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The Commonwealth's Flagship Campus

Smart Wiper Toolkit

Midway Design Review

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Team 22: Smart Wiper Toolkit

Chris Pandiscio

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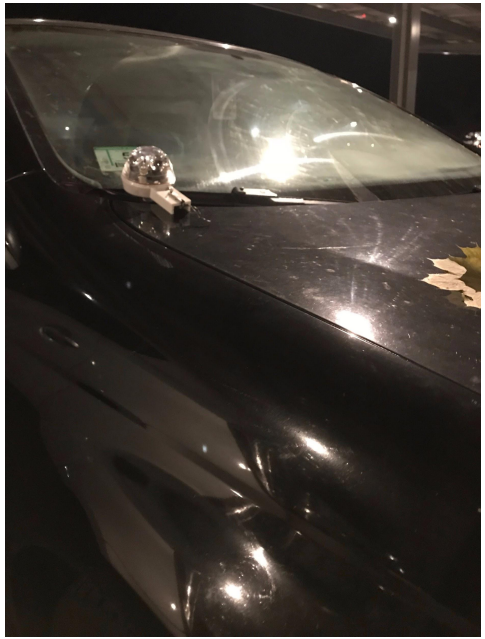
Problem

Driving a car is a scenario where concentration is of vital importance. Ironically, driving a car is also a task that is filled with distractions. Controlling the windshield wipers is one of those distractions. In New England, where precipitation can be quite a nuisance, an automated wiper control would be of great benefit to the driver.

Proposed Product

Create a kit that…

1. Automates windshield wipers for Jetta 2006
2. Can be easily assembled
3. Looks attractive

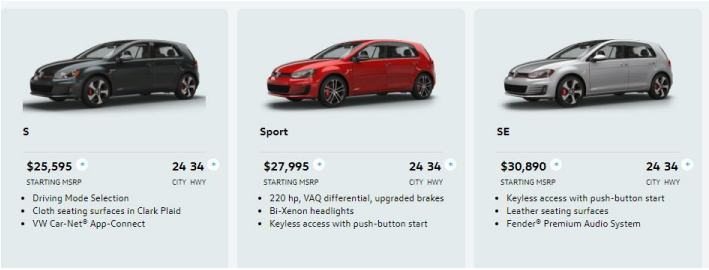


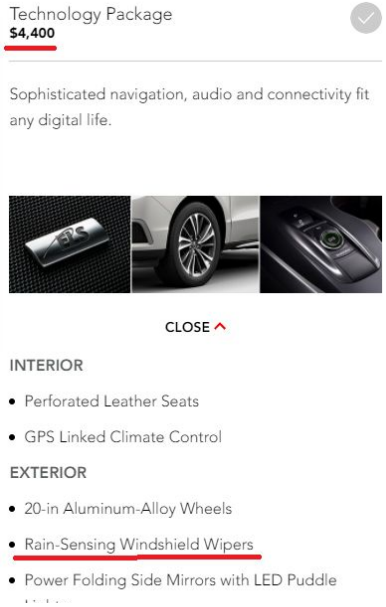
Existing Solutions

Car Companies

1. **Volkswagen Golf (our targeted brand)**
   a. Only available on the SE trim
   b. $3000 more than the trim below
   c. $5000 more than the base sport trim

2. **Acura:**
   a. Feature available in Technology Package
   b. Cost of package is more than $4400





Design Alternatives: Firmware Modification

- OBD stands for On-Board Diagnostic and is installed in most modern cars
- Interact with system bus to read system info and write to system firmware.
- Writing in unauthorized and will break warranty
- Doesn’t exist on older cars
- Exact protocol is not published

