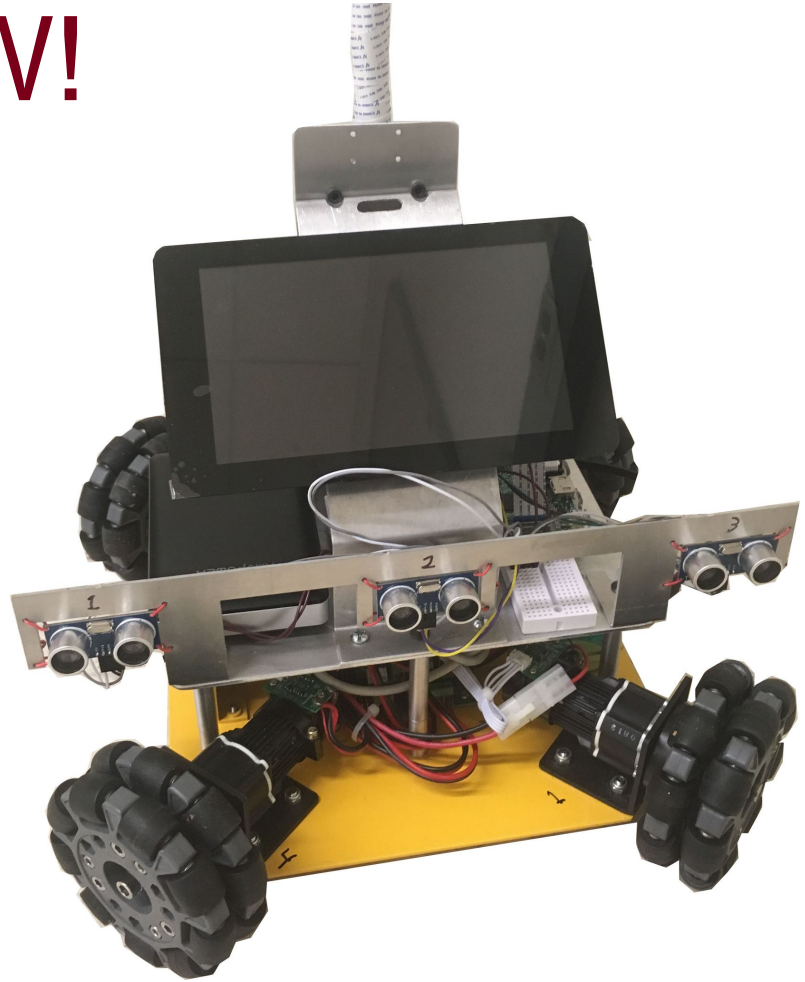
Facial-Recognition, Obstacle-Detection, Omni-Wheel Robot Platform

Team Members: James Kolar, Caden DeRoche, Noble Koshy, Bryan Nestingen,Yao Yao

Advisors: Dr. Chris Kim, Luke Everson

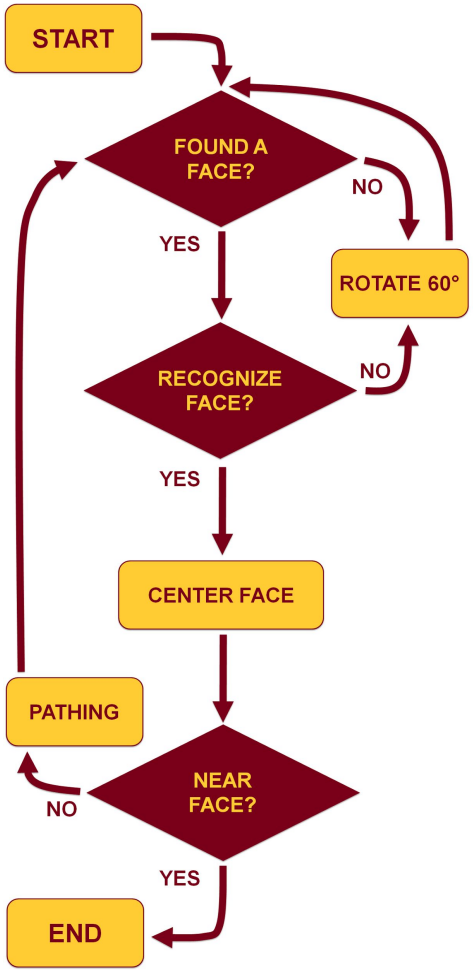
Meet FRODOW!

