

# *Outdoor Visual SLAM and Path Planning for Mobile Robot*

2022 K-SW Square Final Presentation

**Team FarmVroong**

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# *Introduction*

**1. Introduction**

**2. SLAM**

**3. Path Planning**

**4. Prototype**

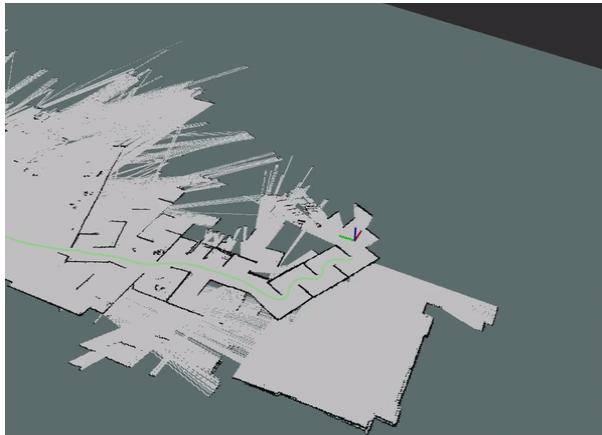
# *Introduction - Our Initial Goal*

## Off-road Autonomous Driving

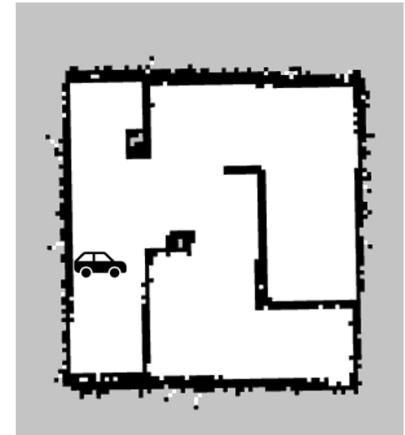
Mobile Robot



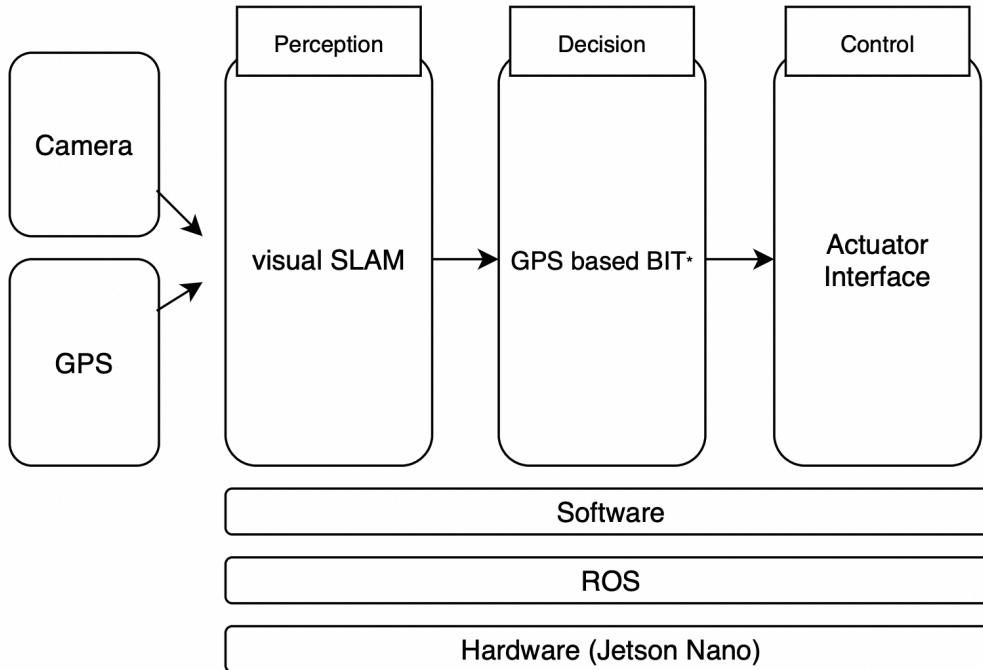
SLAM



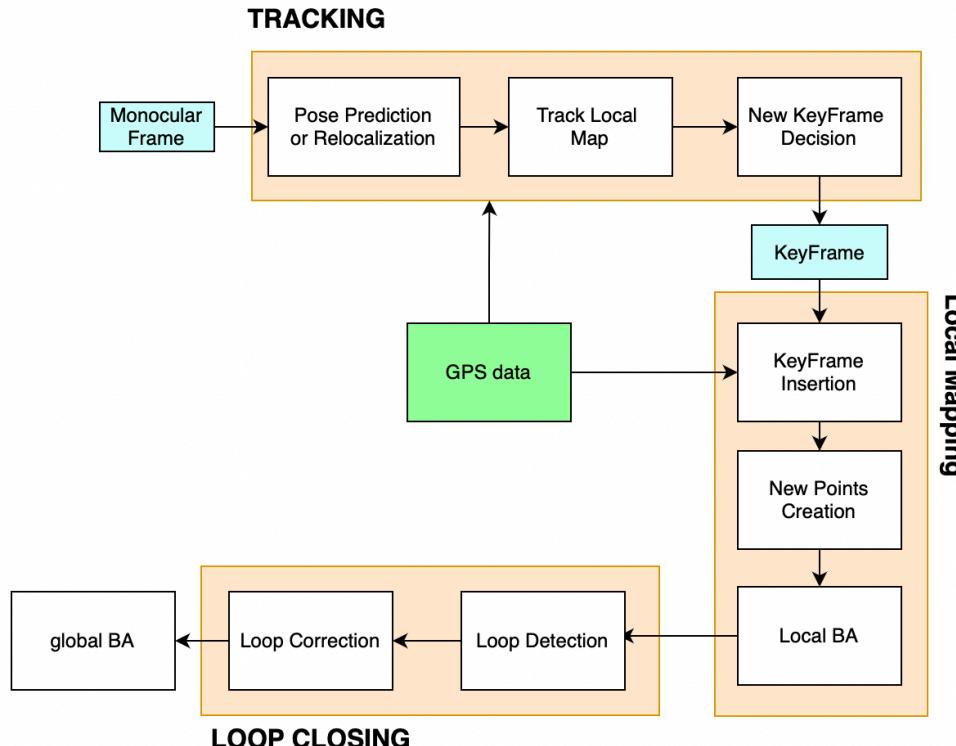
Path Planning



# *System Overview*

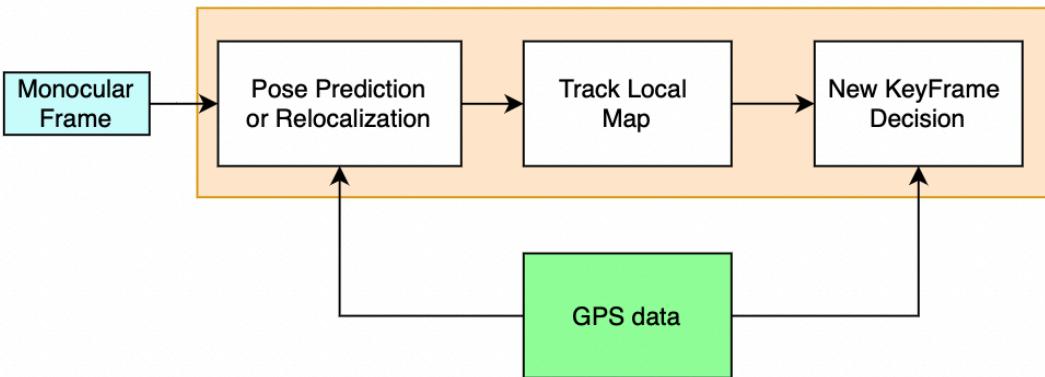


# SLAM Overview



# ***SLAM - Tracking***

## **TRACKING**



**Mud**

**Slope**

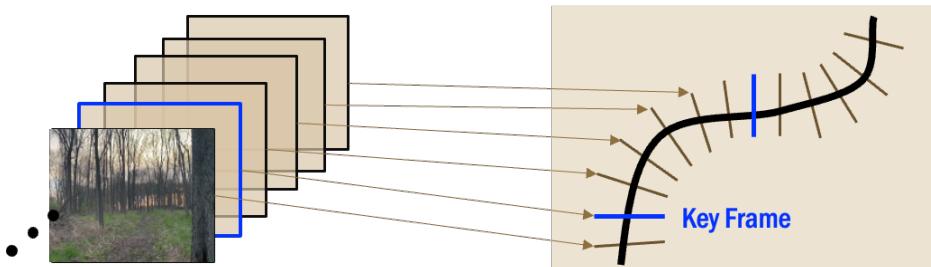
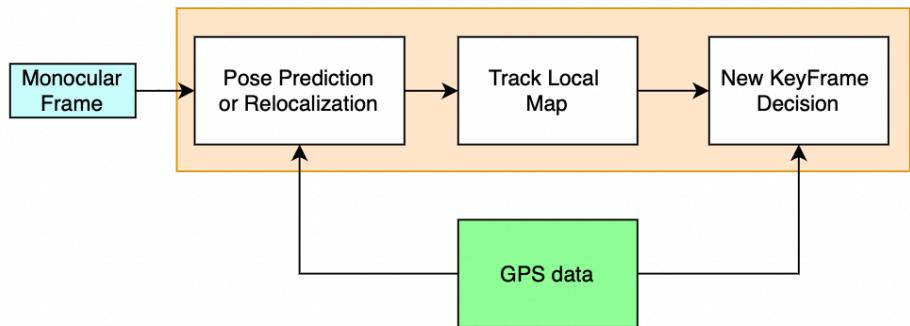
Early Stop by GPS  
if the car does not move due to the  
slope, mud, and bumpiness.