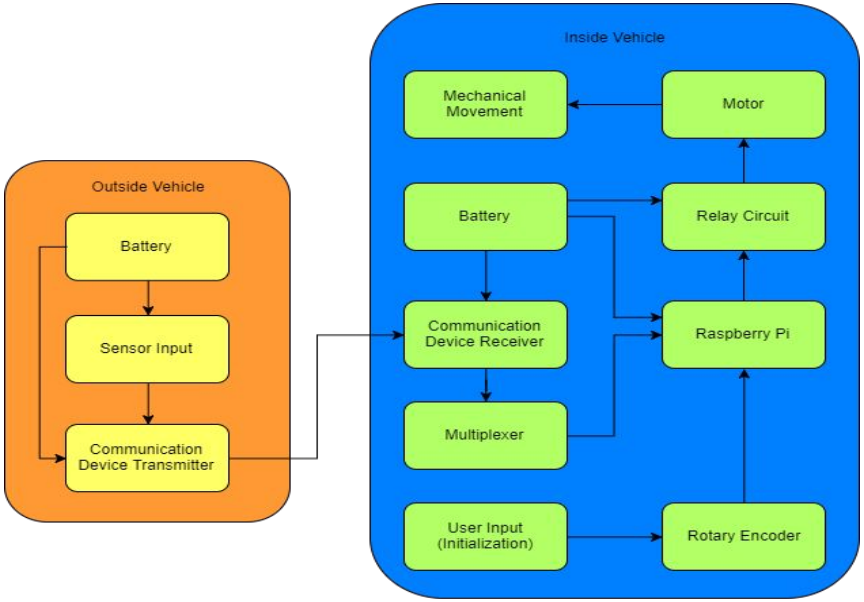
Revised Project Specifications

1. Can be installed in a 2006 Volkswagen Jetta
2. Takes less than thirty minutes for car owner to set up
3. Automates wiper controls based on frequency of rain hitting windshield***
4. Incorporates standard wiper settings (Off, Intermittent, Medium, Fast)

***Will come to later

Original Design Solution

1. Three Rain Sensors
   a. Placed on outside of car, bottom of windshield
   b. Each detect different amount of rainfall (inches per hour)
2. IR Communication
   a. Send rain signals from outside to inside of windshield
   b. Place on top corner of windshield
   c. Interprets three rain signals and sends state signal to raspberry pi
3. Raspberry Pi
   a. Interprets state signal
   b. Sends motor commands
   c. Interprets rotary data
4. Motor + Mechanical Components
   a. Moves an arm attached to the windshield lever and motor to change wiper settings
5. Rotary Encoder
   a. Used to align motor arm movements with motor lever

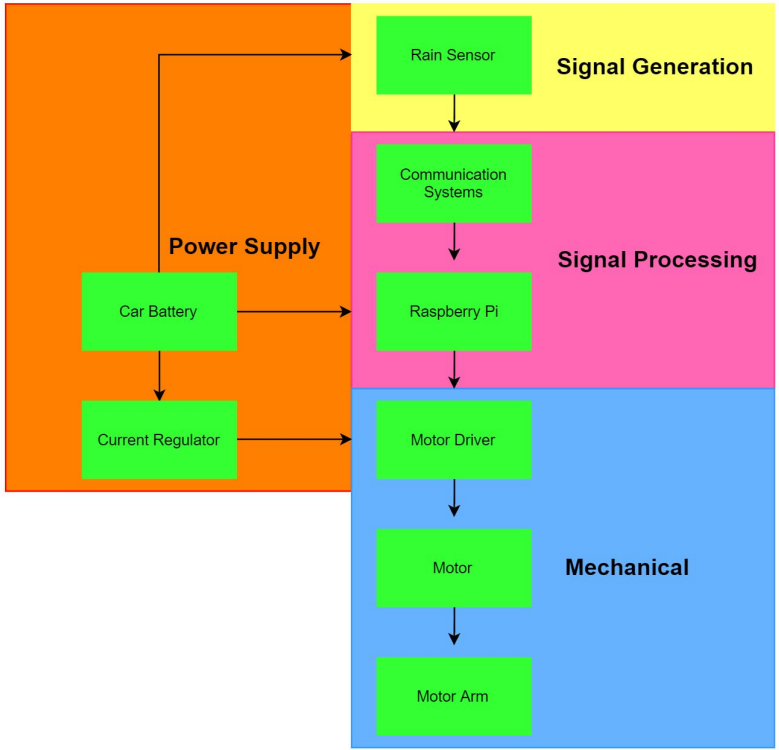


Problems with Original Design

1. Confusing
2. Unnecessary parts in design
3. Stand-alone battery awkward
4. Expensive (~$275)

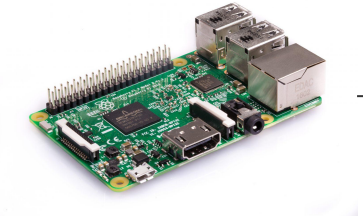
Revised Design Solution

1. Simplified System
2. Whole design hooked up to car battery
3. One Rain Sensor instead of three
4. Hardwired Connection for Rain Sensor to Pi
   a. Involves voltage divider
5. No Rotary Encoder
6. Motor Driver now includes current regulator