- Excellent Robot Platform
  - Obstacle-Avoidance Sensors
  - Absolute-Orientation Sensor
  - Pathing Software
  - Facial Recognition Testing
  - ON-Board Processing
- Potential Applications
  - Automation Processes
  - In-home Care
  - Academia
  - Military/Security
- Great Learning Opportunities
  - Programming
  - Control Systems
  - Mechanical Systems
  - Project Management



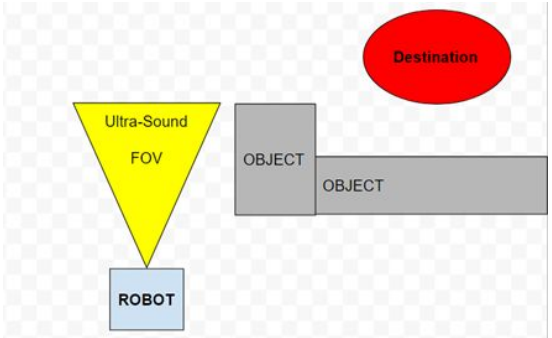
Robot Operations and Demo

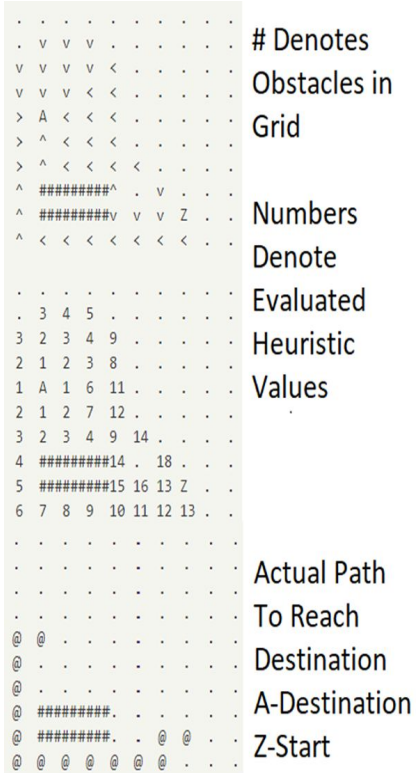
- Flow chart is the basis of robot operations.
- Implements obstacle-avoidance hardware and tracking software on an existing omni-directional platform.
- Project aims to create a fully-autonomous robot to serve as a testing platform for facial-recognition.
- Distance and measurement data are extracted from the sensors to plot obstacle and terminal locations.
- Robot demonstrates its facial-recognition capabilities by locating and plotting a safe course to a targeted individual.