Prevents bootless computing

# SLAM - Tracking

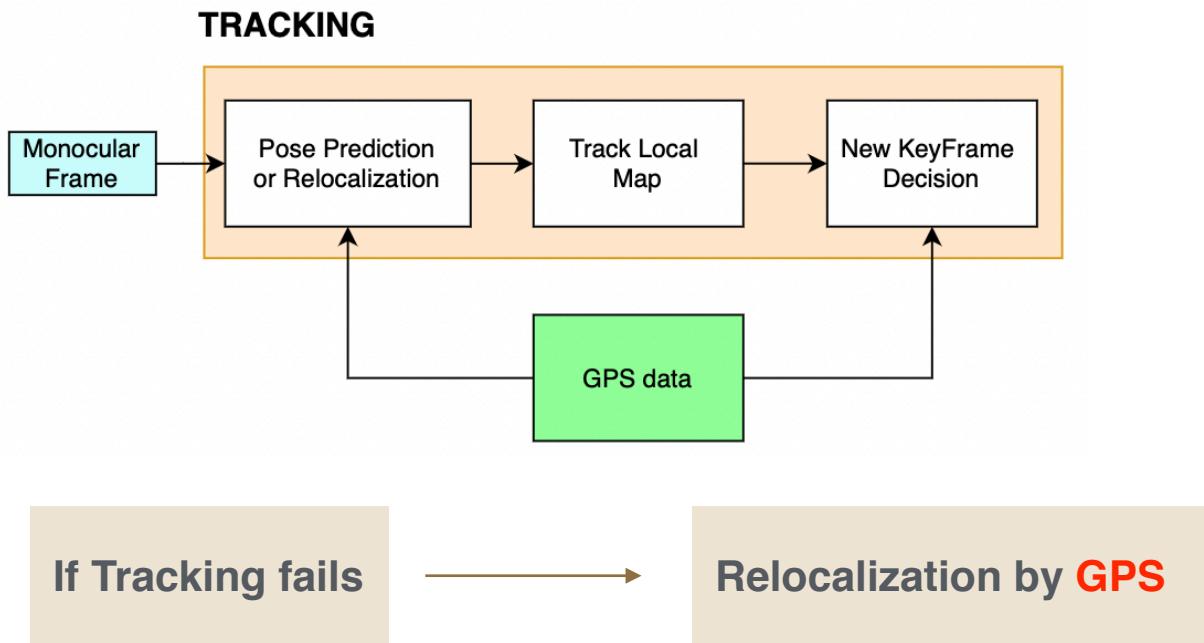
## TRACKING



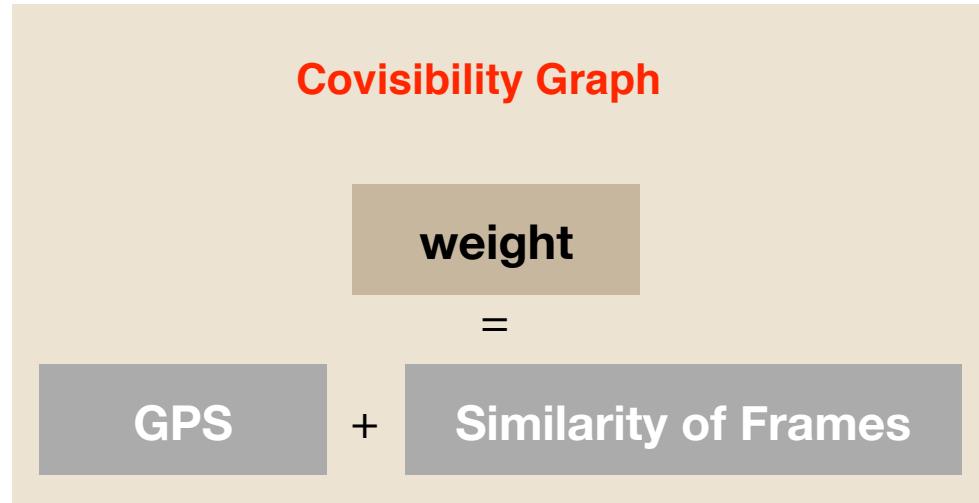
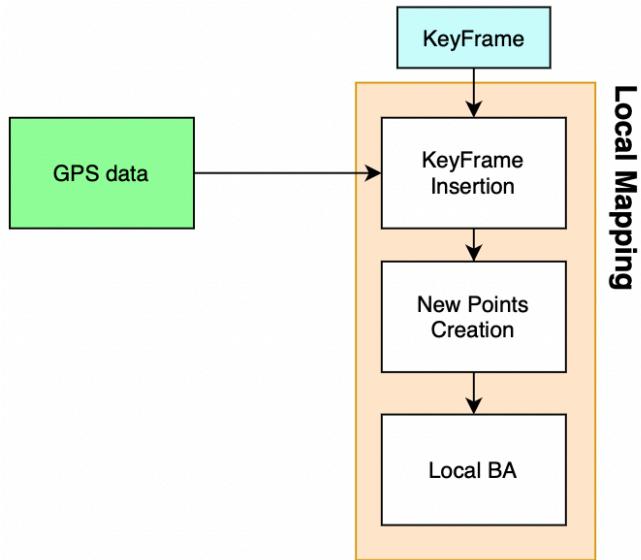
Prevent Creating Useless Keyframe

Compare the **Last Keyframe**  
with the **candidate KeyFrame**

# ***SLAM - Tracking***



# *SLAM - Local Mapping*

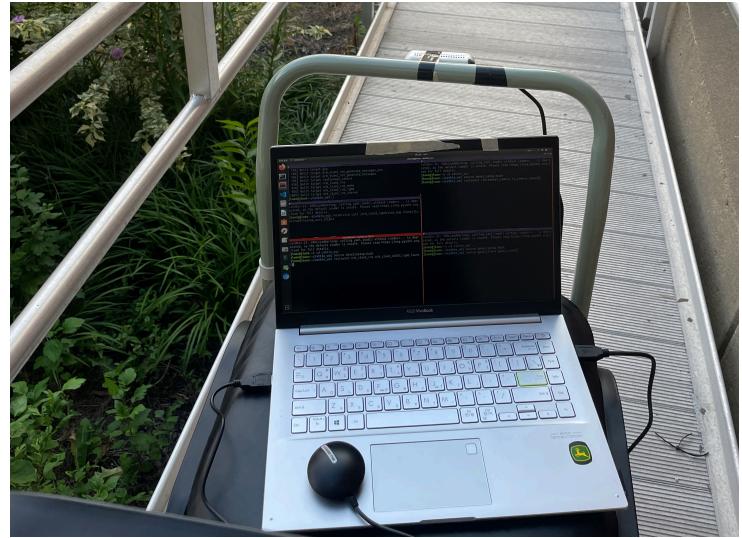


# *Jetson Nano*



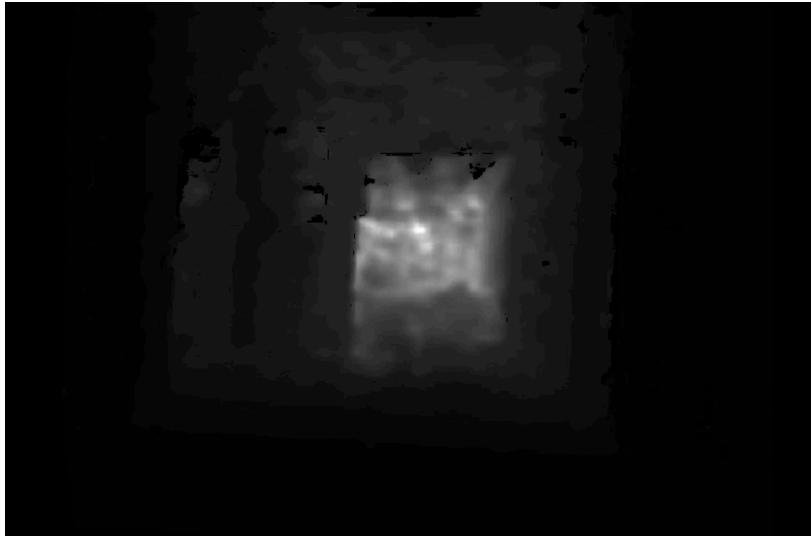
	Ours	ORB-SLAM2
Computer	Jetson Nano	Desktop
CPU	ARM Cortex-A57	Intel Core i7-4790
RAM	4 GB	16 GB