Overall System Diagram

Collect Data



Receive Data
Process Data
Decision Making
Output: motor control signal

Magnifies output of pi and sends to motor

Rotate based on Control

Revised Parts List

1.	RG-11 Sensors	$49
2.	Raspberry Pi Model 3b	$35
3.	MicroSD Card	$8
4.	Car Micro USB Charger	$7
5.	Stepper Motor	$13.95
6.	Motor Driver	<$3
7.	Current Regulator	$10
8.	Plastic Casing and arm	<$10
9.	Wiring + Passive Circuit Elements + PCB	<$1
Total		<$136.95

Potential Cost Reductions

1. Raspberry Pi 3 to Raspberry Pi Zero (-$30)
2. Less Powerful Stepper Motor (-$7)
3. Cheaper Sensor (-?)

Reduced Total: <$99.95

Rain Sensor (RG-11)

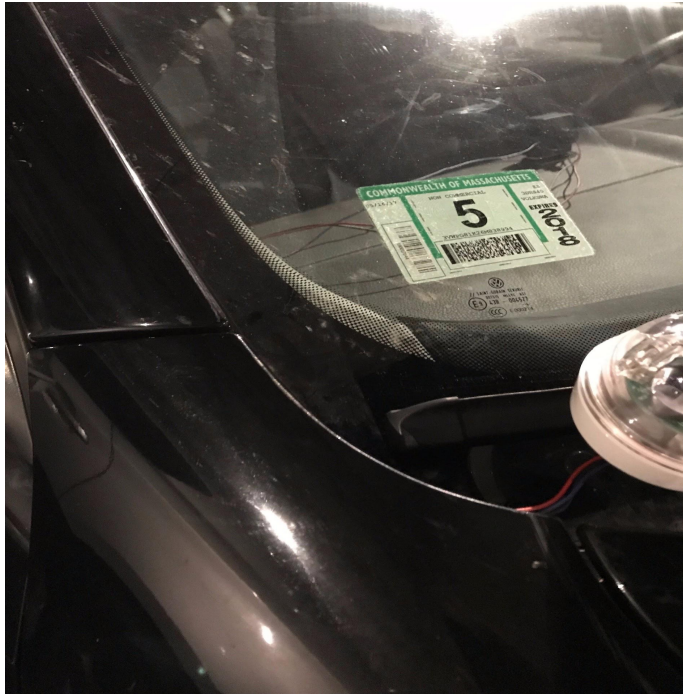
- Original Design called for three
  - Reduced to one
  - Configured for drop detection instead of amount of rainfall
- Mounted outside of the car
  - In between hood and windshield
- Accounts for ambient light and dirt
  - More reliable, more expensive
- Send out a 14V pulse when raindrops are detected
  - 100ms long
  - Limited to 5 pulses per second

Frequency of Rain?

Given 1” of rainfall per hour how many raindrops can one expect to hit the sensor?

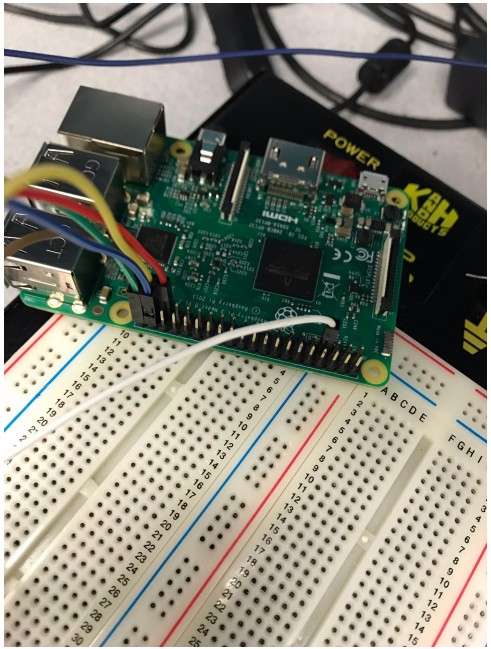
1. According to United States Geological Survey
   a. 1” of rainfall produces 0.6 gallons (138.6 in^3) of rain per ft^2
   b. For a raindrop to be considered a raindrop it must have a diameter of at least 1mm (0.039 in)
      i. Volume of raindrop = 2.485 10^(-4) in^3 (assume spherical)
2. Square size of sensor is 0.04 ft^2 (6cm x 6cm)
3. Using 1 and 2 can calculate:
   a. Total raindrops per square foot hour = 557746
   b. Total raindrops per square sensor area hour = 22310
4. Convert to useful measure
   a. Expect to get ~30 raindrops every 5 seconds for 1” rainfall per hour
5. Similar Calculations can be done for lighter rainfall
   a. Expect to get ~3 raindrops every 5 seconds for 0.1” rainfall per hour