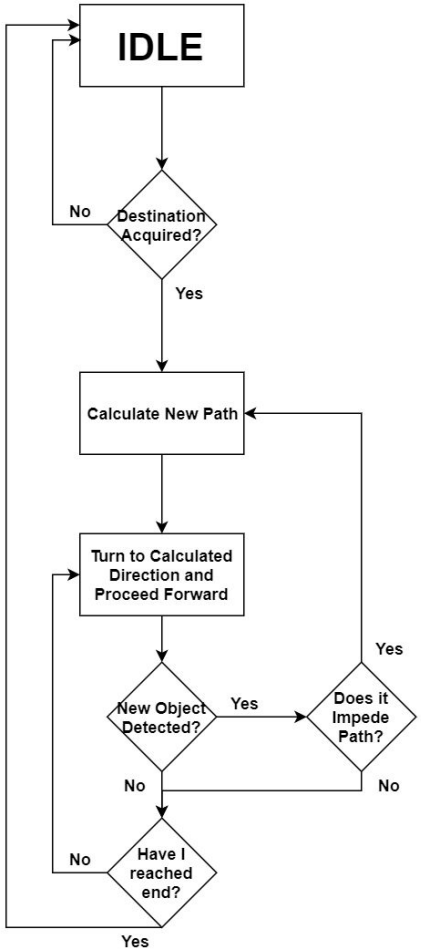


Object Avoidance

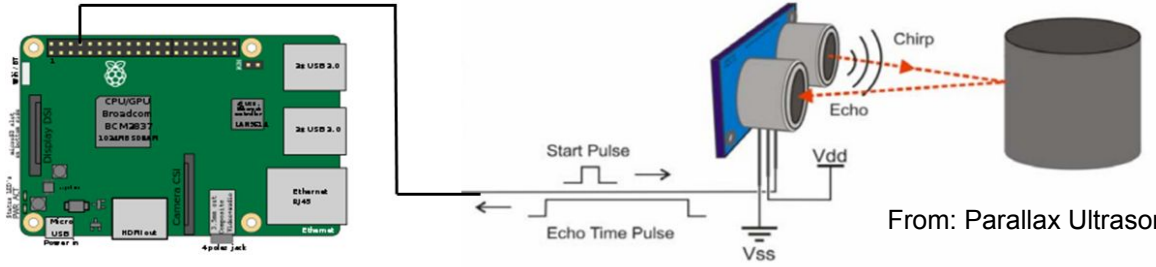
- Goal is to map all known objects into memory in the form of a grid
- Objects will be approximations to avoid collisions
- Dynamic mapping of objects
- Environment mapping updates as it is explored
- Basic Node Search Algorithm to plan path to destination(A*)





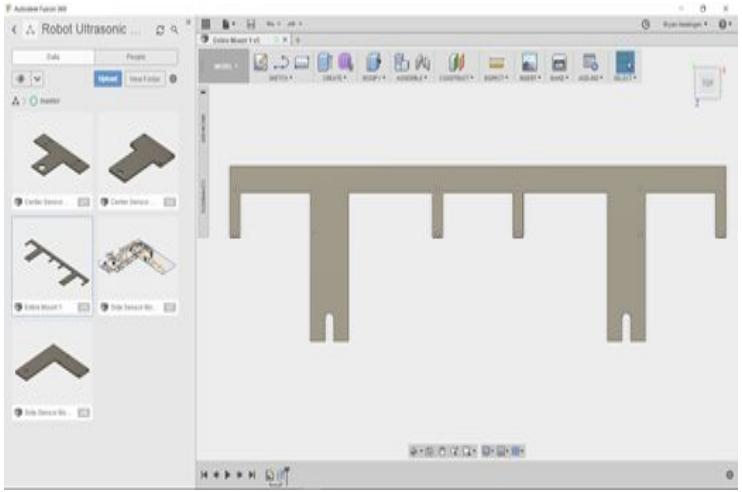


Ultrasonic Distance Sensors



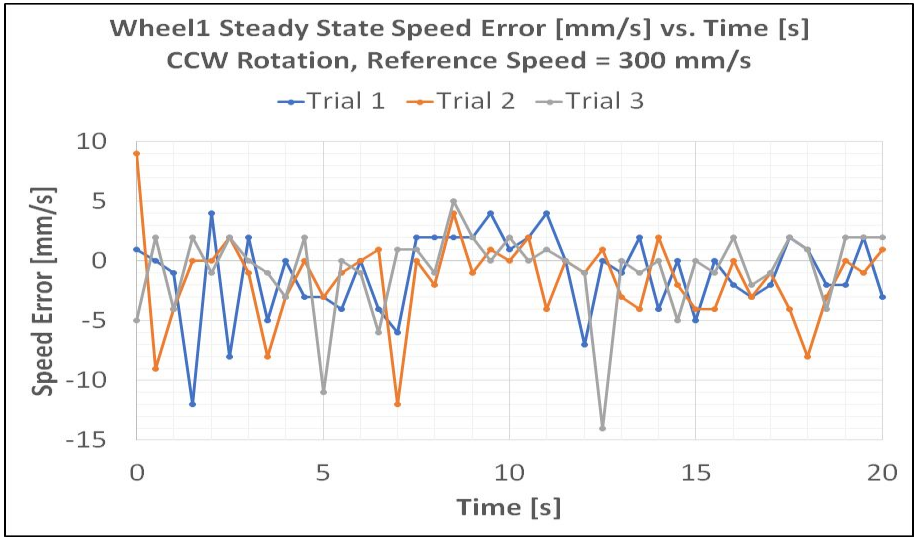
From: Parallax Ultrasonic Sensor Datasheet

