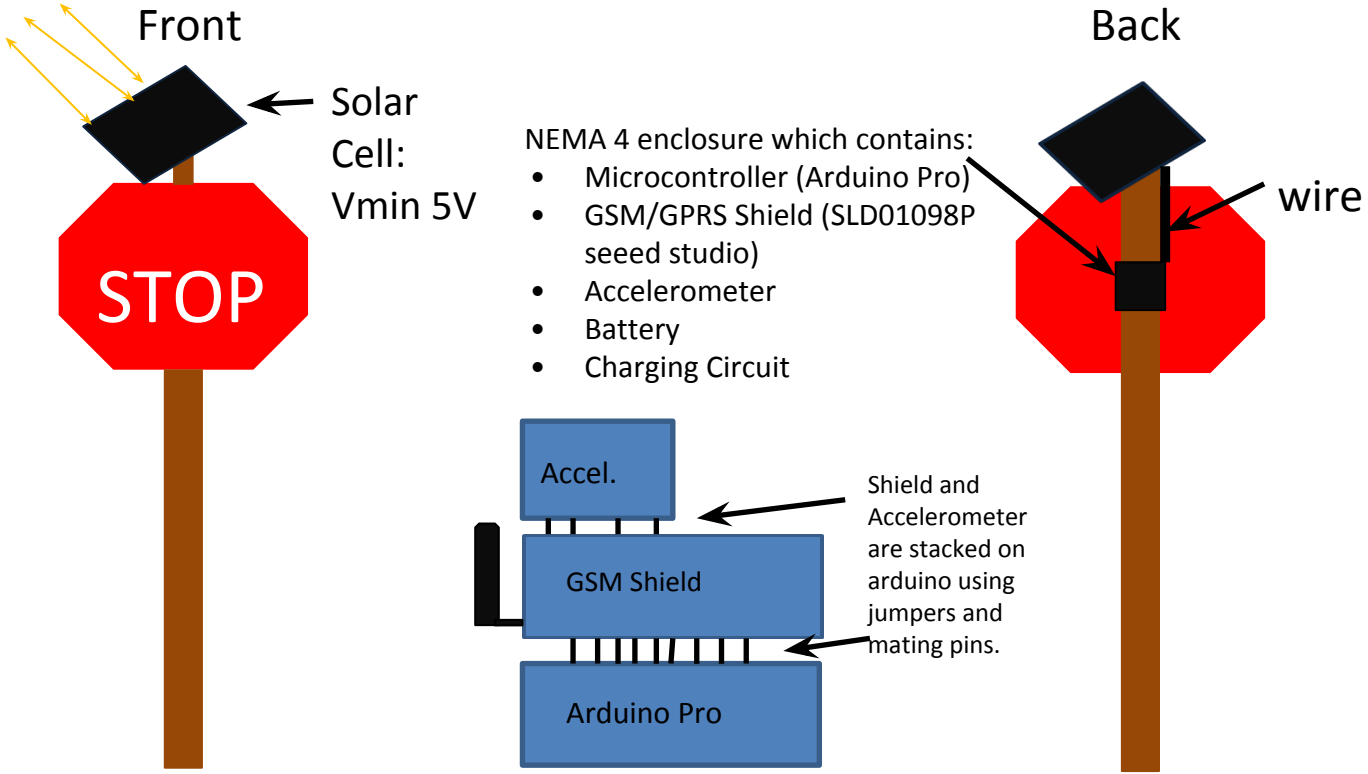
- Reduce response time for critical warning signs in the event of failure.
- For example if a stop sign falls over we would like to notify the DOT as soon as it occurs to prevent a driver running an intersection causing a fatal accident.

