EE491 Senior Design I
Stop Sign Tracking System
Project Plan

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I. Introduction

Abstract

An automated system to track missing stop signs or other important warning signs (such as those related to containment areas or hazardous materials) deemed non-functional by weather related causes or vandalism. Real-time monitoring of road and warning signs can significantly contribute to the overall safety of transportation and other utilities and save money and maintenance time by eliminating the need for visual inspection.

The goals of this project are:

1. Develop a sensor-based (e.g., use of MEMS magnetic compass and an accelerometer to detect the rotation of the stop sign and the static tilt of the sign) tracking/monitoring prototype system that locates the whereabouts of critical warning/stop sign or damage sustained by a warning sign.

2. Develop a prototype wireless communications system in relation to goal #1 to communicate that information back to a central location (e.g., the Department of Transportation office).

Design constraints include delivering energy/power for the developed prototype, especially in remote locations, robust packaging to function in harsh environments, RFID signal interference with metal, etc.

Purpose

The purpose of our senior design team is to develop a Critical STOP Sign Tracking and Monitoring Prototype System.

The device will be data dependent so the sensor alerts us to the STOP signs status if it exceeds the tilt threshold. We are designing the device to have tilt threshold of 15 degrees. Once the sign tilt becomes greater than 15 degrees an alert will be sent out. Alerts will be event driven and only be sent out if an event occurs. The alert will be sent over a wireless communication to mobile devices.

We expect a life cycle for 10 years. The design will withstand the Iowa weather throughout the year.

