REMTEC & EMERGING CONTAMINANTS SUMMIT

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Artificial Intelligence for Obstacle Avoidance and Autonomous Exploration by Robotic Platforms

Ian Krause, *Aaron Johnson, Greg Lowry, Thomas Hoelen*

Carnegie Mellon University

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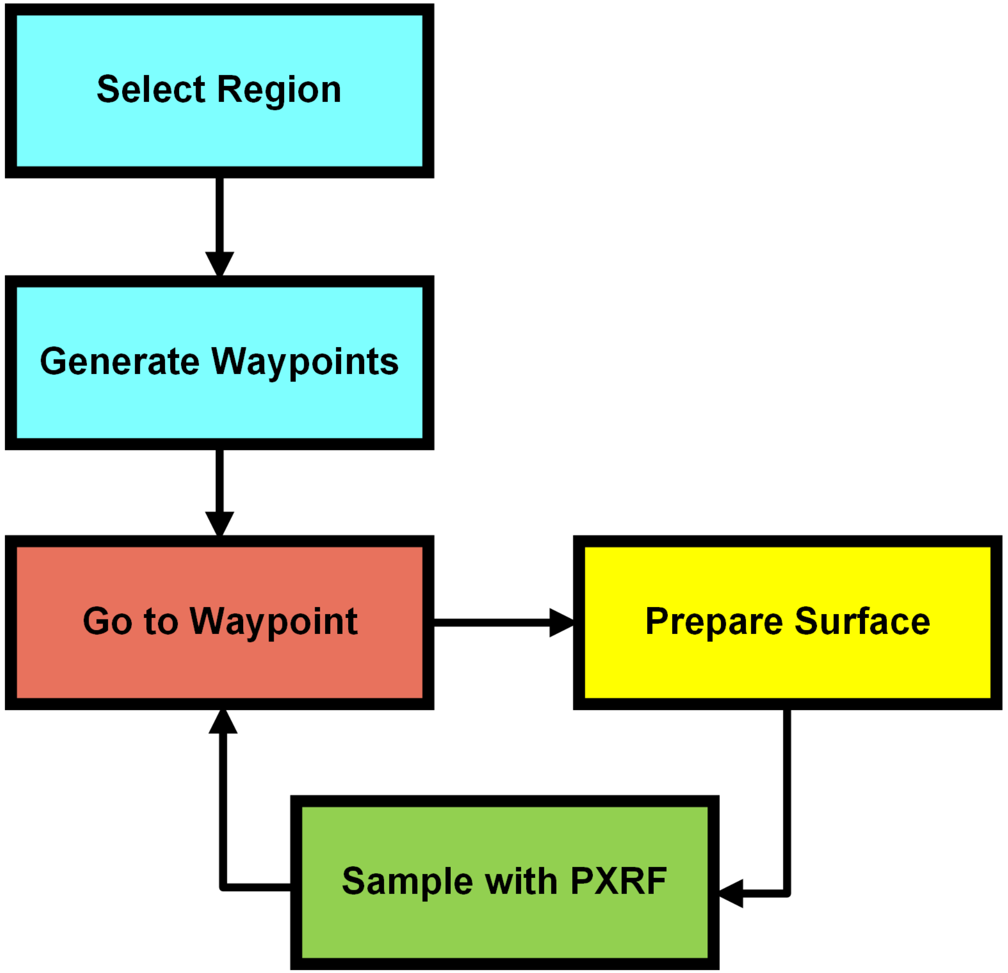
Sampling across impacted areas in difficult terrain is challenging

Our goal is to have robots do autonomous exploration and characterization instead of people