Why Hardwire?



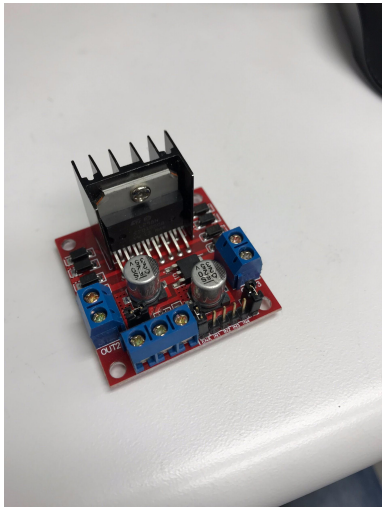
- Reliable
- Clean
- Easy

Raspberry Pi Model 3

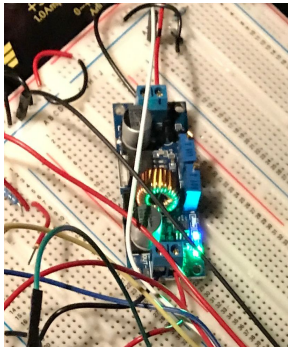


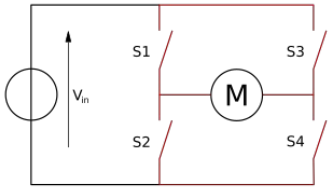
- Communicate through GPIO pins
- Takes in signal sent by the rain sensor
  - Translates signal into raindrops per second
  - Decides proper wiper state
- Remembers the current wiper state
- Control algorithm will be loaded automatically after power is connected
- Control motor by altering the combination of the four control pins
- All components are common grounded

Motor Driver + Current Regulator



Qunqi L298N



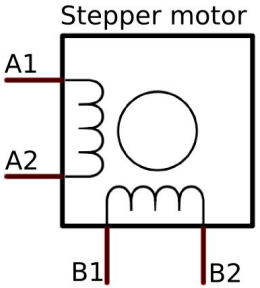


H-bridge schematic

- Bridge between low power computing unit and high power motor
- Outfitted with current regulator to insure proper motor operation
- Constant current of 1.2 A
- Drives a Bipolar stepper motor
- Direction of current is controlled by dual H-bridges based of GPIO signals from Raspberry Pi

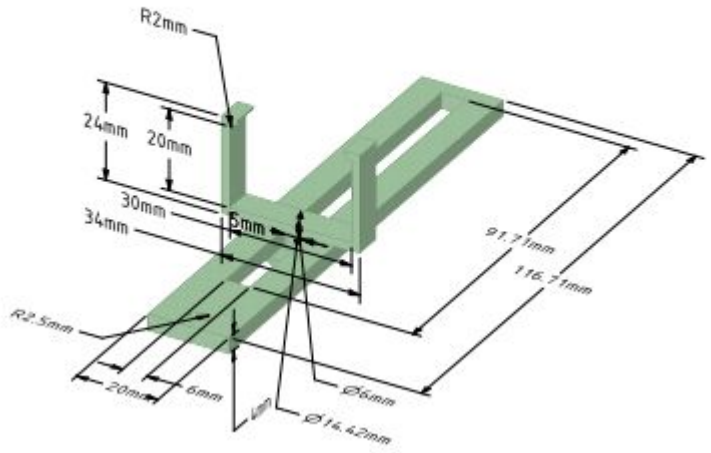
Stepper Motor

NEMA-17



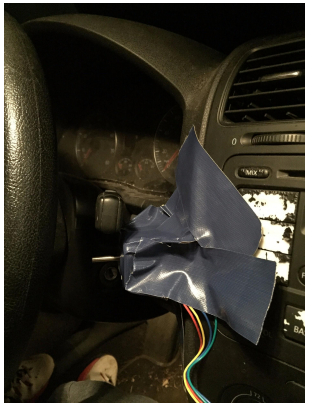
- Takes input from motor driver
- Connected to arm
- Able to move lever to two predetermined positions