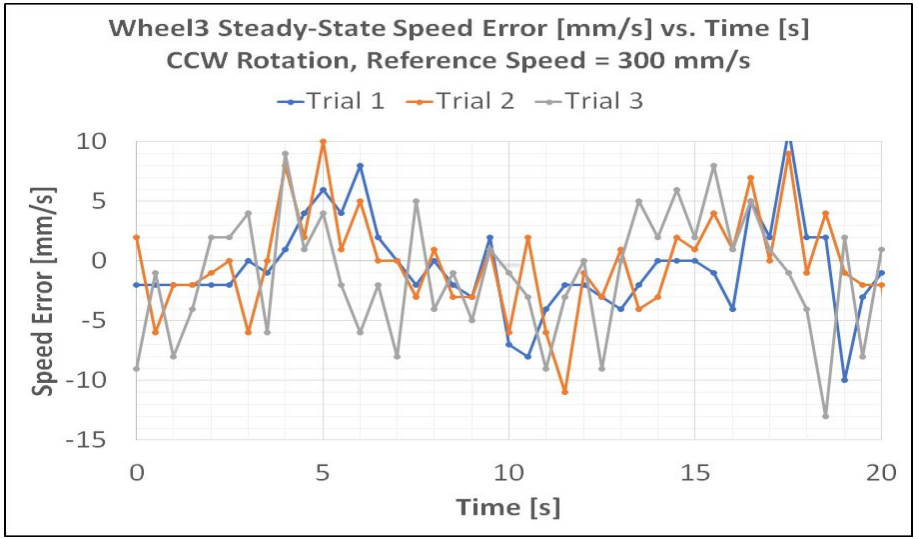
- Pros:
  - Range: Up to 1 meters
  - Very narrow field of view (<15°)
  - Takes 20ms per ping
  - Three sensors for ‘Field-Of-View’
  - Low Cost, $2.00 Unit Cost
- Cons:
  - Pinging off the floor can be a problem
  - Needs to directly face objects
  - Difficulty with soft or irregular surfaces

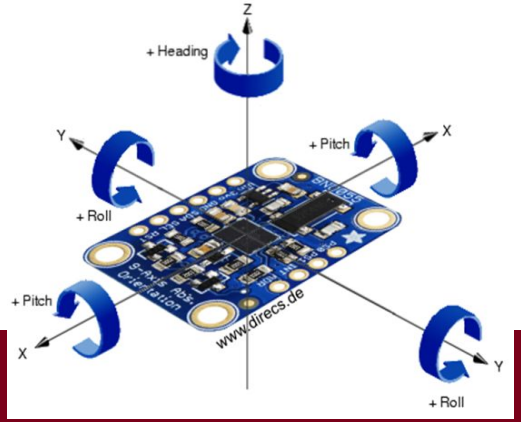


Sensor mount prototyped in Autodesk Fusion, created using waterjet cutter in CSE machine shop.