# *Change the vehicle for collecting Data*



# *Change from RGB-D SLAM to Monocular SLAM*

## Limitations of Depth Camera

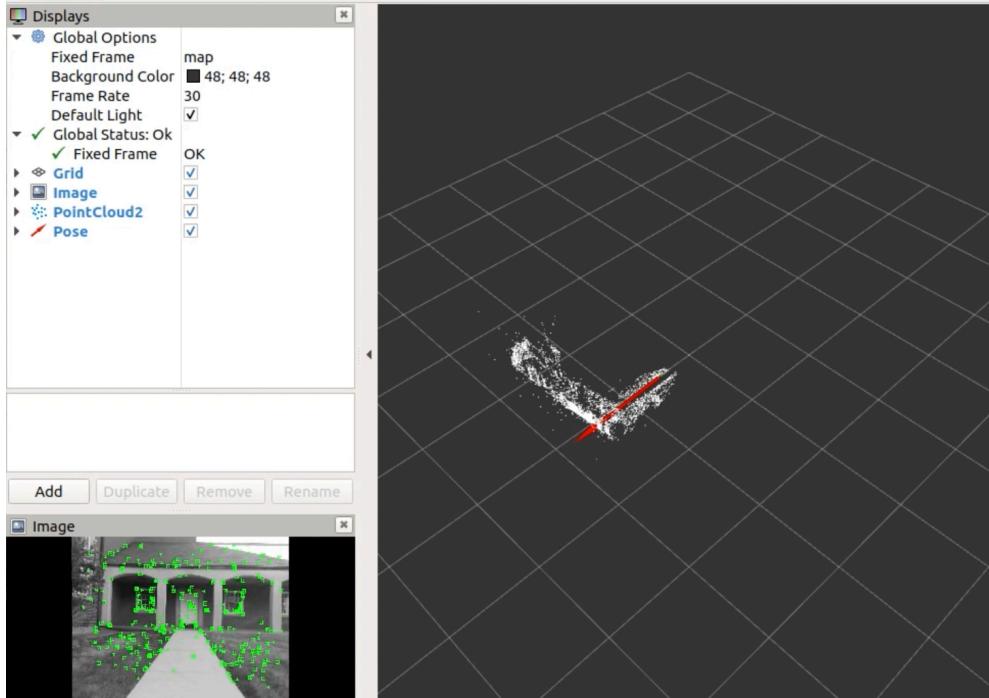


Under the building, depth is collected well

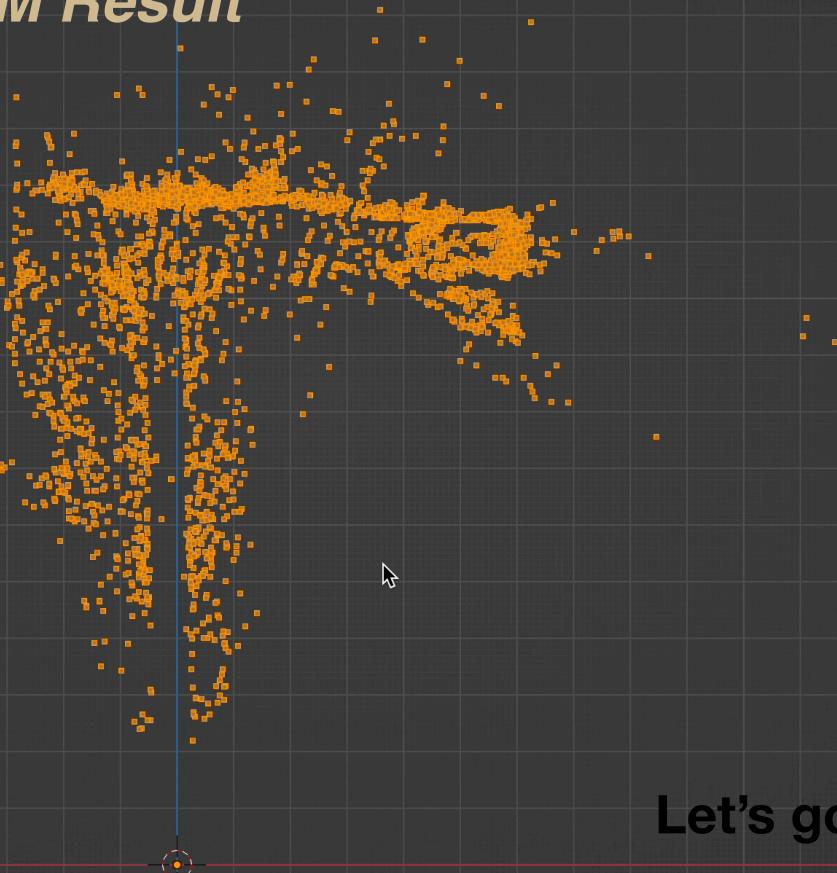


At the open outdoor, depth is not collected

# Monocular SLAM



# *Monocular SLAM Result*



Let's go to the Farm !! 🚗

# *Outdoor experiment at the Prof.Smith's Farm*

## Experiment at the Farm



Problem : Camera Shaking during recording



Off-road driving → Outdoor driving for mobile robot

## ***Subject changed from Off-road to Outdoor***

Outdoor autonomous driving has similar features with off-road driving.



1. Choosing the stable path from the bumpy and muddy road is still important.

## *Subject changed from Off-road to Outdoor*

Outdoor autonomous driving has similar features with off-road driving.



2. Due to the lack of the landmarks and rules which are at the pavement, perception of the environment is still important.