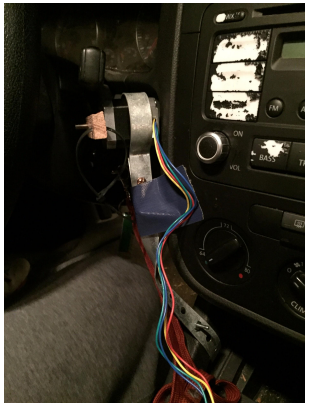
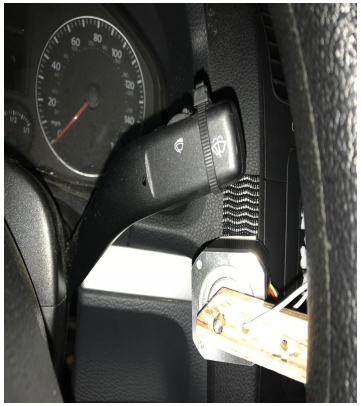
ARM 3D model



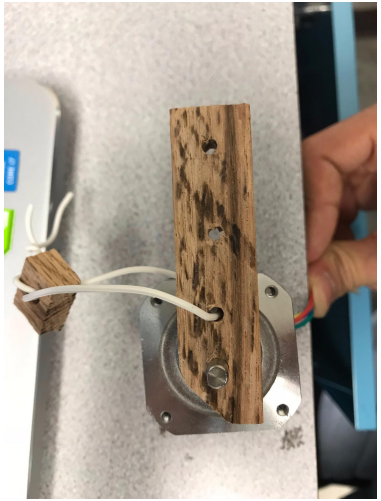
- Ring fine tuned for our specified car
- Easily detachable with new snap on design while maintaining a secure hold
- Rotatable Ring to avoid unnecessary torque on the arm
- Slidable design to compensate the increased distance as the setting goes up in preparation for our four setting final design

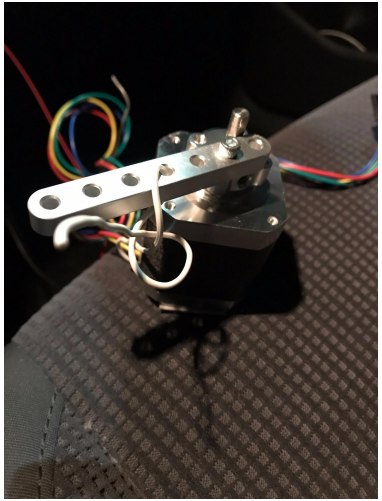
Stepper Motor (Mounting Progression)

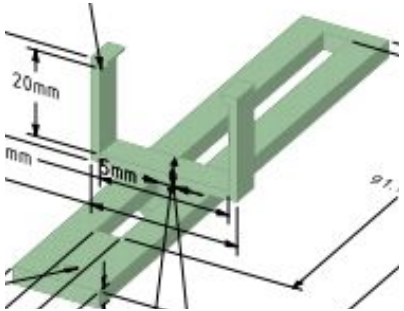



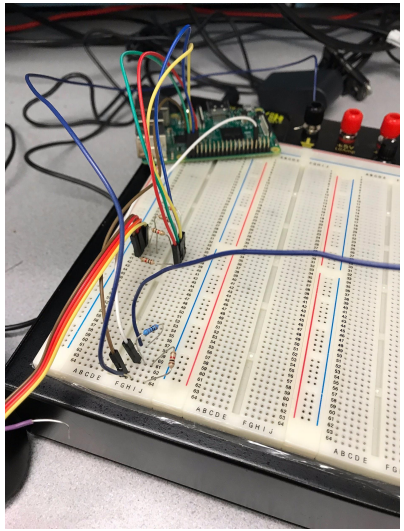
Motor Arm (Design Progression)