A waypoint based mobile robot can characterize analytes

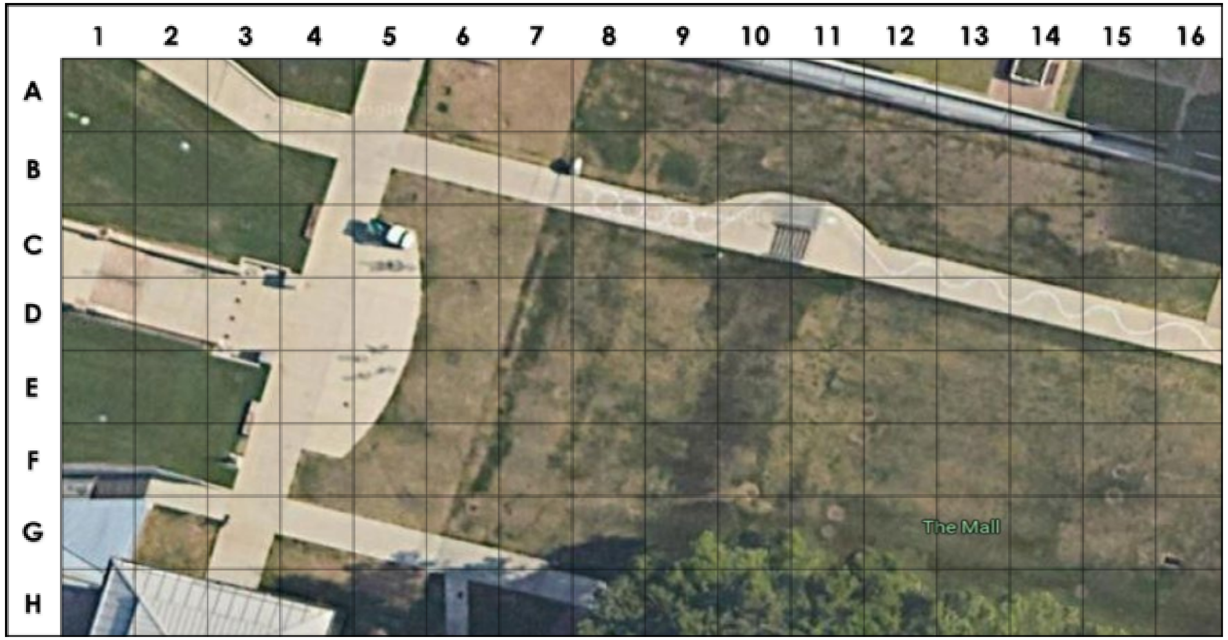
- The user selects a region by clicking points on satellite imagery
- The robot generates a list of waypoints to visit within that region
- The robot goes to each waypoint to take a sample




HEBI

We need to navigate across an area to characterize it

- Many measurements must be taken to fully characterize an area
- Robot can not only take samples but also navigate exactly where it needs to go while avoiding obstacles



What are the challenges with multi-purpose robot solutions?

Every robot must go somewhere and perform a function

- Needs to be able to navigate the widest variety of environments with the largest amount of flexibility.
- Needs to have a flexible assortment of tools for each sampling environment.

A robot must know where it is and avoid obstacles

- A robot must be able to localize within the world.
- A robot must be able to see where it is going to avoid obstacles.

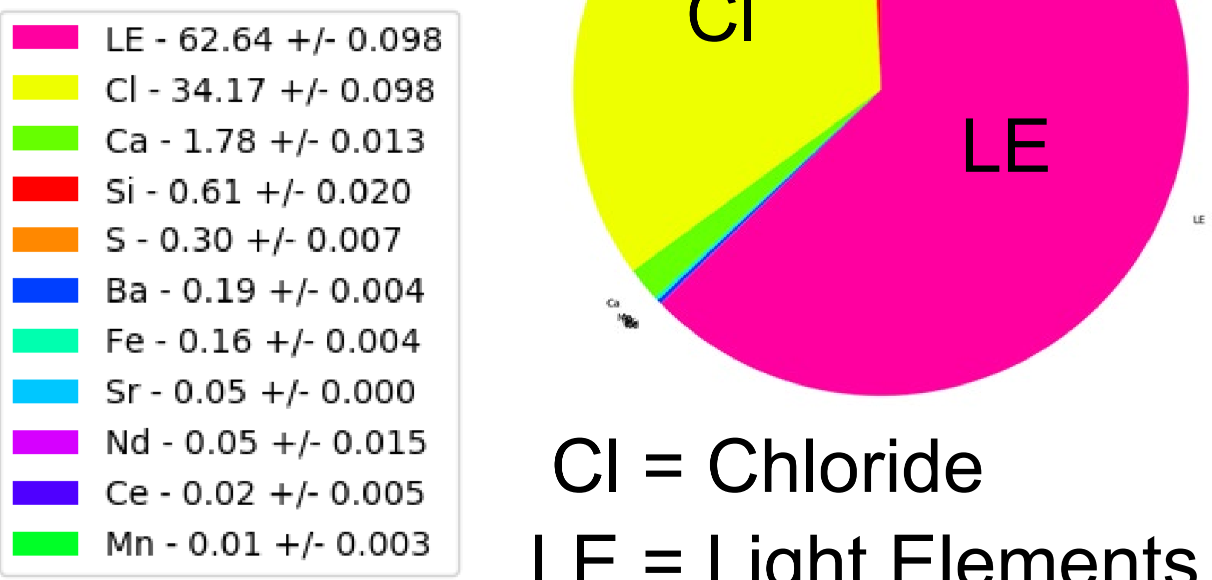
How does the system operate?