II. Requirements

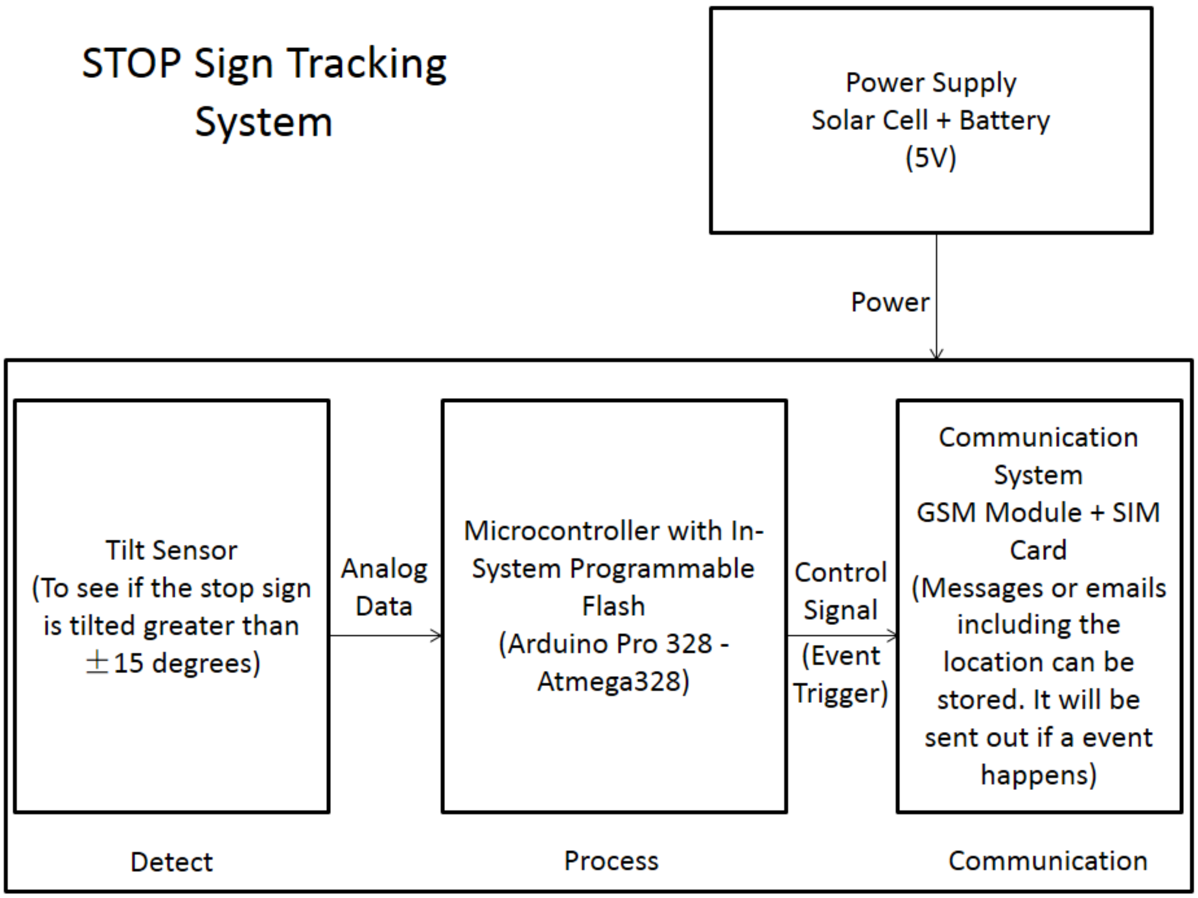
Functional Requirements

1. Tilt threshold: Once the sign tilt becomes greater than ±15 degrees, an alert should be sent out.
2. Send Alerts: Alerts should be event driven and only a message is sent out if an event occurs. Events are something that is being monitored that will render the sign non-functional or an incoming request for information from the user. The sensors should specifically figure out what rendered the STOP sign non-functional.
3. Wireless Communication: Communication to mobile devices should be wireless to keep cost low and easy to use.
4. Self-Calibrate: System should calibrate itself to reduce maintenance and installation time.
5. False-Positives: 10% of alerts can be false-positive alerts (alert sent out that sign broke constraints but constraints weren't actually broken).
6. False-Negatives: No false-negatives are allowed (No alert sent out even though constraints were broken).
7. Power Supply: System (the battery) should be supplied 5V. Some of which will be used to directly supply system and the rest to be used to charge a rechargeable battery.
8. Tracking: Should be able to locate the sign from the signal.

Non-functional Requirements

1. Size: The package shouldn't be larger than 20% of the hardware being used.
2. Package: The system should be packaged within NEMA enclosure that is weather resistant.
3. Weather Resistant: The package should operate in through
    - -temperatures from -22 F to 120 F;
    - -water-proof (rain, snow, fog…);
    - -wind resistant: should stay attached to sign under strong wind (~60MPH).
4. Cost-effective: The price for the package should be no more than $155.
5. Easy to Install: Installation onto stop sign should be no more than 10 minutes.
6. Lifetime: System should be able to sustain itself for 10 years.

III. Design Sketch



IV. Risks

Technical Risks

Risk	Probability of Going Wrong	Criticality (0 - 100)	Risk Factor	Mitigation Strategy
GSM module may not send the message if the signal is bad.	10%	95	95 * 0.1 = 9.5	To mitigate the issue, we will do our best to find a best carrier to be used in GSM module.
The solar system may not	20%	80	80 *	We will test the solar system to

supply enough energy to whole package.			0.2 = 16	find a best suitable one to supply power in our package.
Micro Controller may not handle the computation from the sensor	5%	100	100 * 0.05 = 5	We will test the microcontroller to find a most suitable for compute all data.

Organizational Risks

Risk	Probability of Going Wrong	Criticality (0 - 100)	Risk Factor	Mitigation Strategy
The whole package may cost over our budget.	25%	60	0.25 * 60 = 15	Setting up a realistic budget from the start with extra wiggle room is the key. We will decide a cheapest combination of all components to test. If it doesn't work, we will try second cheap component.
There is not enough knowledge on programming the microcontroller and sensors connection	10%	30	0.1 * 30 = 3	We are going to do some researches and find some tutorials. Also we will ask Dr. Daji for more coming problems.

V. User Interface

The software should make sure that once the module is installed and powered on for the first time, the system is expected to self-calibrate and the tilt sensor should keep checking the angle between the stop sign and horizontal ground. The sensor will transmit the data to the microcontroller, which determines if the tilt has reached a pre-determined tilt threshold of ±15 degrees. Once the data reaches or exceeds this threshold, the microcontroller is going to control the GSM module to send a text message to certain clients' cellphones to tell them what happened to the stop sign and where it is.

Before the product is installed, we will program for each GSM module to be able to send specific information including the location of each device with stop sign. In addition to this we can determine the location of the device once it is installed using a set of AT commands that will return the latitude and longitude coordinates of the GSM module. Besides, we can also edit more information such as strength of wind and temperature. Then the clients' phones will be notified by a text alarm that contains location of the stop sign.

Another way for clients to check the status of a stop sign is that they can send a text message with a certain command to a GSM module. Once the GSM module receives the message, it will transmit the data to the microcontroller. After that, the microcontroller will check the tilt sensor for collecting angle information, and then will control the GSM module to send the status to clients.