# *Changed Camera*



Intel RealSense D435i



GoPro HERO 10

# *GoPro Test*



30fps



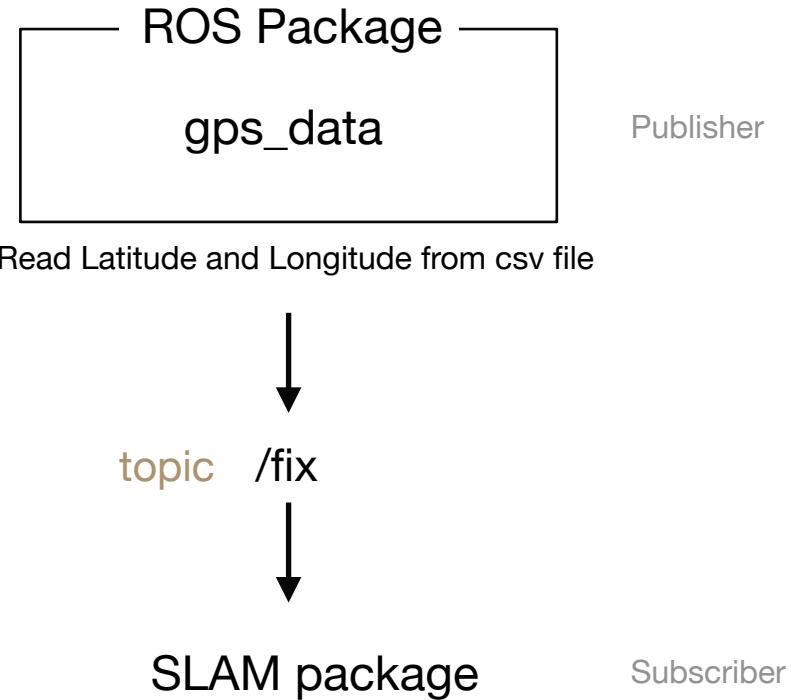
120fps

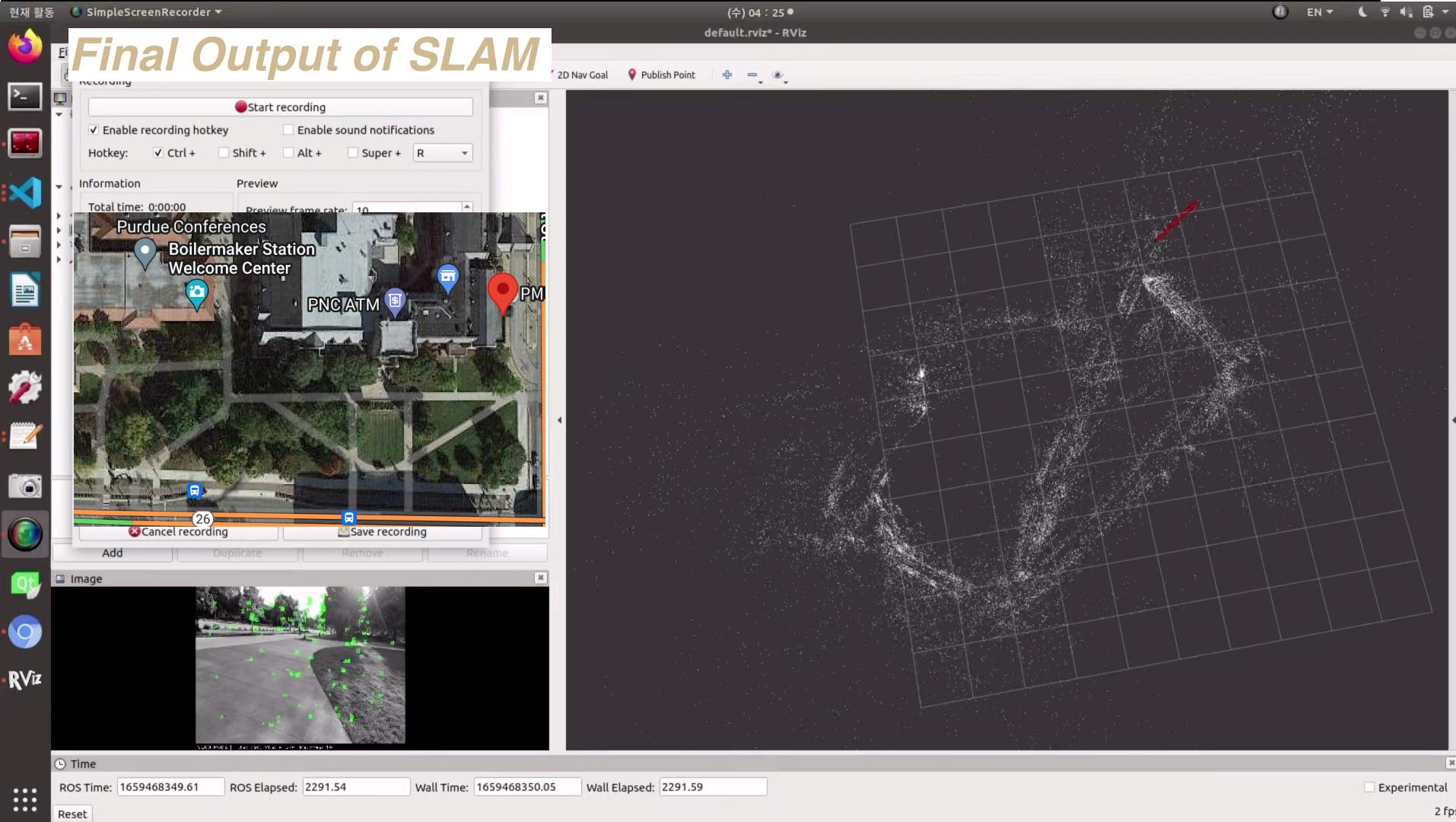


240fps

# *Extracting the GPS data from GoPro*

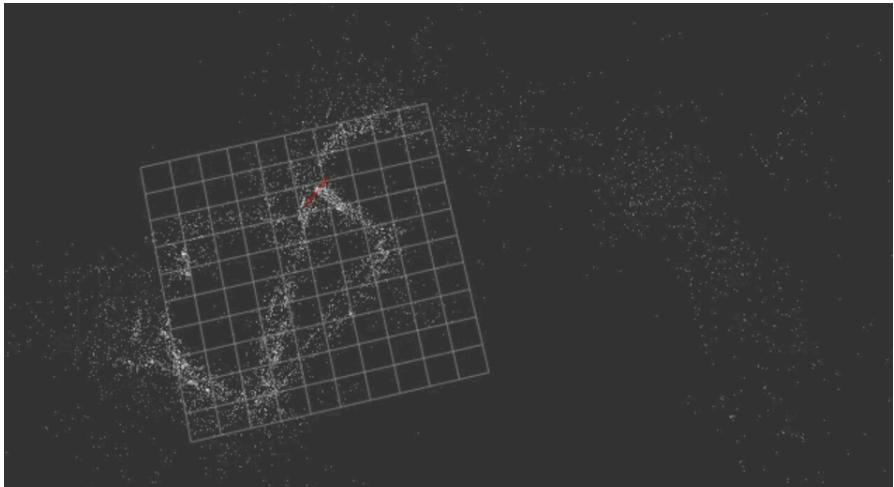
<b>date</b>	<b>GPS (Lat.) [deg]</b>	<b>GPS (Long.) [deg]</b>
2022-07-31T00:02:41.794Z	40.4733925	-86.9470333
2022-07-31T00:02:41.919Z	40.4733924	-86.9470333
2022-07-31T00:02:42.044Z	40.4733925	-86.9470335
2022-07-31T00:02:42.169Z	40.4733926	-86.9470334
2022-07-31T00:02:42.295Z	40.4733927	-86.9470333
2022-07-31T00:02:42.420Z	40.4733929	-86.9470332
2022-07-31T00:02:42.545Z	40.473393	-86.9470331
2022-07-31T00:02:42.670Z	40.4733931	-86.947033
2022-07-31T00:02:42.796Z	40.4733932	-86.9470328
2022-07-31T00:02:42.921Z	40.4733935	-86.9470327
2022-07-31T00:02:43.046Z	40.4733936	-86.9470326
2022-07-31T00:02:43.172Z	40.4733937	-86.9470325
2022-07-31T00:02:43.297Z	40.4733939	-86.9470324
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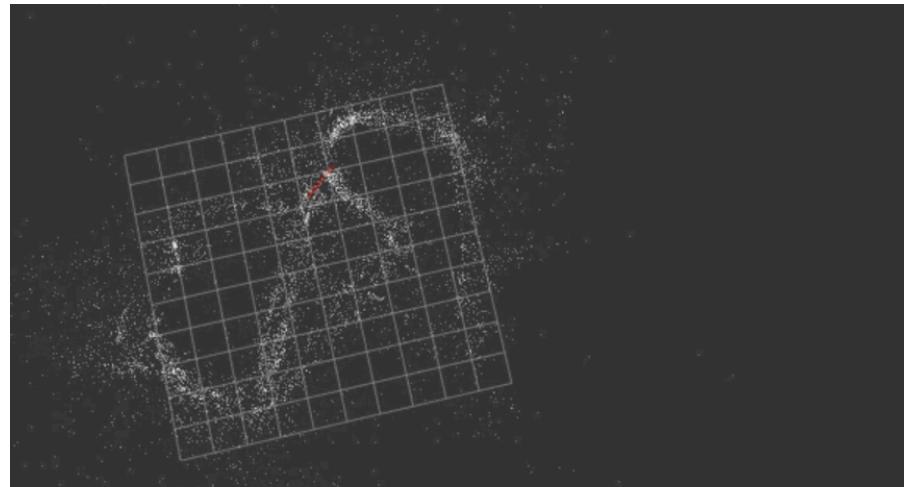