Navigation is needed for proper autonomy

- Navigate to points of interest in the world
- Points of interest exist as waypoints
- Avoid obstacles along the way

Analytes must be measured in real time

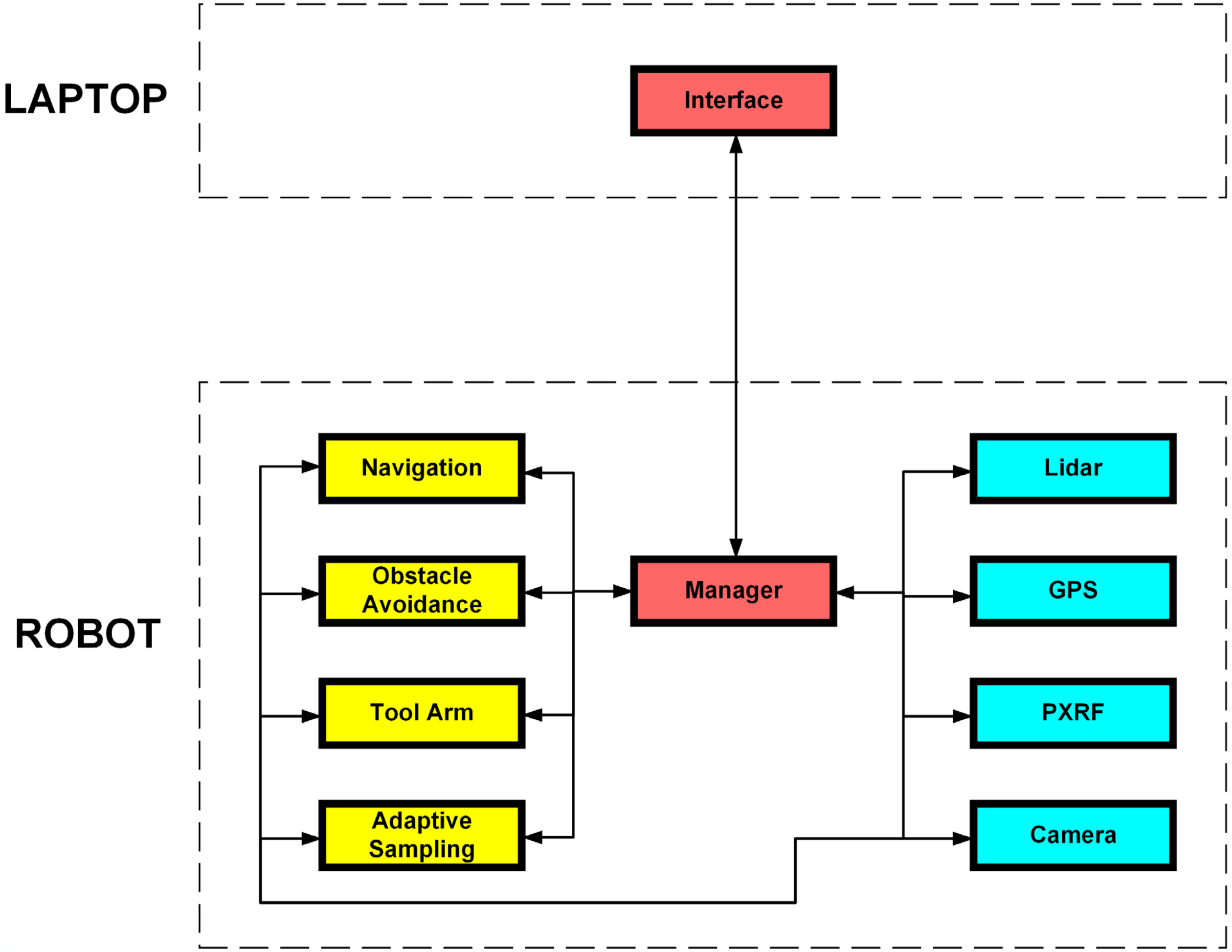
- Obtain quantitative information about soil concentrations in *real time*
- Return this data in the form of visual graphics