VI. Cost Estimate

The estimate cost of this project is $154.18 this does not include shipping fees and taxes. All parts are being shipped from US distributors and will arrive within 8 to 14 days. This project is still within the price range of a stop sign. The average cost per sign is $300 this includes material, maintenance and installation. The cost of the project is half of the price of installing a stop sign but would reduce maintenance fees dramatically. This device will not be place at every stop signs but critical stop signs points where there is high levels of traffic or missing/crooked stop signs.

Part List

1) Solar panel 5V- $20

2) Lithium ion battery rechargeable - $3

3) GPRS Shield V2.0 (SIM900) -GSM - $59.90

Product Code: SLD01098P

http://www.epictinker.com/GPRS-Shield-V2-0-p/sld01098p.htm

4) Triple Axis Accelerometer Breakout - ADXL345- $27.95

https://www.sparkfun.com/products/9836

5) Arduino Pro 328 (ATmega328) - $14.95

https://www.sparkfun.com/products/10915

6) Sim card and Plan $10 at $.20 per text using a pre-paid AT&T plan -$9.88

Model No.: 40950

Walmart No.: 551683177

http://www.walmart.com/ip/AT-T-GoPhone-Sim-Card/22700044

7) Nema enclosure box type -$18.50

http://www.automationdirect.com/adc/Shopping/Catalog/Enclosures/Metal/NEMA_3R/Screw_Cover_Wall_Mount/RSC040404

NEMA Type	Definition
1	General-purpose. Protects against dust, light, and indirect splashing but is not dust-tight; primarily prevents contact with live parts; used indoors and under normal atmospheric conditions.
2	Drip-tight. Similar to Type 1 but with addition of drip shields; used where condensation may be severe (as in cooling and laundry rooms).
3, 3S, 3X	Weather-resistant. Protects against weather hazards such as rain and sleet; used outdoors on ship docks, in construction work, and in tunnels and subways. 3X includes corrosions.
3R	Intended for outdoor use. Provides a degree of protection against falling rain and ice formation. Meets rod entry, rain, external icing, and rust-resistance design tests.
4 and 4X	Watertight (weatherproof). Must exclude at least 65 GPM of water from 1-in. nozzle delivered from a distance not less than 10 ft for 5 min. Used outdoors on ship docks, in dairies, and in breweries. The 4X model has corrosion resistance.
5	Dust-tight. Provided with gaskets or equivalent to exclude dust; used in steel mills and cement plants.
6 and	Submersible. Design depends on specified conditions of pressure and time;

6P	submersible in water or oil; used in quarries, mines, and manholes.
7	Hazardous. For indoor use in Class I, Groups A, B, C, and D environments as defined in the NEC.
8	Hazardous. For indoor and outdoor use in locations classified as Class I, Groups A, B, C, and D as defined in the NEC.
9	Hazardous. For indoor and outdoor use in locations classified as Class II, Groups E, F, or G as defined in the NEC.
10	MSHA. Meets the requirements of the Mine Safety and Health Administration, 30 CFR Part 18 (1978).
11	General-purpose. Protects against the corrosive effects of liquids and gases. Meets drip and corrosion-resistance tests.
12 and 12K	General-purpose. Intended for indoor use, provides some protection against dust, falling dirt, and dripping noncorrosive liquids. Meets drip, dust, and rust resistance tests.
13	General-purpose. Primarily used to provide protection against dust, spraying of water and noncorrosive coolants. Meets oil exclusion and rust resistance design tests.