# *Final Output of SLAM*

## Optimizing Process



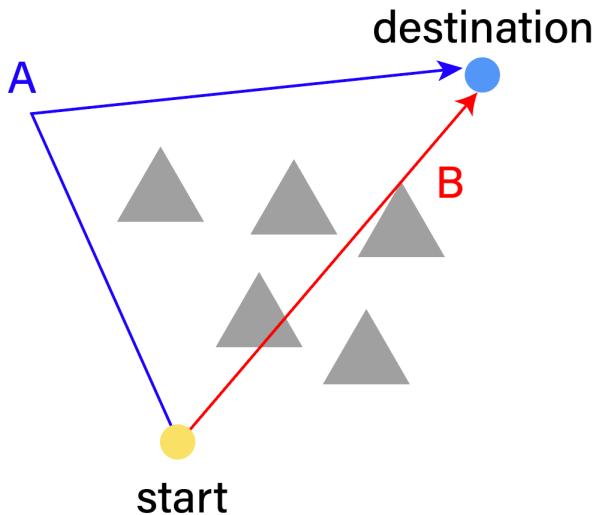
Before



After

# *Path Planning*

## Problem Statement



Length :  $A > B$

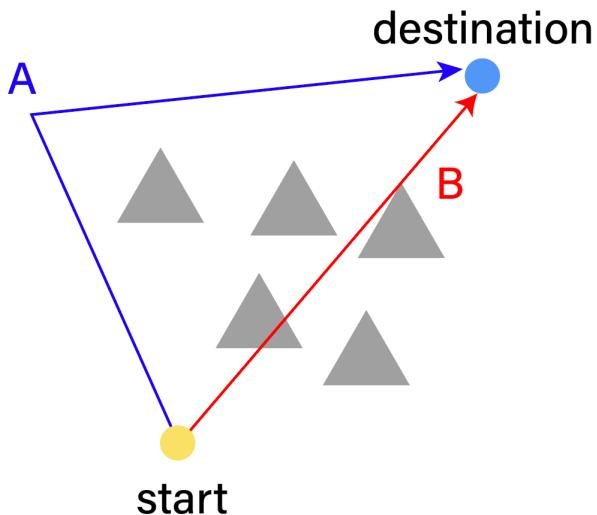
But route A is better than route B



Path finding algorithm has to be developed

# *Path Planning*

## Problem Statement



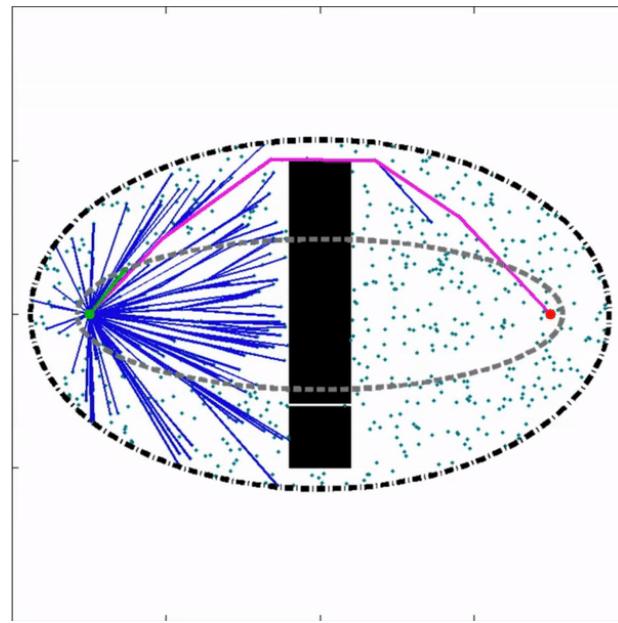
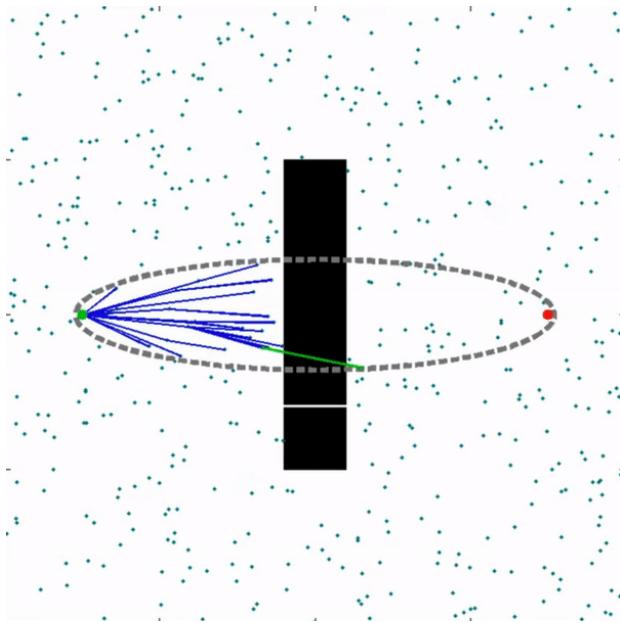
Two factors were added