Cl = Chloride
LE = Light Elements

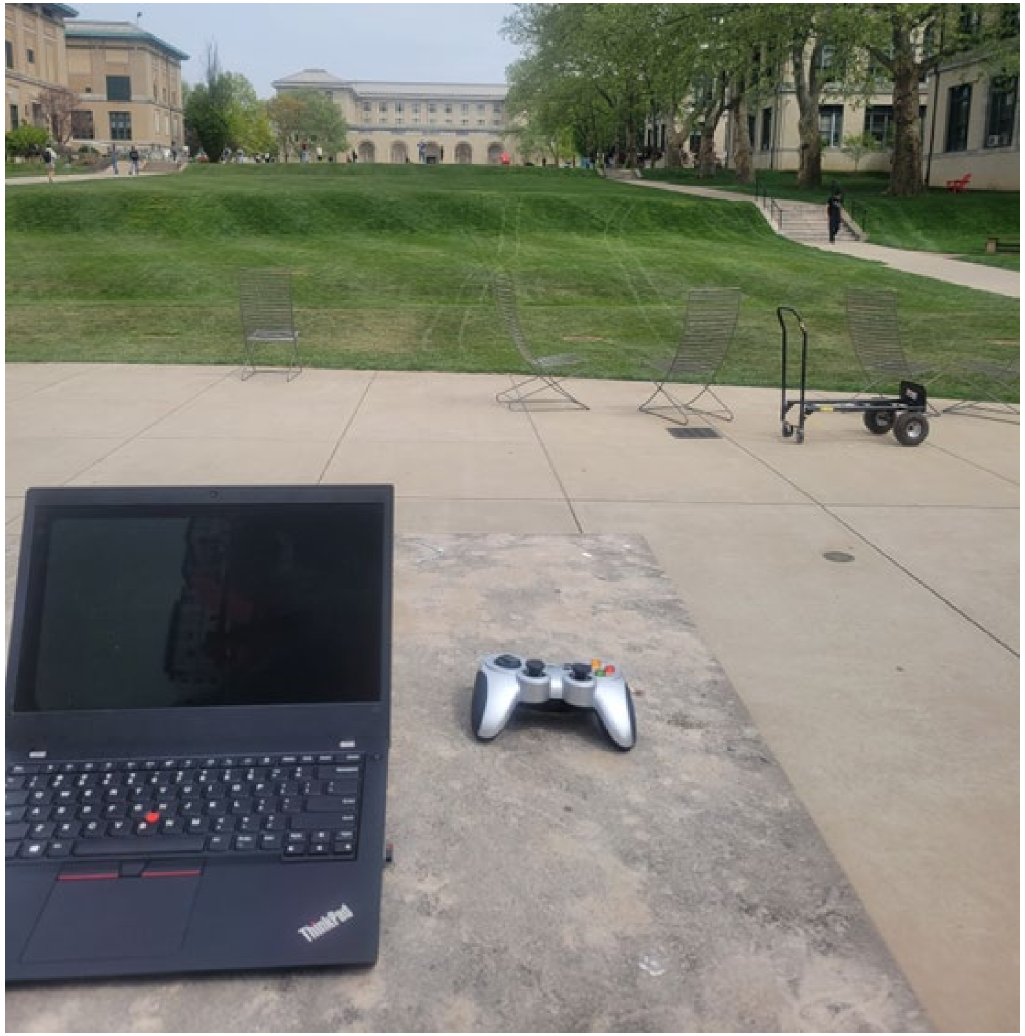
Robot performs its tasks in isolation

- All the autonomy happens on the robot.
- Other devices only serve as an interface for the robot.