Current Design: Overview

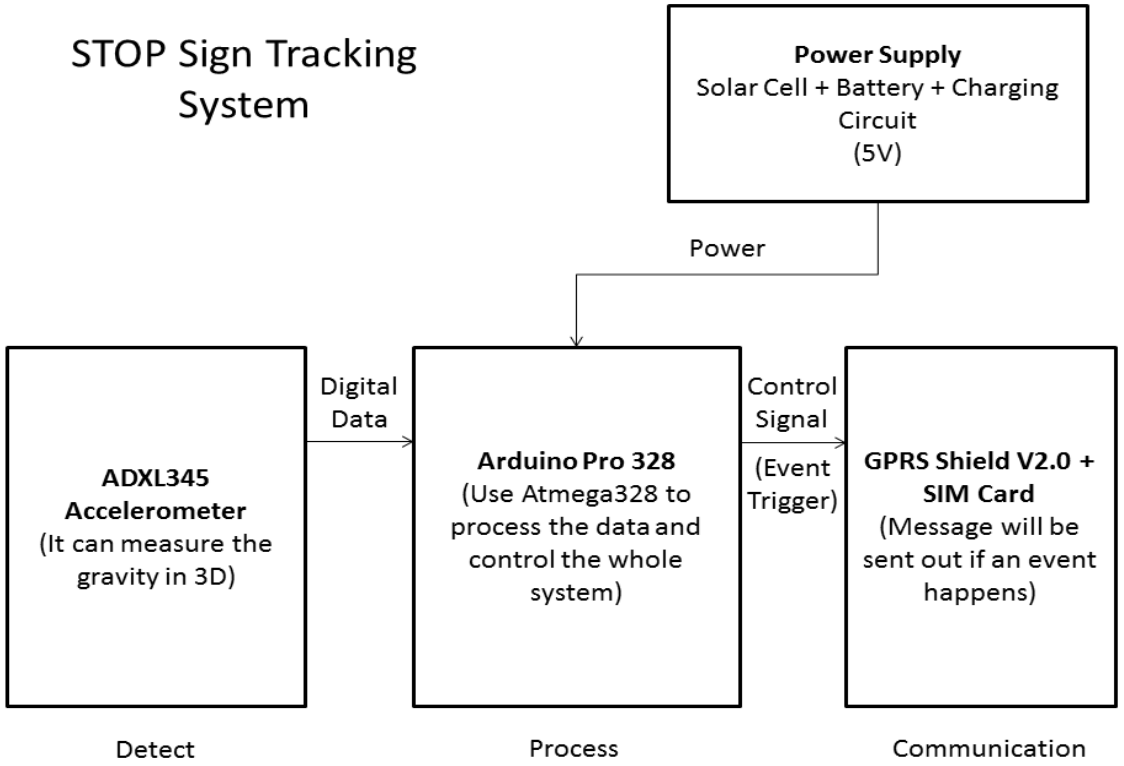
Current design consists of four parts:

1. System Management: Used to combine the system monitoring and communications.
2. System Monitoring: Monitors the current state of the critical stop sign. Based upon the tilt of the sign.
3. Communications: Used to send out alerts to the end-users which will reduce response time to a broken sign.
4. Power: Harvest energy (solar), Store excess energy, and supply energy to monitoring/management system.