Clearance

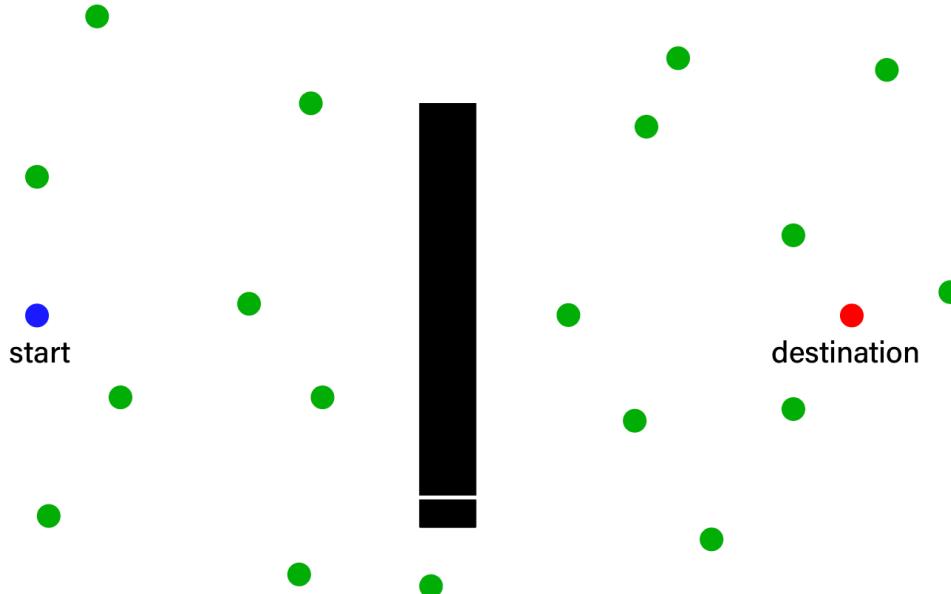
Stability

# *Path Planning*

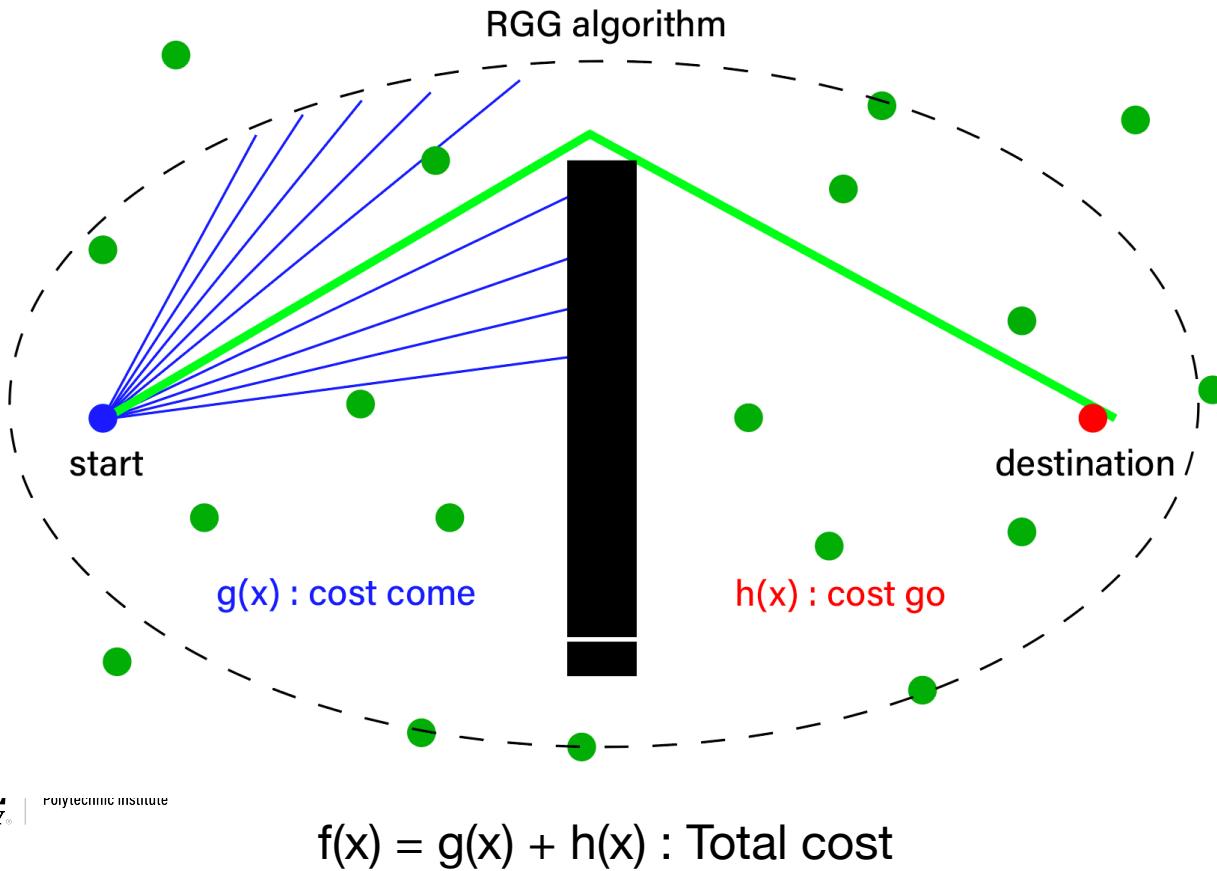
## BIT\* algorithm



# *Path Planning*

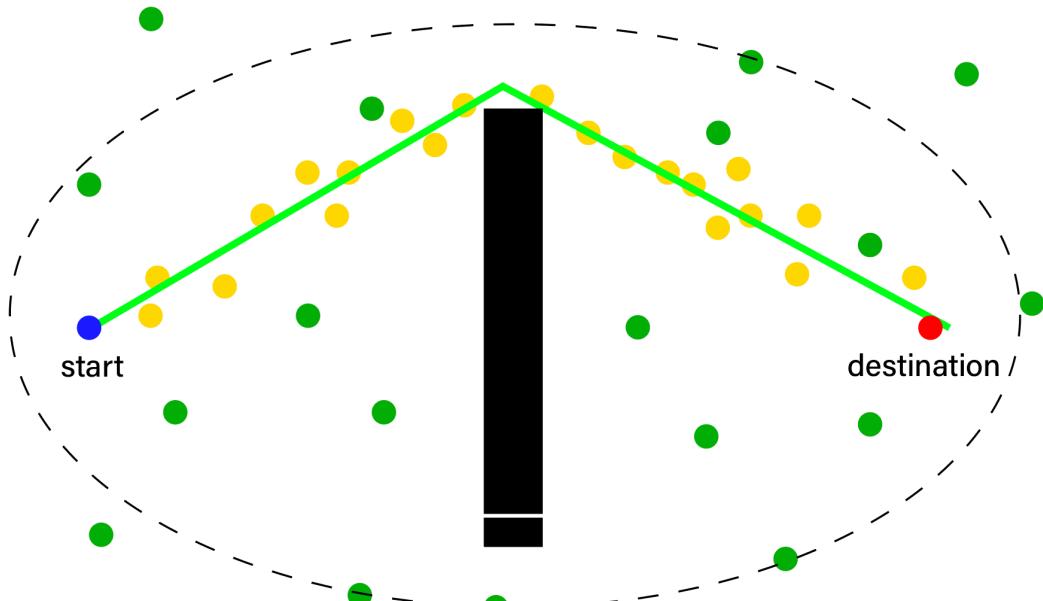


# *Path Planning*



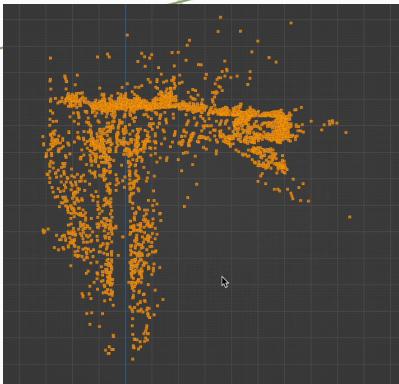
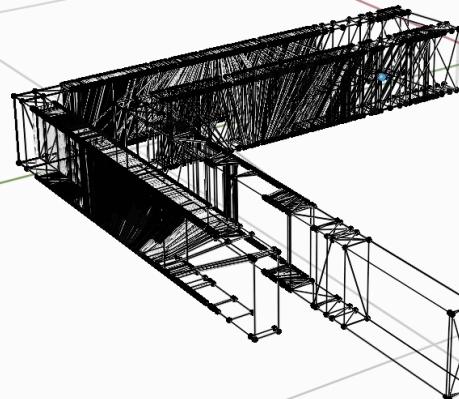
# *Path Planning*

## Developing the algorithm



The path is more likely to occur where there are many yellow spots.

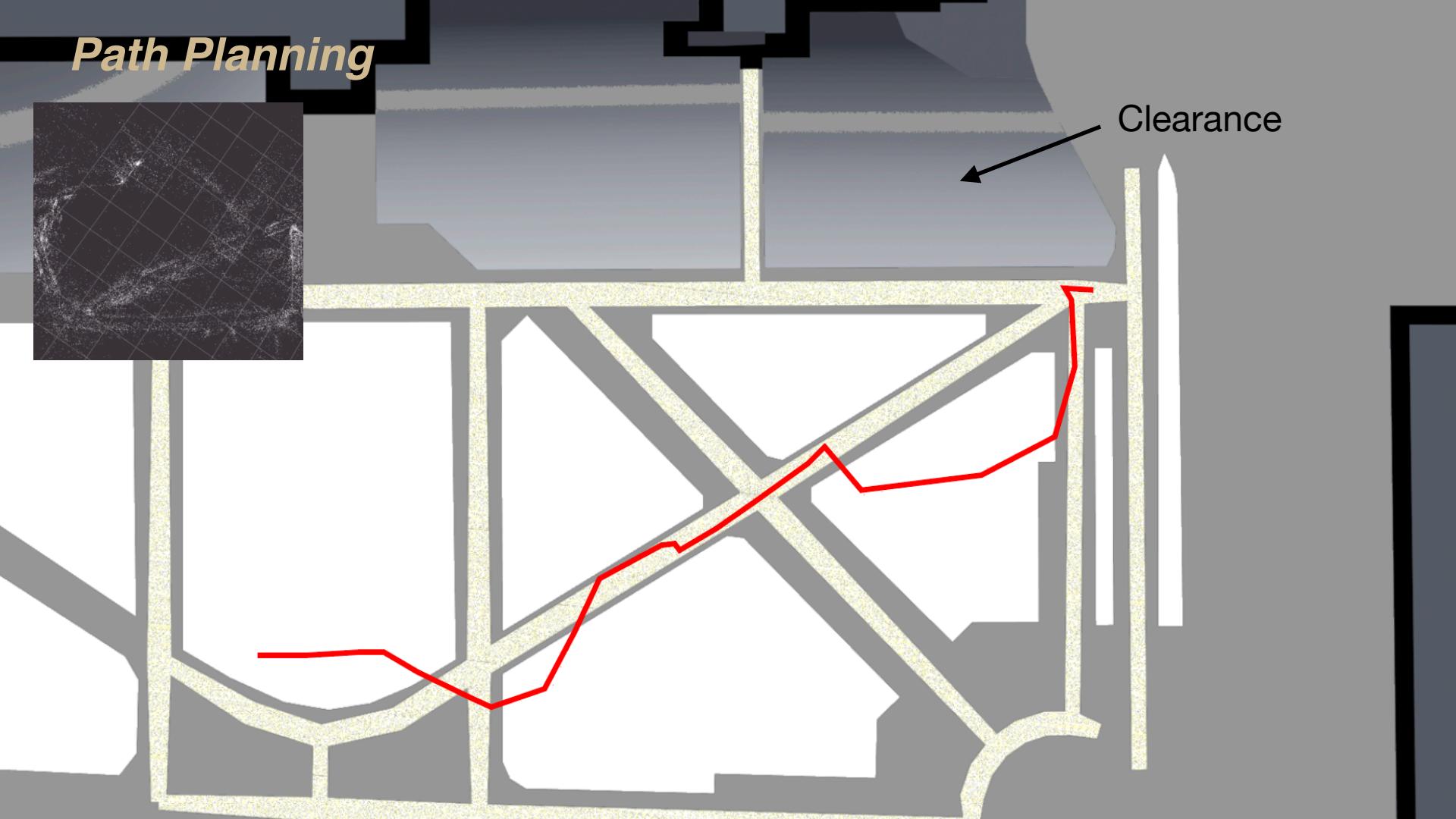
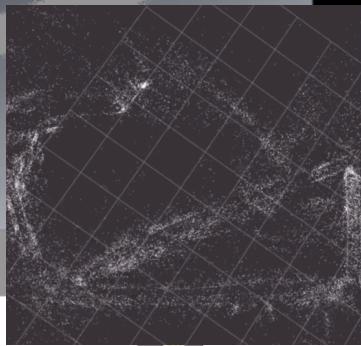
# *Path Planning : Point Cloud Processing*