Expanded Movement Capabilities



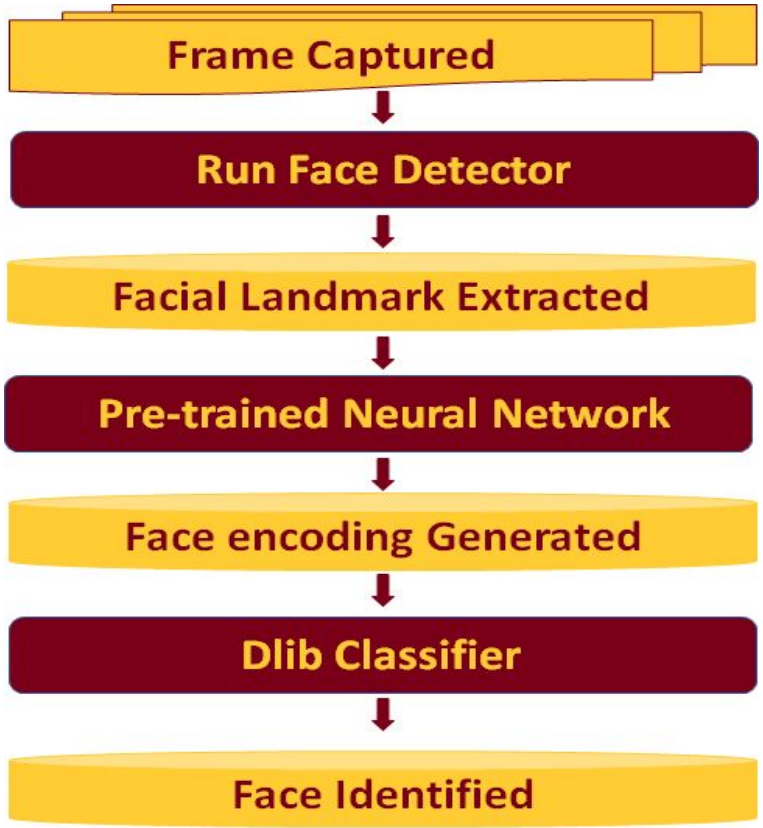




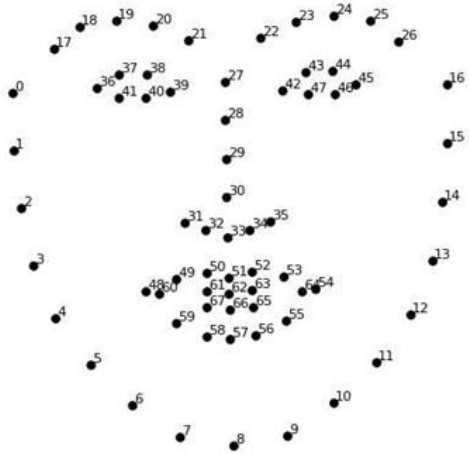
From: www.direcs.de

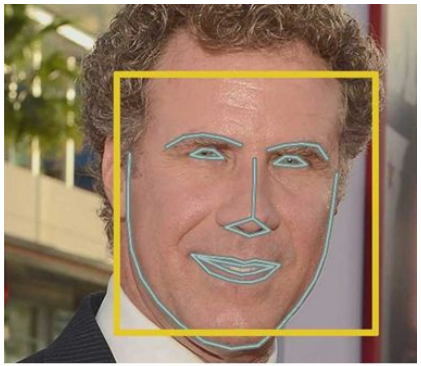
- Nexus Robot Omni-Wheel Drive Train
  - Only frontal movement to avoid side or rear collisions(limited to no side sensors)
  - Movement library refinement for accurate estimation of distance traveled
  - Wheel 3 needs tuning or replacement
- Adafuit Inertial Measurement Unit (IMU)
  - Needed to accurately map rotations as robot moves

