Development of a Smart Sensing System for Road Performance Data Collection

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Project Vision

- Road roughness monitoring device

- Road maintenance depends on data collected about road quality

- Iowa Department of Transportation (DOT) vehicles drive Iowa roads

- Enabling DOT vehicles to cheaply collect data about road roughness

- Live, periodic data for long-term analysis

Project Vision – IRI

- International Roughness Index (IRI)
  - Widely adopted model
- Quarter-car model
  - Single tire model represents entire system
- Golden Car
  - Ratio of constants estimating typical vehicle
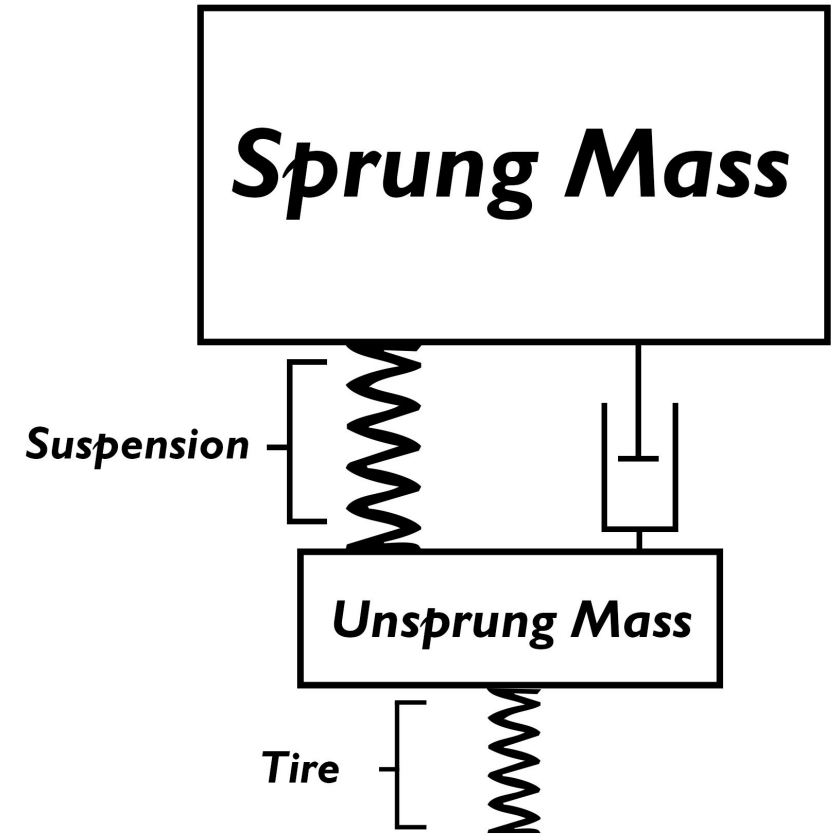
Conceptual Need