Current Design: Overview



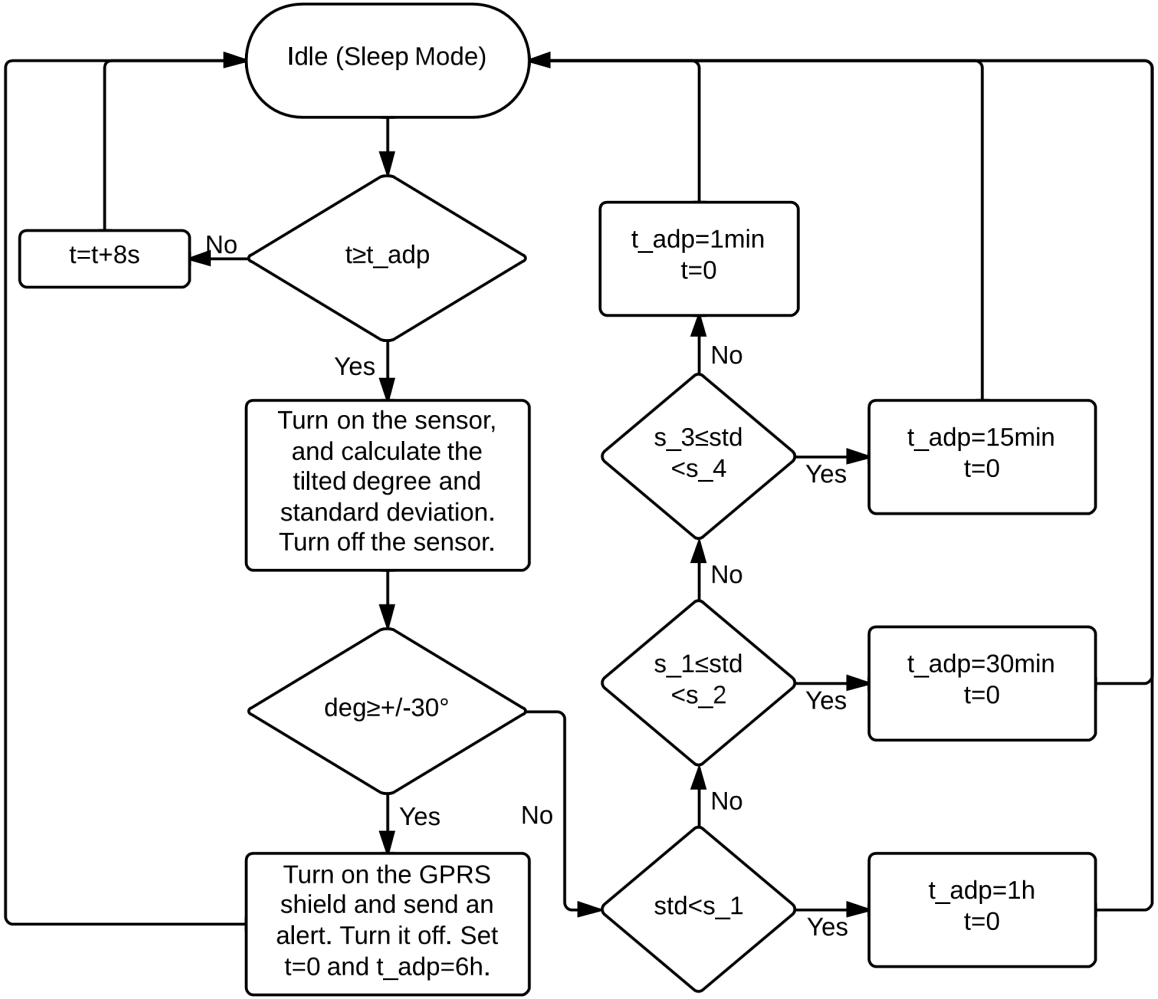
Current Design: Overview



Embedded Program

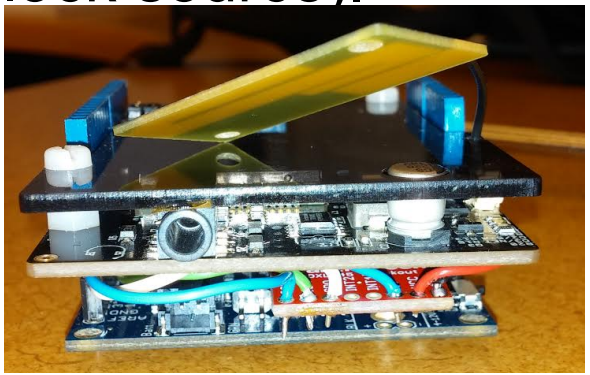
- The tracking system has an adaptive duty cycle to be efficient.
- When the measurement is not needed, the system will go to its sleep mode.
    - In the sleep mode, the sensor (accelerometer) will be in the standby mode which is best status to save power. The Atmega328 will go to its sleep mode with only a “watchdog” timer on in order to calculate time for the duty cycle.
- The GPRS shield will be turned on only when a message needs to be sent out because the shield consumes a lot of power (1W) when working.
- To change the duty cycle is based on the standard deviation of the measured tilt degrees which is influenced by the wind speed.