VII. Operating Environment

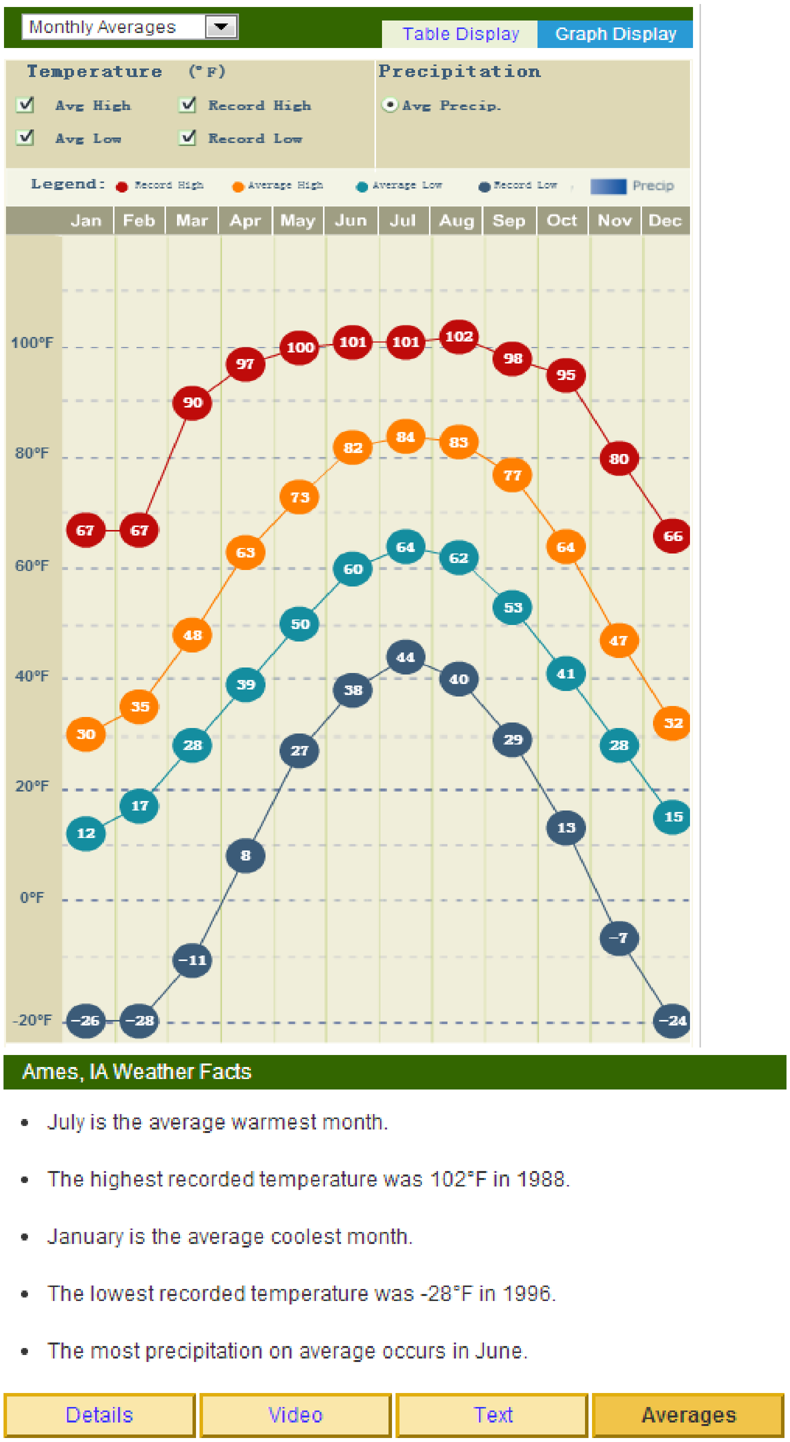
At what conditions we are going to use it:

The weather in Iowa is very volatile. Therefore we design the system to be able to withstand winds, rain, snow, and other severe storms. These volatile conditions are what we typically cause traffic signs to become non-functional.

Where: (High Traffic Intersections)

We are going to install our product on the stop signs at each high traffic intersections that are controlled by stop signs. First of all, a lot of vehicles go through the intersections every day, there must be stop signs to control the traffic. Once stop signs disappear, it will be a disaster. Secondly, if there is a car accident, it may damage some stop signs. The Transportation department is responsible for performing maintenance in a timely manner so that the accident will not influence other coming vehicles.

We also need to consider the nature situation. First is the temperature. The narrowest temperature range is GSM module, -22 Fahrenheit to 176 Fahrenheit.



Here is Des Moines temperature history. Because Des Moines locates in the middle of Iowa, it can represent an appropriate temperature range in Iowa. As we can see, in the past 25 years, the lowest temperature is -28 Fahrenheit and the highest temperature is 102 Fahrenheit. This range is acceptable, which is from -22 Fahrenheit to 176 Fahrenheit.

We are also going to use NEMA enclosure box type to contain our devices inside. It can protect our product against the various weather elements. We will test this enclosure with our system to verify that the system will operate in the expected conditions that it will be used.

VIII. Calendar

Week Ending In:

September 15: Discussed the project with our client to establish a common vision of what the project was to accomplish.

September 23: Define functional and non-functional requirements and met with our advisor for the first time.

September 30: Research key areas to be put into project plan. This included potential design solutions, design flow/sketch and calendar.