- Target clientele: Iowa DOT maintenance analysts

- Affordability

- Reliability

- Standardized roughness model

- Scalable
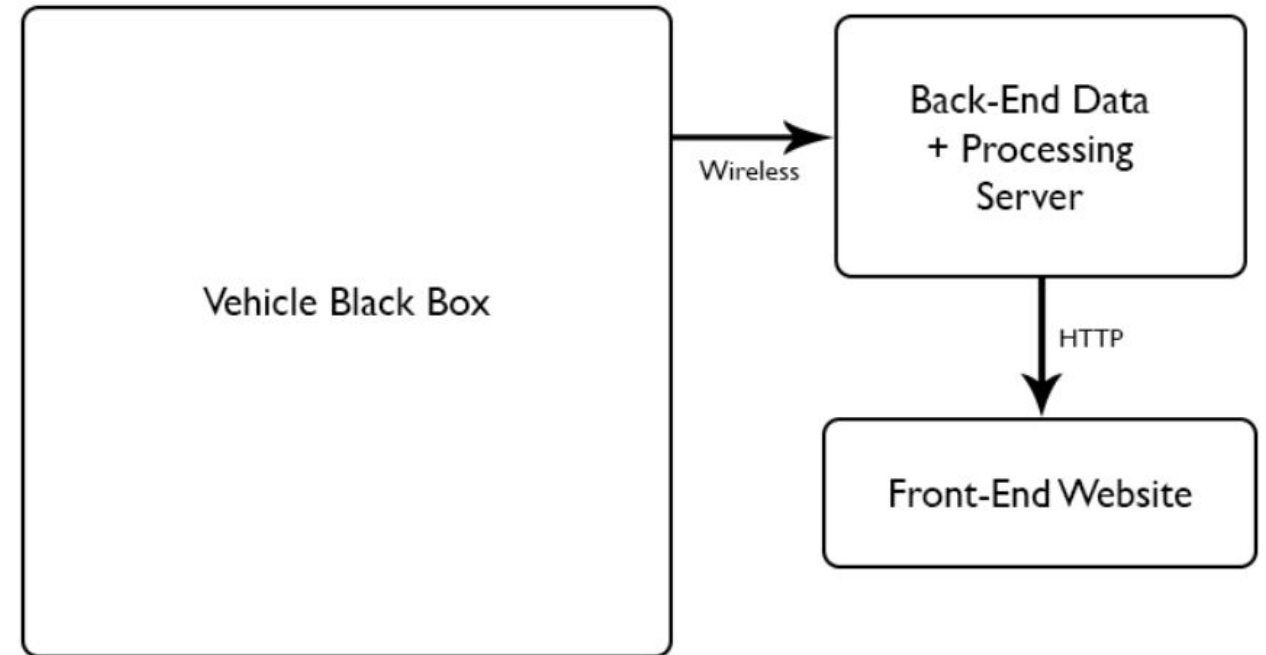
Visual Sketch – Website Goal

Requirements – Functional

- Device should collect accurate data
  - GPS data
  - Accelerometer data
- Communicate with the server
  - GSM module
- Proper data handling
  - Server

Requirements – Non–Functional

- Reasonable cost (~$100)

- Minimal user interaction

- Weather resistance

- Rugged design

Project Plan for Connected Components

- Ensure individual components are working

- Connect all components together

- Implement data sampling rate (Accelerometer, GPS)

- Implement local data storage

Project Plan for Wireless Components

- Enable data transmission to server

- Implement database for incoming/outgoing data

- Implement IRI calculation using server

- Consider client application

Risks for Proposed Plan

- Technical Risk
  - Component communication issues
  - Speed and coverage consistency
  - Integration issues with public APIs
- Cost Risk
  - Scaling cost
- Scheduling Risk
  - Milestones subject to roadblocks
- Sustainability Risk
  - 2G network support ending

Risk Management

- Technical Risk
  - Reliable hardware
  - Reproducible behavior
- Cost Risk
  - Proper documentation
- Scheduling Risk
  - Work with stakeholders to overcome hurdles
- Sustainability Risk
  - GSM device should be modular

System Design (Overview)

- Black Box enclosure
  - Microcontroller
    - Accelerometer
    - GPS
    - GSM
    - Removable storage
- Data server
- Client application

System Design (Arduino)

- Microcontroller capabilities
- Factors in microcontroller selection
  - Power Consumption
  - Pin availability
  - IO availability
  - Processing power
  - Available Software Libraries
- Versus alternatives
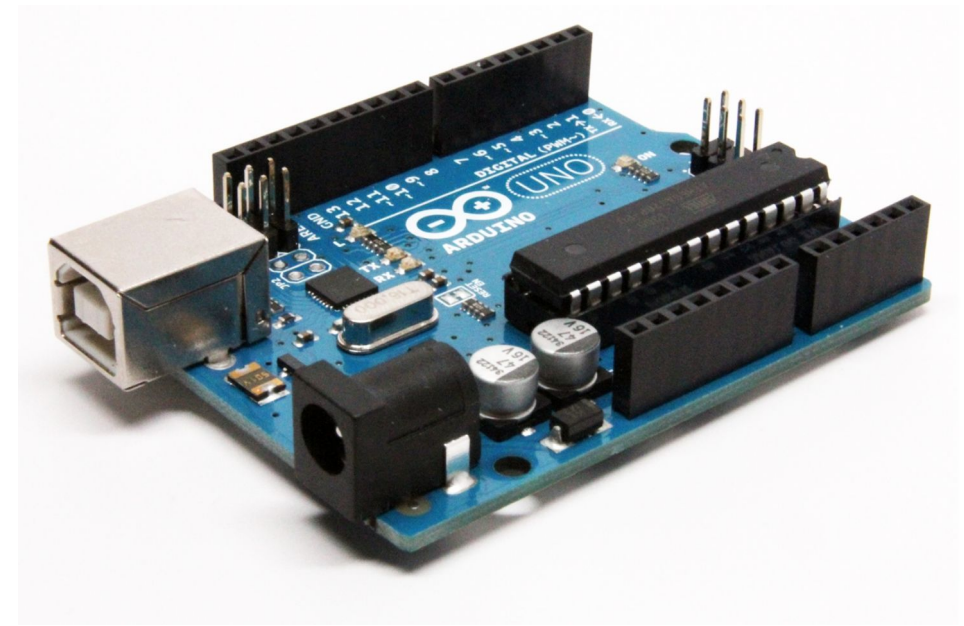
System Design (Sensors)