Manual control offers greater flexibility

- A human can take control at any time!
- Control the camera to investigate environmental features remotely!



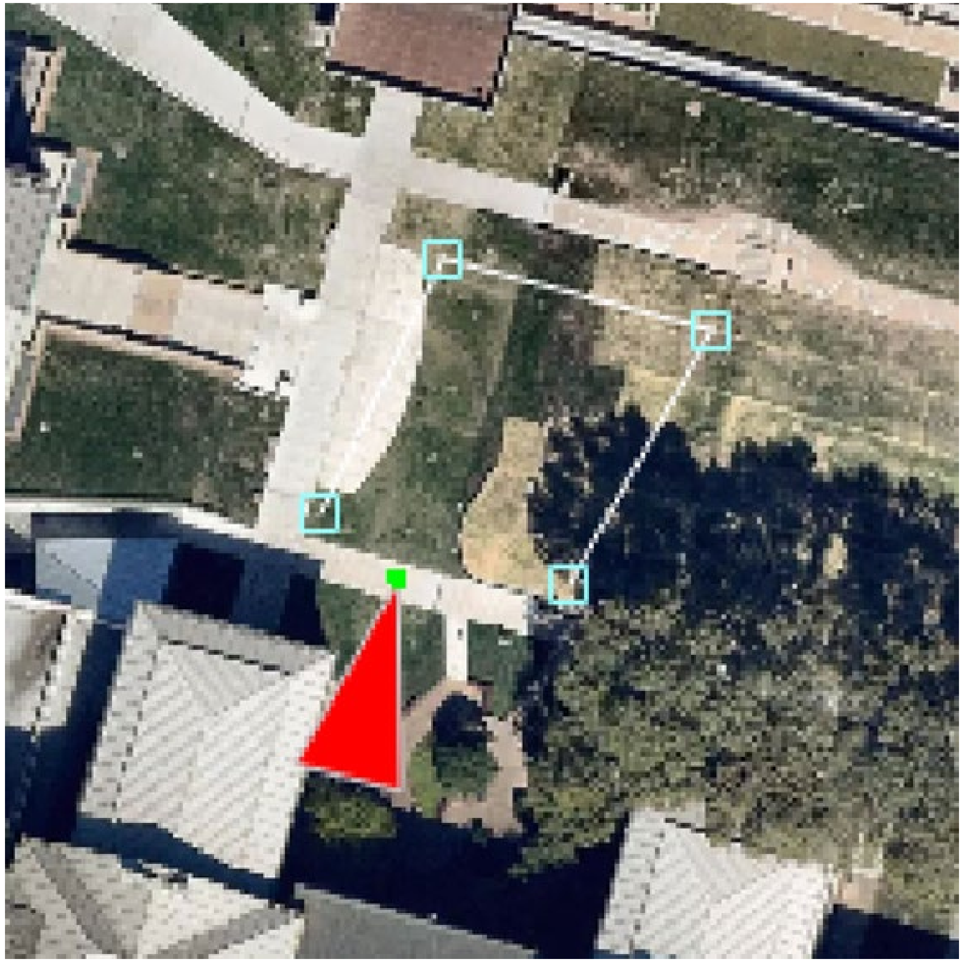
How does the robot know where it is as it explores?

Position can be projected onto satellite imagery

- Cached satellite imagery represents the environment.
- Robot position is marked on the map.

Regions can be selected for exploration

- The user click on points on the map.
- These points act as boundaries for exploration and sampling.



Scripted behaviors happen at each waypoint

- The robot goes from waypoint to waypoint.
- Scripted behaviors take place at each waypoint.