# *Path Planning : 2D map*



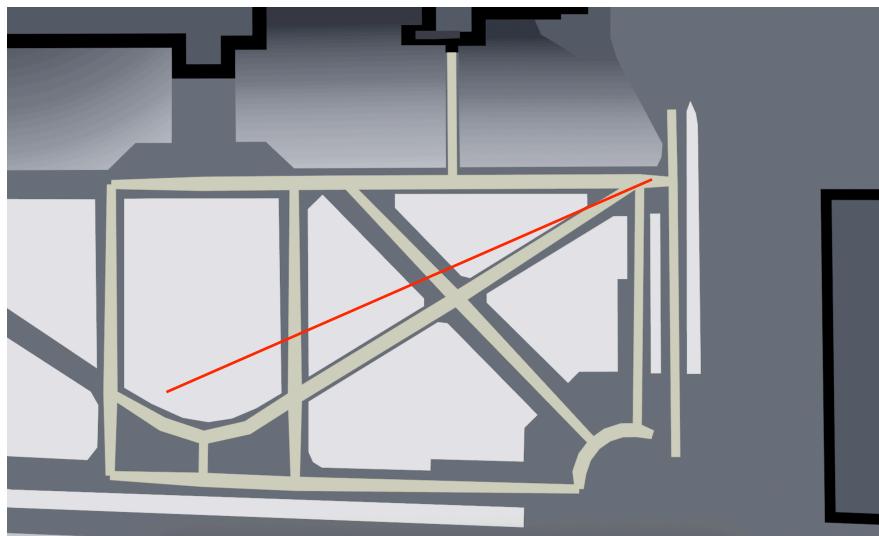
# *Path Planning*



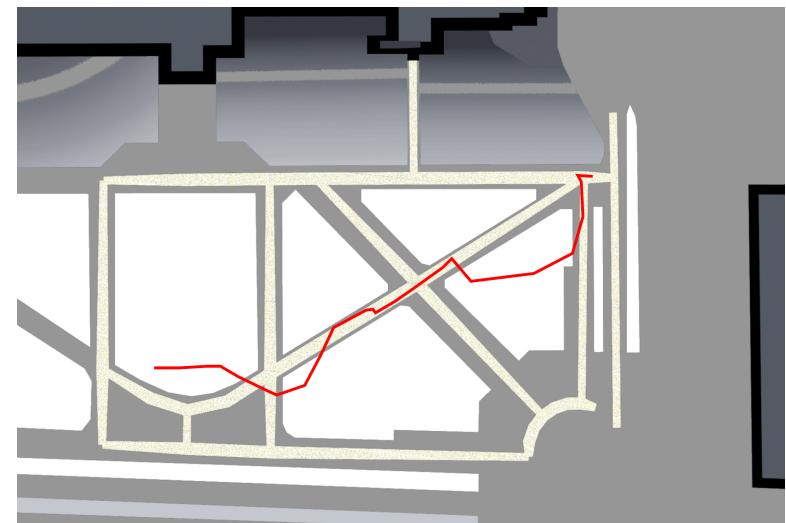
Clearance

# *Path Planning*

## Result



Original Path Planning Algorithm



Our Path Planning Algorithm

# Prototype Making

## Car Building

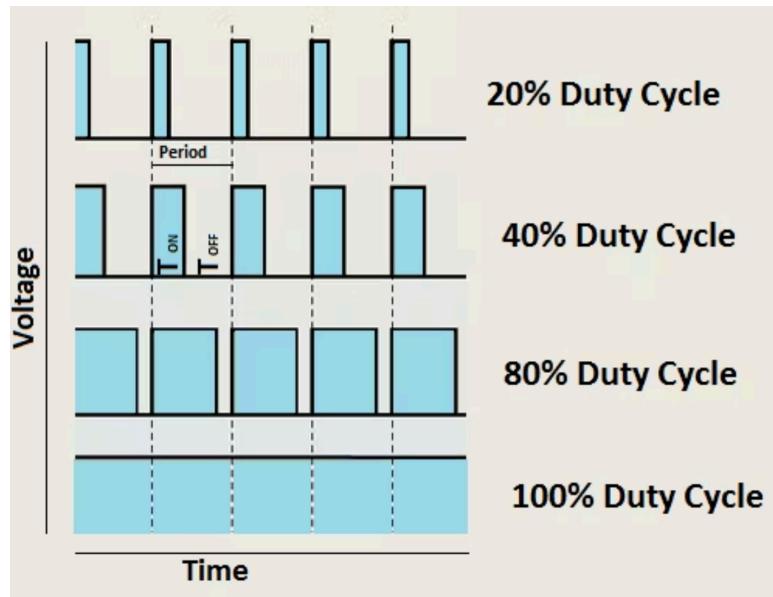


Figure. PWM (Pulse Width Modulation)

# Prototype Making

## Failures and Retries

### Trial #1

CPU



Jetson Nano

Motor Driver



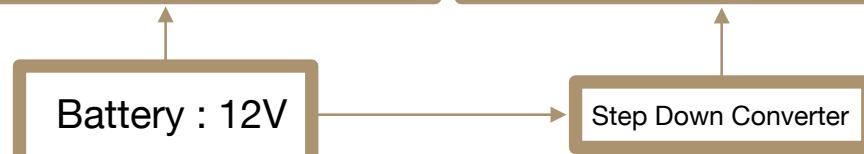
L298N

PWM Controller



PCA9685

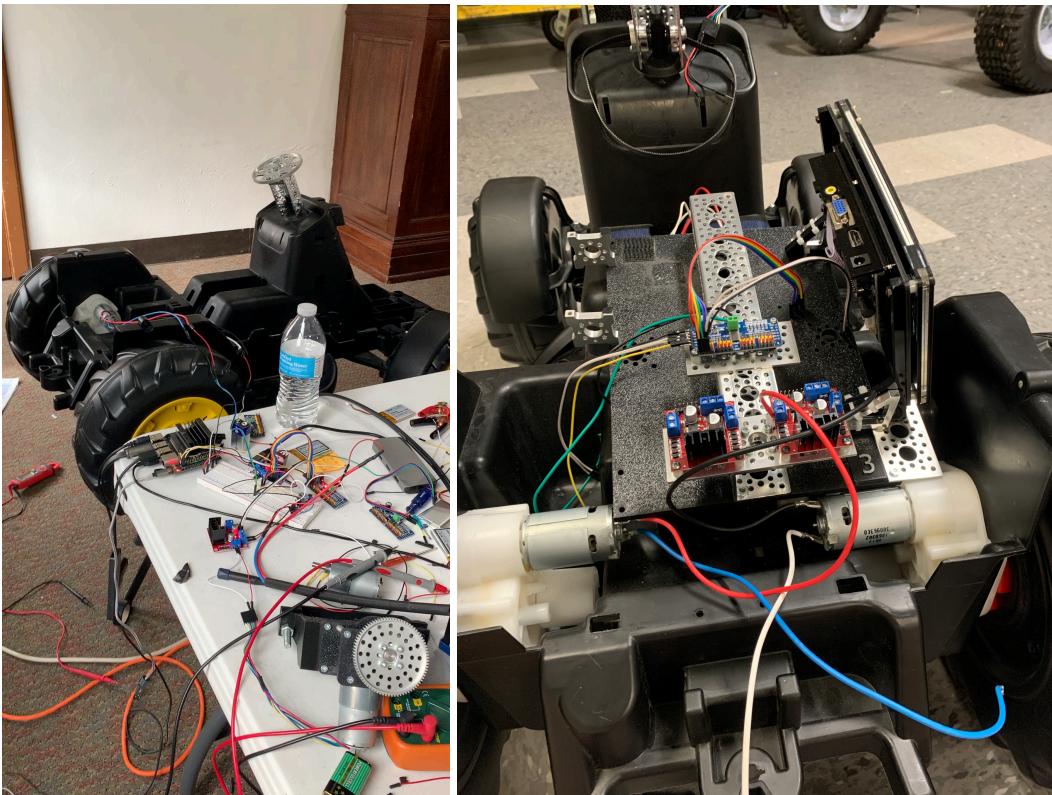
Battery : 12V



# Prototype Making

## Failures and Retries

### Trial #1



# Prototype Making

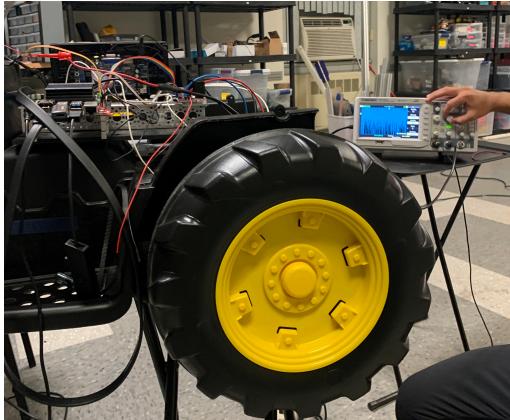
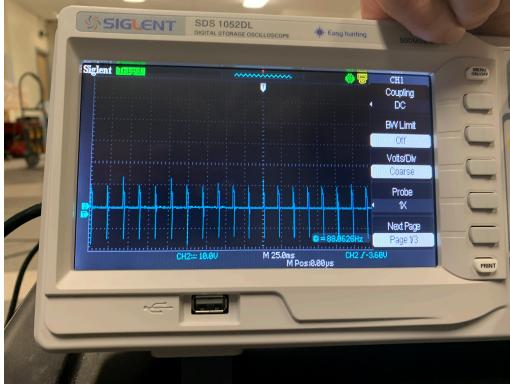
## Failures and Retries