Stop Sign Tracking System Flow Chart



Microcontroller

- Arduino Pro 328 / Atmega 328 (5V 16MHz)
- Chosen for ease of use and access to shields.
- Atmega328 has a sleep mode with only 1μA current consumption. A sleep cycle can hold up to 8s using a “watchdog” timer (separate 128kHz clock source).

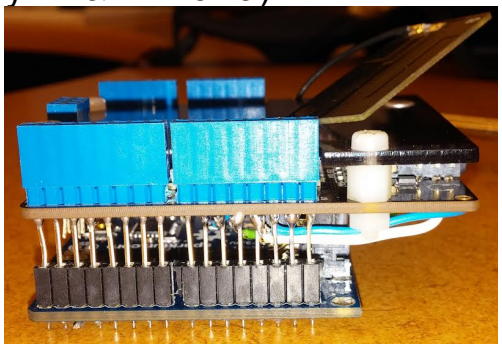


Front view of the Arduino connected to the GPRS shield and accelerometer

Energy Storage

A 3.7V, 1100mAh Li-Ion battery is used to store the energy for the system. Based on different duty cycles, the battery can last for different time.

- If all of parts are turned on:
  - GPRS shield: 303 mA (for 1900 MHz frequency band used by AT&T in Iowa).
  - Accelerometer: 40μA in measurement mode.
  - Microcontroller: 15mA in running mode (5V, 16MHz).
- If all of parts are kept in sleep mode:
  - GPRS shield: no power consumption (disconnected).
  - Accelerometer: 0.1μA in standby mode.
  - Microcontroller: 1μA in sleep mode.



In general, the system can last for 3 days in a windy season without charging.

Energy Harvesting

- The energy for this system is collected by the solar film from daylight.
- The thickness of the solar film is 1mm with weather proof.
- The solar film has a dimension of 270mm×175mm, and a 7.2V, 200mA output in standard operation.

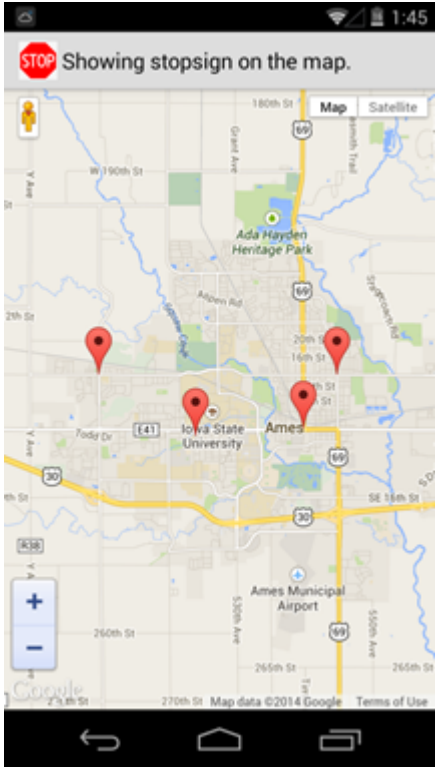
App Communication

Text message notification:

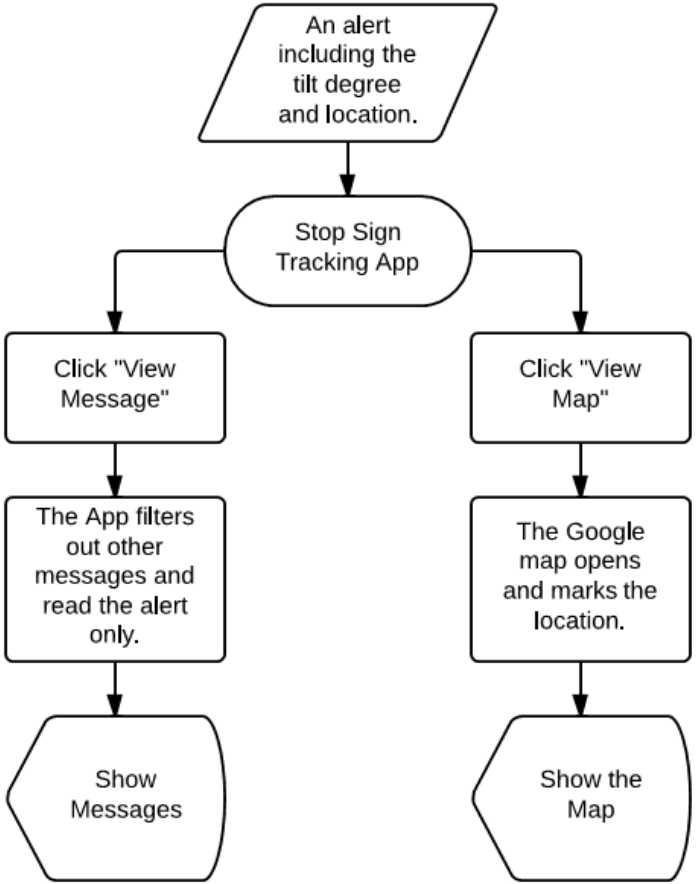
Before the product is installed, each GSM module will be programmed with specific information including location of each devices. Then, the clients' phones will be notified by a text alarm that contains location of the stop sign once stop signs tilted.

Android application interface:

An android application was made as the user interface. It views all alerts received by our client's cell phone. It will filter all alerts messages in cell phone's inbox. It can also show all issued stop signs on Google map at the same time, which is convenient to monitor the status of stop signs and collect data from cell phone.



User Side: Cellphone Software Design



Design Challenges

- Obtaining location area code and cell id.
- Reliable wind testing to establish reasonable values to use for our adaptive duty cycle.
- We tried to use server to store all data of stop sign. But it is hard to understand and implement to transfer data between android side and server side due to lack of related knowledge. It cost a lot of time to research it and we used an alternative way to store data, which is to store on SD card of a cell phone.

Test Plan

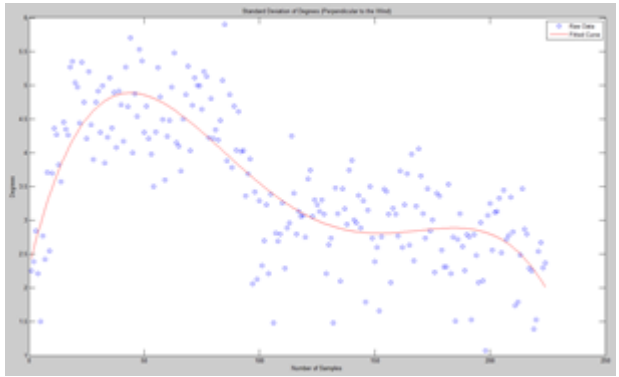
- Moisture Resistance Test:
  - place paper in enclosure
  - place enclosure under shower
- Vibration/Shock Test:
  - low speed wind tunnel at various speeds and angles.
- Cell Signal Reliability Test:
  - issue AT+CSQ command returns RSSI (dBm value)
- Power Generation Test:
  - measure solar cell output in different sun conditions at different angles
- Battery Lifetime Test:
  - determine time takes to kill battery under max loading and min loading conditions