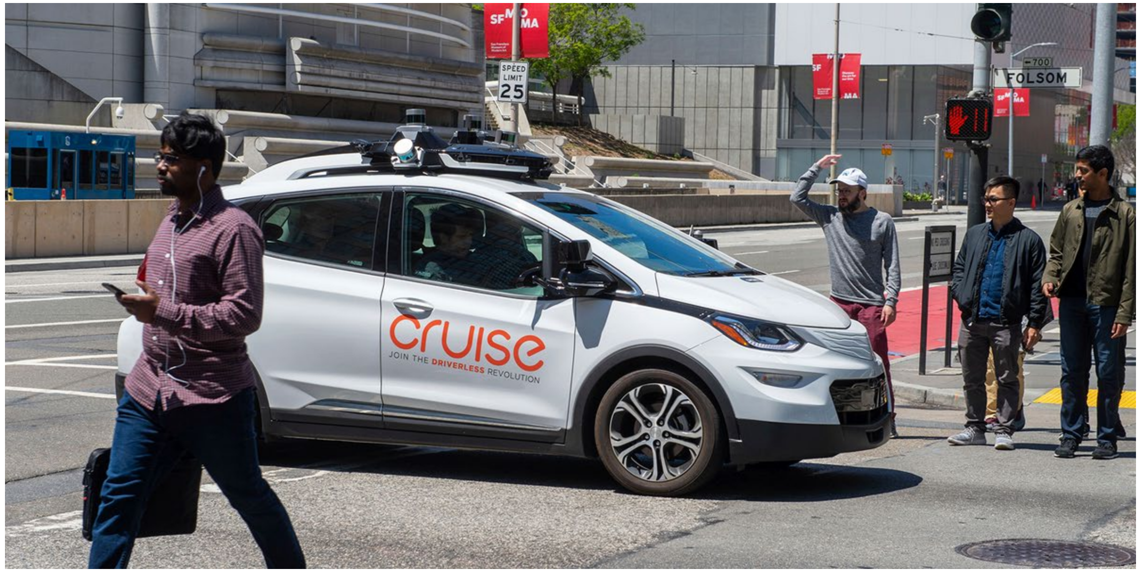
Position is obtained from GPS data

- Lat-Long is converted to local XY coordinates (UTM)

Place	Latitude	Longitude	UTM Easting	UTM Northing	X (m)	y (m)	X (yd)	Y (yd)
SW	39.743529	-105.020412	498251.14	4399292.28	0	0	0	0
SE	39.743528	-105.019835	498300.57	4399292.15	49.43	-0.13	54.06	-0.14
NW	39.744357	-105.020401	498252.1	4399384.17	0.96	91.89	1.05	100.49
NE	39.744353	-105.019828	498301.02	4399383.16	49.88	90.88	54.55	99.39

How does obstacle avoidance fit in?