- Accelerometer
  - Resolution
- GPS/GSM
  - Power consumption
  - Accuracy
  - Speed
- Removable storage
  - Transfer speed
  - Size
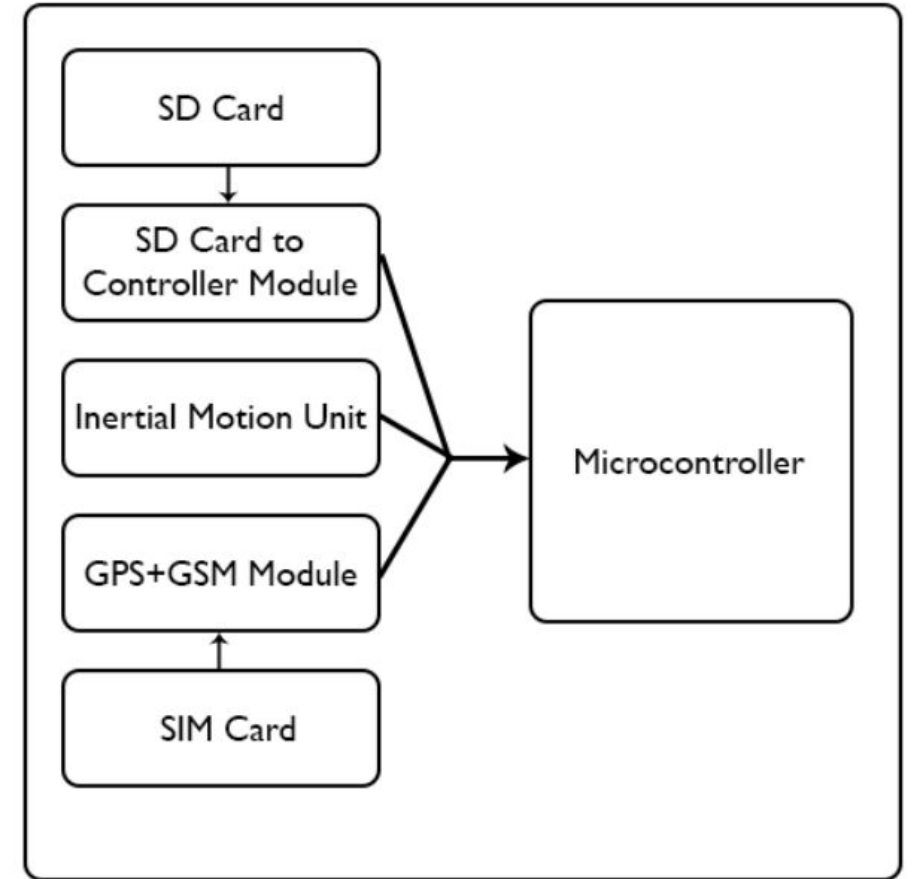
Black Box

System Design (Back-End)

- Data transport
  - HTTP calls via GPRS
- Back-end data handling
  - Azure Web Server running Apache
  - Retrieval
    - Code to store data from HTTP
  - Parsing to data tables
    - Javascript, SQL
  - IRI calculation versus GPS location
  - Store data for front-end retrieval

System Design (Front-End)

- Front-end data retrieval
  - Requests from back-end database
- Front-end data display
  - OpenLayers mapping API
  - Color coded regions over measured roads + legend
  - Interactive regions to show IRI

Test Plan

- System Tests:
  - Rigor testing
  - GPS and Accelerometer versus phone measurements
  - GPRS ping server
  - SD card file creation & transfer speed
  - HTTP Post from GPRS
- Unit Tests:
  - Truck data
  - PhD work data comparison with calculated IRI values

Test Plan – Integration Tests

- Four phases
  - Hardware modules on Arduino
  - Embedded code on Arduino
  - Back-end server
  - Front-end mapping application: webdriver

Project Plan – Milestones

- Milestone 1
    - Assembled Arduino

- Milestone 2
    - Working IRI Calculation

- Milestone 3
    - Automated web server

- Milestone 4
    - A user interface

Conclusions

- Currently testing components

- Next semester: Assembly, prototyping, software, testing

- Contributions
    - Shlok Singh -- Research, Hardware
    - Ethan Young -- Research, Software
    - Victor Guerra -- Research, Physics
    - Michael Petersen -- Research, Data Processing

References

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