October 7: Continue research to develop a list of potential options. Discuss with different professors for other possibilities.

October 13: Presented project plan to advisor. Performed more focused research and parts that we deemed the best option for the project so we could explain why it was the best option.

October 20: Present and discuss different possible solutions with our advisor and choose the best option.

October 27: Research each component that we decided would provide the best solution. This included finding the best supplier for each component and researching how they would each component would interface with each other.

November 4: Outline what needs to be done for the design document. Develop initial parts list of what we would like to order.

November 8: Finish design document. This included developing a CAD drawing, discussing how the end user would use our product, developing potential testing strategies, and writing pseudo code. In addition to completing the design document we finalized our parts list.

November 17: Revise product plan document to include market research and to reformat the document. Place parts order. Plan meeting with December 492 group.

November 24: Receive parts for communication system and begin testing with communication system. Form to-do list for thanksgiving break and divide tasks.

December 1: Work on tasks given for thanksgiving break.

December 8: Finalize working prototype of communications system and prepare a presentation.

December 15: Give final presentation. Discuss goals for winter break and outlook of spring semester.

December 22: Winter Break

January 19: Discuss plan for spring semester and refresh where we left off.

January 26: Research power supply system (renewable energy, energy storage, charging circuit). Tilt testing accuracy/reliability.

February 2: Continued Power Supply Research. Make changes to communication system as test results come back. Start temperature testing.

February 9: Finalize power supply design and order parts. Test NEMA enclosure for water resistance. Test mounting hardware for wind/vibration.

February 16: Receive parts. Build power system.

February 23: Begin testing power system longevity if system is built and consistently working.

March 2: Test weather resistance of solar cell. Begin putting all pieces together into final design.

March 9: Make alterations and finalize design.

March 16: Finish working prototype. Begin Documentation.

March 23: SPRING BREAK (The Last One)

March 30: Continue to draft outline for poster, presentation, and other documentation. Test final prototype for good measure.

April 6: Put together first draft of materials to be put on poster and presentation. Real world prototype testing.

April 13: Revise documentation.

April 20: Finalize Documentation.

April 27: Practice presentation. Print and organize other documentation.

May 3: Presentations.

IX. Market Research

Upon surveying the current market for existing solutions to our problem it can be said that our project is one of a kind. There are products on the market that may have a few similar functions as what our project will but nothing that will alert users when a traffic sign becomes non-functional. The closest solution that currently exists is Ayantra's FleetSignal product. Their product uses a GSM module as well to track and monitor the activity of the desired asset. The end user of this product is able to interact with the system through a designated website as well as a personal cell phone. They are able to see the activity logs of the system and send commands to the system. The one thing this system is lacking that we need is the accelerometer. While you can track the position of a sign using GSM Module, the system is accurate to 22m. If a traffic sign simply falls over the location wouldn't change enough to determine that the sign has fallen over. The accelerometer provides us with that accuracy.
http://www.ayantra.com/mobile-road-sign-management.html

Other similar products that are readily available are high visibility traffic signs that have blinking LED's around the outside. The only similarity between these products and ours is the renewable energy harvesting that is used to power the LED's. Most of these traffic sign systems are powered by solar power with a rechargeable backup battery. The average lifetime of these systems appears to be about 3-5 years.
http://www.tapconet.com/solar-led-division/flashing-led-stop-sign-blinkerstop
http://www.xwalk.com/pages/TS40-R1-1-Stop.htm

X. Deliverables

Fall 2013 Semester -Communication Application

1) The GSM module with Sim Card will send out a text to alert the user of the condition of the stop sign it will also receive a text from the user requesting the status of the stop sign.
2) The Accelerometer will monitor and report the tilt of the Stop sign in the text.
Tilt threshold: Once the sign tilt becomes greater than 15 degrees an alert will be sent out.
· Send Alerts: Alerts will be event driven and only a message is sent out if an event occurs or if the user request for information.

- Self-Calibrate: System should calibrate itself to reduce maintenance and installation time.
- False-Positives: 10% of alerts can be false-positive alerts (alert sent out that sign broke constraints but constraints weren't actually broken).
- False-Negatives: No false-negatives are allowed (alert sent out that sign broke constraints but constraints weren't actually broken).
- Data dependent: The sensor should specifically figure out what happens to the STOP sign (whether it is covered by snow, or broken, or others).

Spring 2014 Semester -Power Supply

The solar panel will power the ardunino and recharge the battery. At night the battery will recharge the device throughout the night.