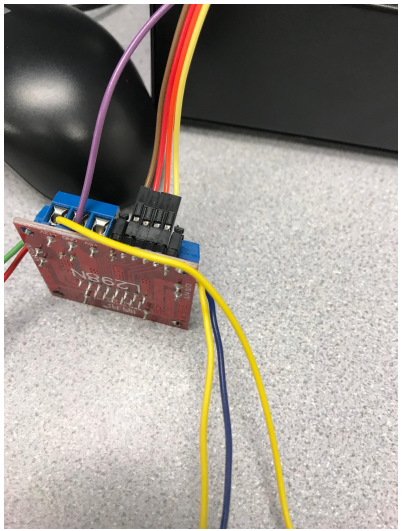


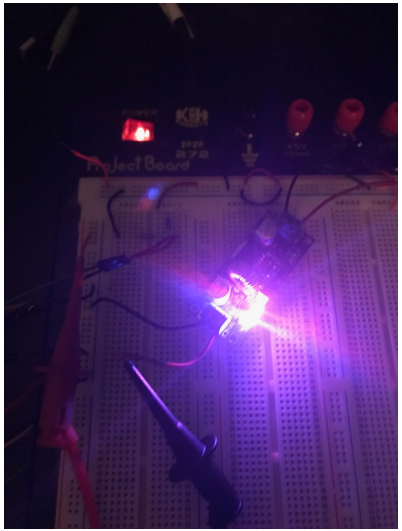


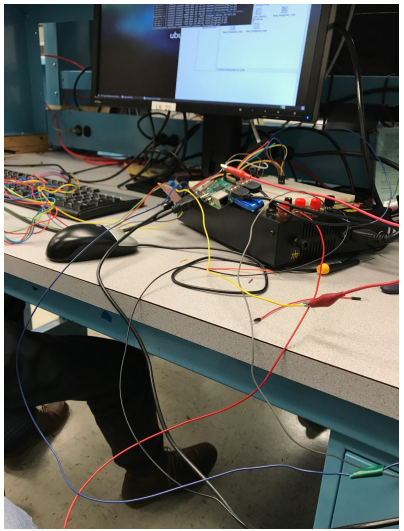


System Progression









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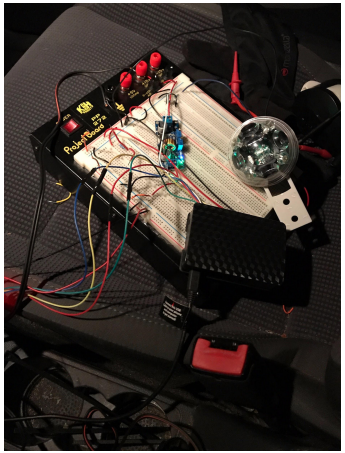
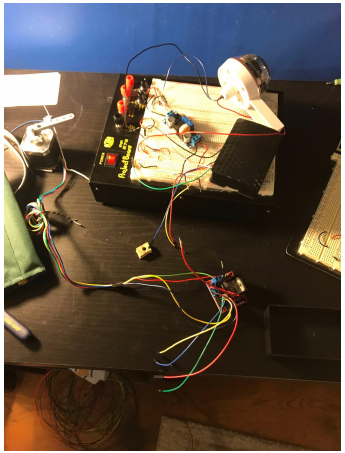
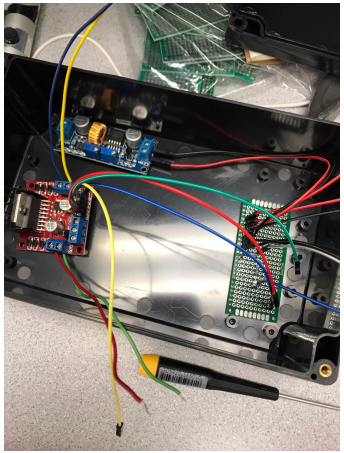
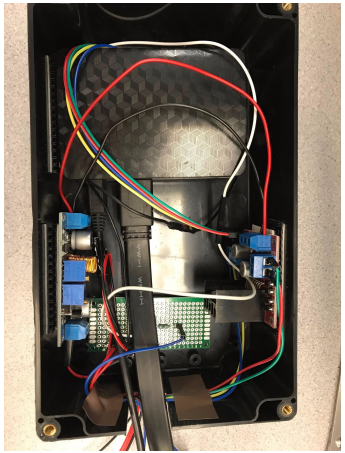
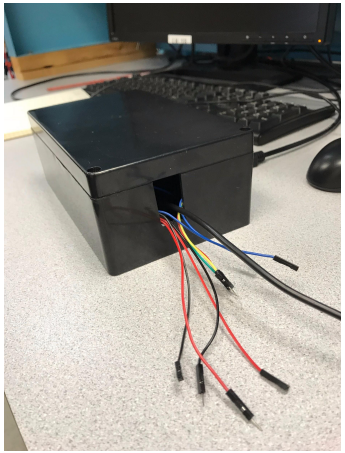