Test Results

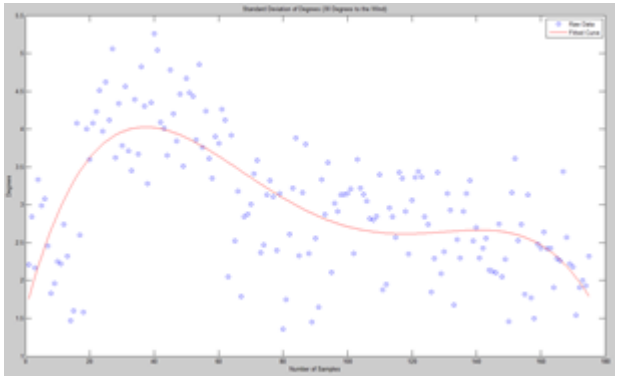
- Cell Signal Reliability Test:
  - Testing occur throughout central Iowa
  - All signals received are reliable
- Power Generation Test:
  - Results match the expected values from the datasheet.
- Vibration/Shock Test:
  - We were granted access to the wind tunnels, tested wind speeds of 10 mph, 20 mph, and 30 mphs at various angles data is on the next slide
- Moisture Resistance Test:
  - Control water flow test over the enclosure
  - left enclosure in the pouring rain results the enclosure was waterproof

Wind Test

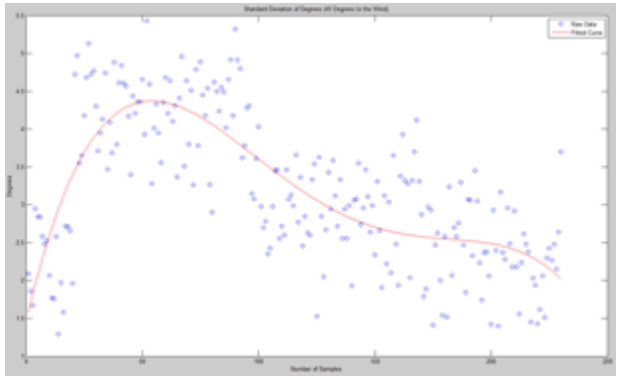
0 degrees



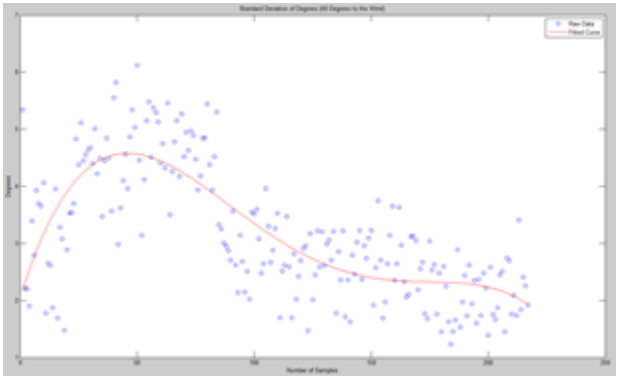
30 degrees



45 degrees



60 degrees



Budget

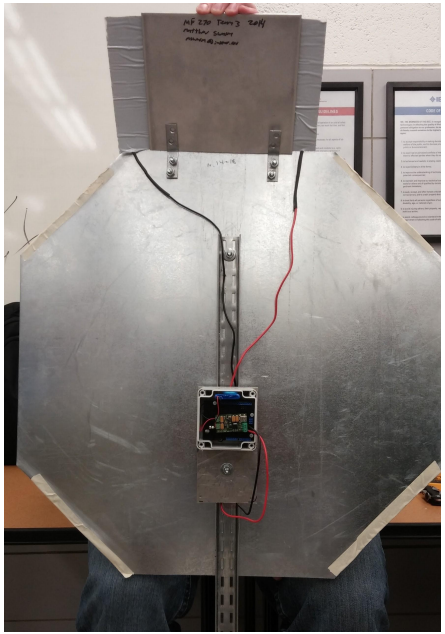
Project Cost

- Solar panel - $25.00
- Nema enclosure - $30.77
- GPRS Shield V2.0 (SIM900) -GSM - $59.90
- ADXL345 module - $27.95
- Arduino Pro 328 (ATmega328) - $14.95
- 5V Regulator/Charger Module w Li-Ion Battery - $50.00
- Sim card using a prepaid AT&T plan -$9.88
    - AT&T Plan 200 text - $4.99

Total = $223.44

Prototype

Inside of the enclosure



Stop sign Prototype

Demo

https://www.youtube.com/watch?v=BSYHVFoKs80&feature=youtu.be