### Trial #1 : Problems

Output voltage was not reliable



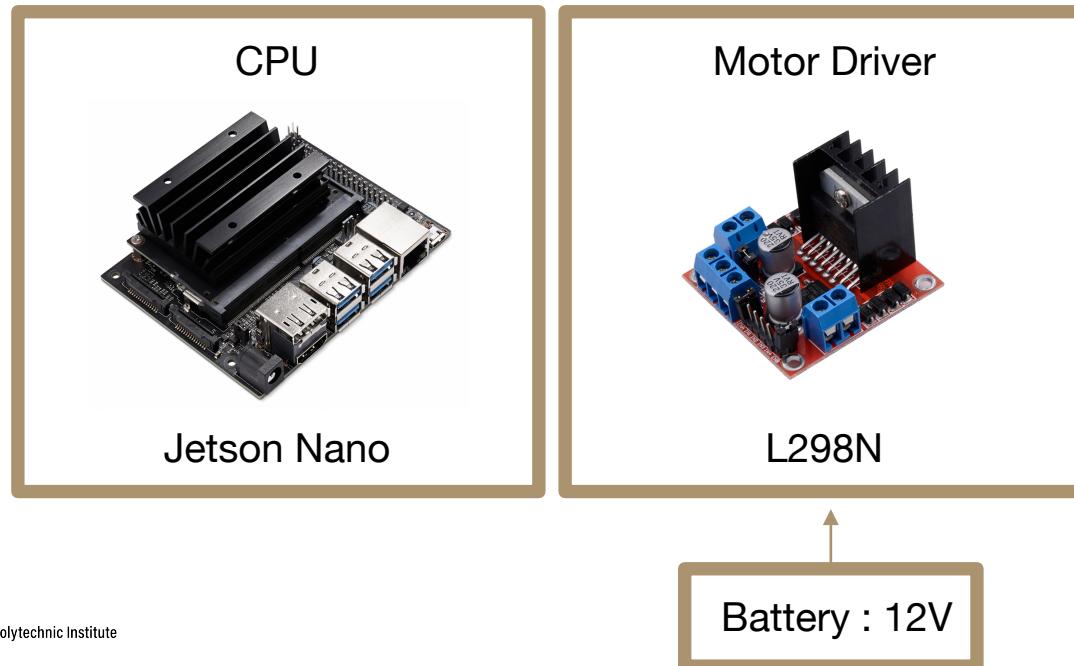
To use the PWM controller,  
Diodes and Transistors are needed.



# *Prototype Making*

## Failures and Retries

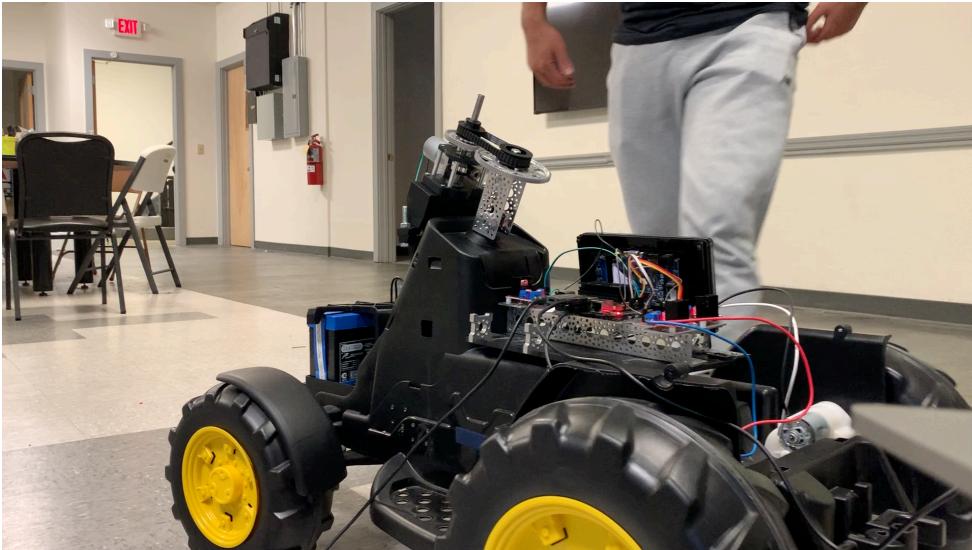
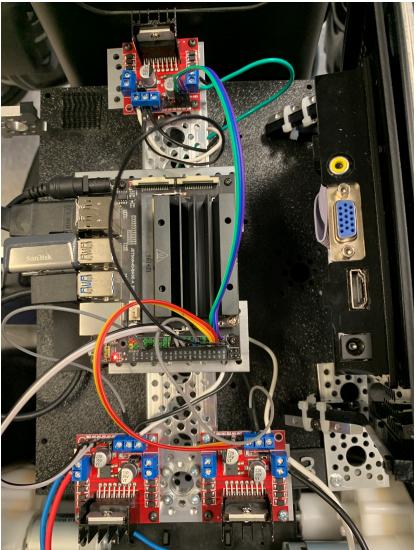
### Trial #2



# Prototype Making

## Failures and Retries

### Trial #2



# *Prototype Making*

## Failures and Retries

### Trial #2



# *Prototype Making*

## Failures and Retries

### Trial #2 : Problems

Output voltage was too small

12V →



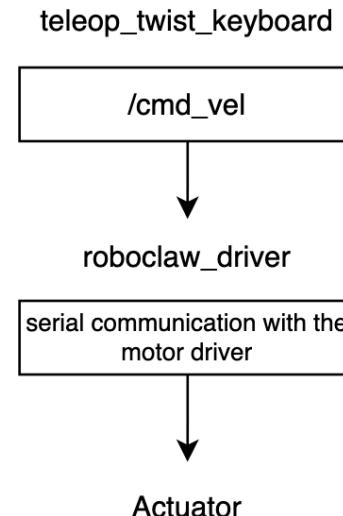
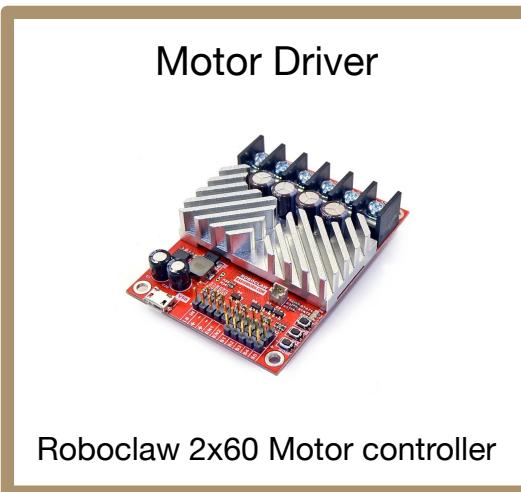
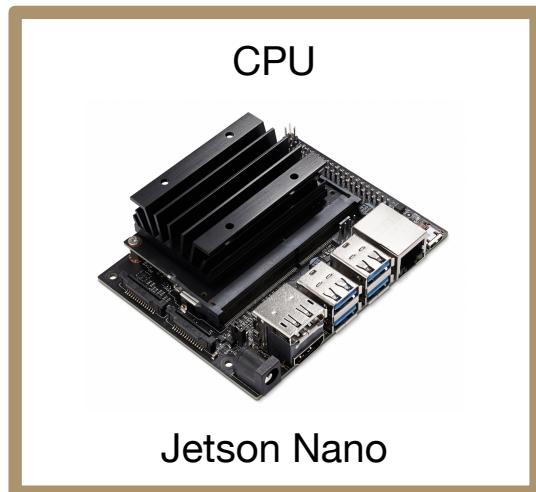
→ 7V



# Prototype Making

## Failures and Retries

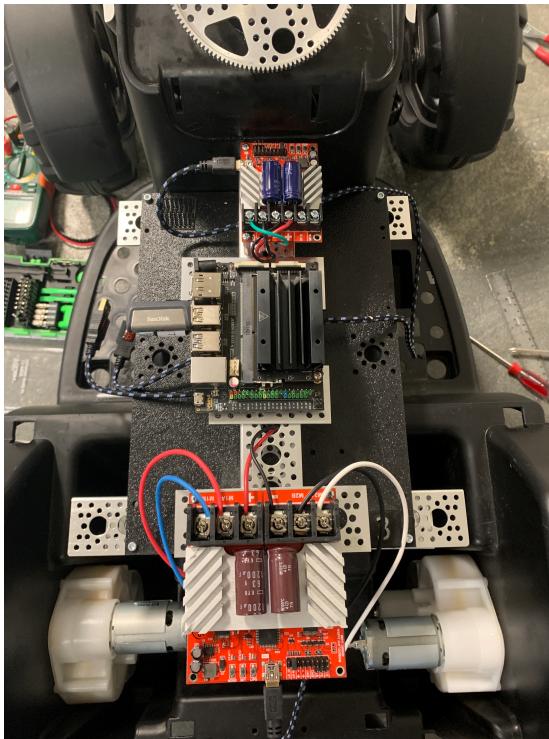
### Trial #3



# *Prototype Making*

## Failures and Retries

### Trial #3



# Prototype Making

## Failures and Retries

### Trial #3



# *Prototype Making*

## Failures and Retries

Trial #3



# *Prototype Making*

## Failures and Retries



# *Future Plan*

## Feedback Learning

### SLAM

- RGB-D SLAM
- Jetson CPU
- Realsense Cam

### Prototype

- L298N
- PCA9685
- 12V



- Monocular SLAM
- Laptop
- GoPro



- Roboclaw
- 22V