Design is Messy
-Prof. Hollot

MDR Deliverables (Overview)

1. Smart Windshield Wiper Kit can be installed on 2006 Jetta
2. Works for two settings (Wipers off, intermittent)

MDR Deliverables (Specifics)

1. Rain Sensor
    a. Enabled for drop detection
2. Communication System
    a. Voltage divider will be hardwired to Raspberry Pi
3. Raspberry Pi
    a. Interprets drop detection signal in a useful way for determining wiper states
    b. Makes decision about next state based on current sensor signal
        i. The states will be either no wiping or wiping
    c. Translates state decision into action for motor
        i. Finite state machine

MDR Deliverables (Specifics)

4. Stepper Motor
   a. Interfaced with a Raspberry Pi via a motor driver
   b. Able to rotate to a specific angle accurately and hold position indefinitely
   c. Able to return to original position

5. Motor Arm
   a. Connects to motor securely
   b. Attached to the lever

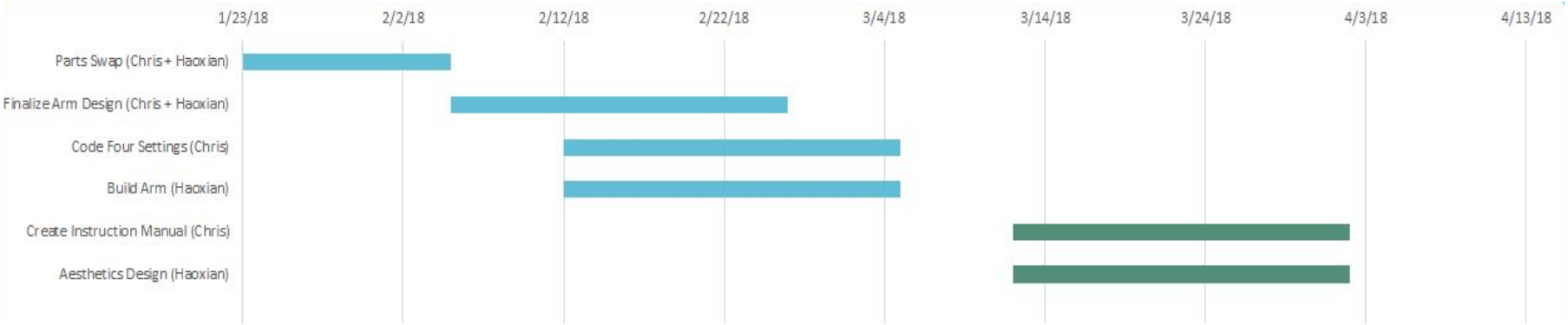
CDR Deliverables (Overview)

1. Smart Windshield Wiper Kit can be installed on Jetta 2006 quickly
2. Works for all four wiper settings (wipers off, slow, medium, fast)
3. As inexpensive as possible (Functionality takes precedence)

CDR Deliverables (Specifics)

- Motor Arm
  - Designed finalized
  - Hard plastic or metal
- Raspberry Pi
  - Interprets Rain Sensor Data for four settings
  - Adjusts motor according
- Reduce cost to under $110
- Can be installed in under thirty minutes by car owner

Semester II Timeline



Team Responsibilities

Chris:

1. Sensor Implementation
2. Wood/Metal Motor Arm Design
3. Subsystem Merging
4. Sensor-Pi Coding
5. Motor-Pi Coding
6. Enclosure Design
7. Electronics Error Testing
8. Code Error Testing
9. Motor-Car Implementation
10. Scheduling/Project Manager

Haoxian:

1. 3D Arm Design
2. 3D Arm Printing
3. Subsystem Merging
4. Motor-Pi Coding
5. Motor driver implementation
6. Pi System setup and admin
7. Auto booting system code
8. Sensor-Car Implementation
9. Electronics Error Troubleshooting
10. Code Error Troubleshooting

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