Dlib Facial Recognition Software



Faces are encoded
Eye distance acquired





Face identification via neural network

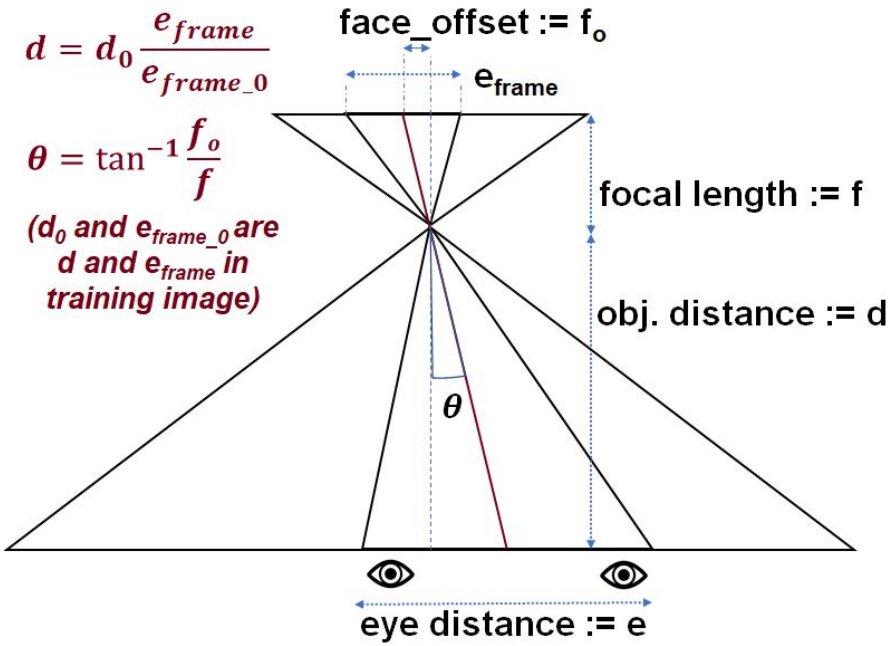
Facial Recognition Software

Position Calculation

$$d = d_0 \frac{e_{frame}}{e_{frame\_0}}$$

$$\theta = \tan^{-1} \frac{f_o}{f}$$

(d_0 and e_{frame_0} are d and e_{frame} in training image)



Requirements Specifications

Movement Patterns

- More robust and expanded movement library
- Optimize PID control
- Calculate path to destination

Obstacle Avoidance (Indoors)

- Additional peripherals and sensors
- Adjust path due to obstacles

Image Processing

- Face-tracking recognition and identification of team members

Improve Testing Interface

- Documentation/Schematic of robot
- Storing live-feed data, display on LCD

Requirements Specifications

#	Need #'s	Metric	Units	Ideal Value	Acceptable Range	Importance
1	1,2,3,4	Minimum distance from obstacles	m	0.1	>0.05	1
2	1,2,4	Minimum displacement from rest	m	0.05	<0.1	1
3	4,5,6	Facial recognition in group of N or more	N	5	2	1
4	1,2,6	Time to re-acquire facial tracking	ms	500	<5000	1
5	9	Refresh rate on displaying captured image to LCD	fps	24	>5	2
6	5	Time to run facial Recognition	s	5	<60	1

Budget

Item #	Product Description	Vendor	Vendor Part #	Per Unit Cost ($)	Qty	Total Cost
1	Raspberry PI 3 Model B 1.2GHz 64-bit quad-core ARMv8 CPU, 1GB RAM	Amazon	See description	35.20	1	35.20
2	Raspberry Pi 7" Touchscreen Display	Amazon	See description	69.99	1	69.99
3	Ultrasonic Sensor HC-SR04 (5-pk) - 8.99	Amazon	See description	8.99	1	8.99
4	Adafruit IMU Fusion Breakout BNO055	Microcenter	See description	37.62	1	37.62
5	Breadboard	ECE Depot	See description	2.36	3	7.08
6	Wire with pre-crimped connectors (long)	ECE Depot	See description	0.45	6	2.70
7	Wire with pre-crimped connectors (med)	ECE Depot	See description	0.35	23	8.05
8	Wire with pre-crimped connectors (short)	ECE Depot	See description	0.20	9	1.80
9	Connector housing (large)	ECE Depot	See description	0.40	2	0.80
10	Connector housing (1x4)	ECE Depot	See description	0.05	9	0.45
11	Connector housing (1x1)	ECE Depot	See description	0.02	28	0.56
12	Cable, USB A male to USB B female	ECE Depot	See description	2.45	1	2.45
13	Plano Case for electronics	ECE Depot	See description	8.99	1	8.99
			Total Cost			184.68

Moving FRODOW Forward

- **Accomplishments**
  - Introduction of a path to destination algorithm utilizing ultrasonic sensors
  - Through our solution, the Robot has the ability to avoid obstacles and perform facial identification
- **Recommendations**
  - More robust sensor package for 360° obstacle avoidance
  - Take advantage of omni-directional movements vs using 90° rotations
  - Update PID algorithms (tune or replace wheel 3's motor)
  - Real time facial-recognition and identification. Use a more powerful alternative to the Raspberry Pi.
    - NVIDIA Jetson TK1
    - Tegra K1 SOC
    - Access to CUDA cores
    - Improve performance of facial recognition API

Question and Answer Session