There is no “off the shelf” obstacle avoidance

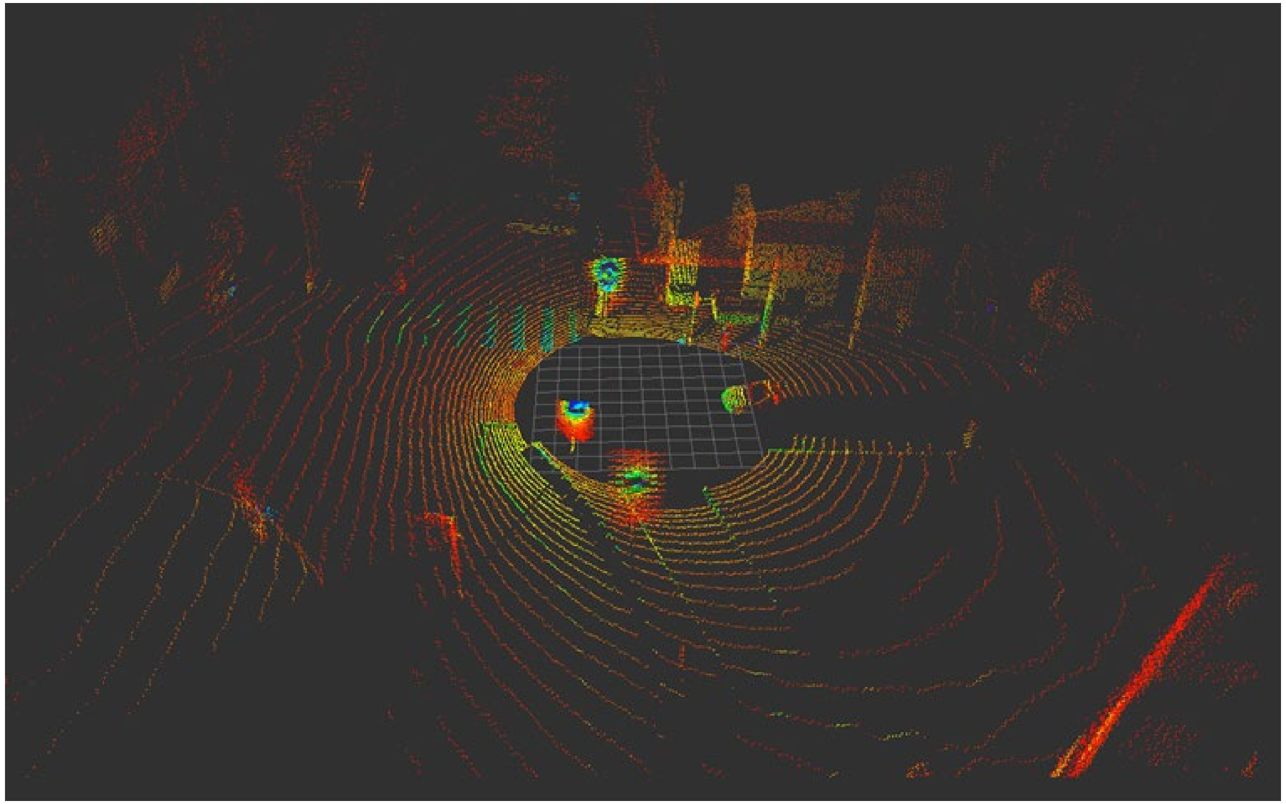


Lidar is our primary source of vision

- Measures distances to surfaces in 3D space.
- Standard effective range of 90 meters in all directions.
- Returns data in the form of a point cloud.

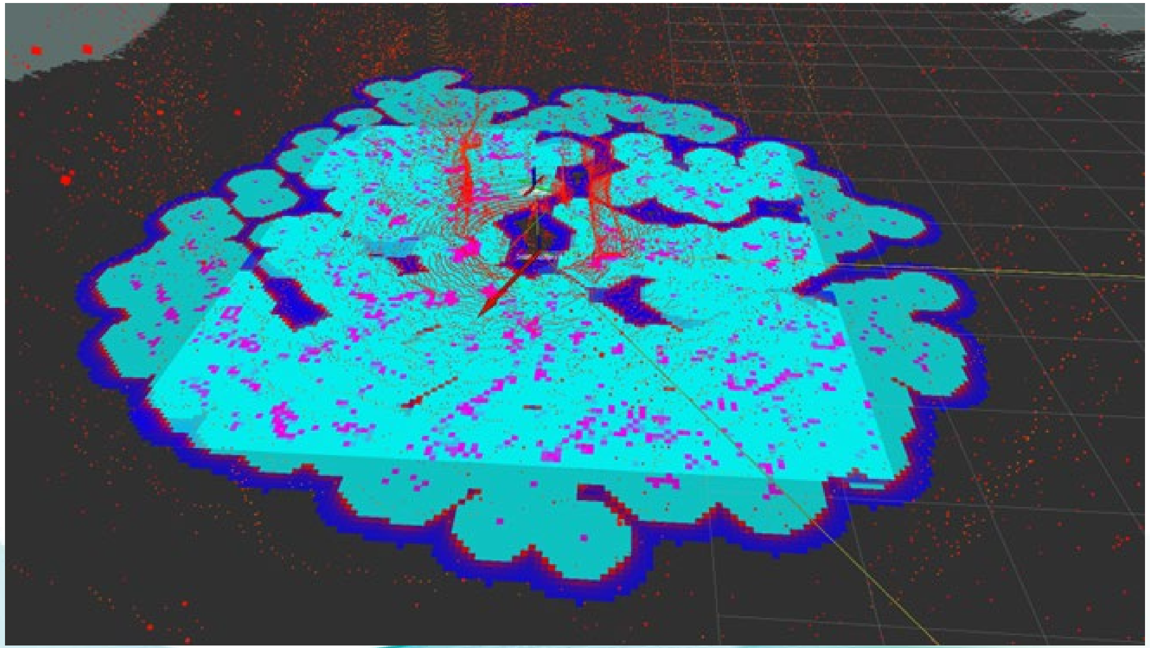
Point clouds represent surfaces

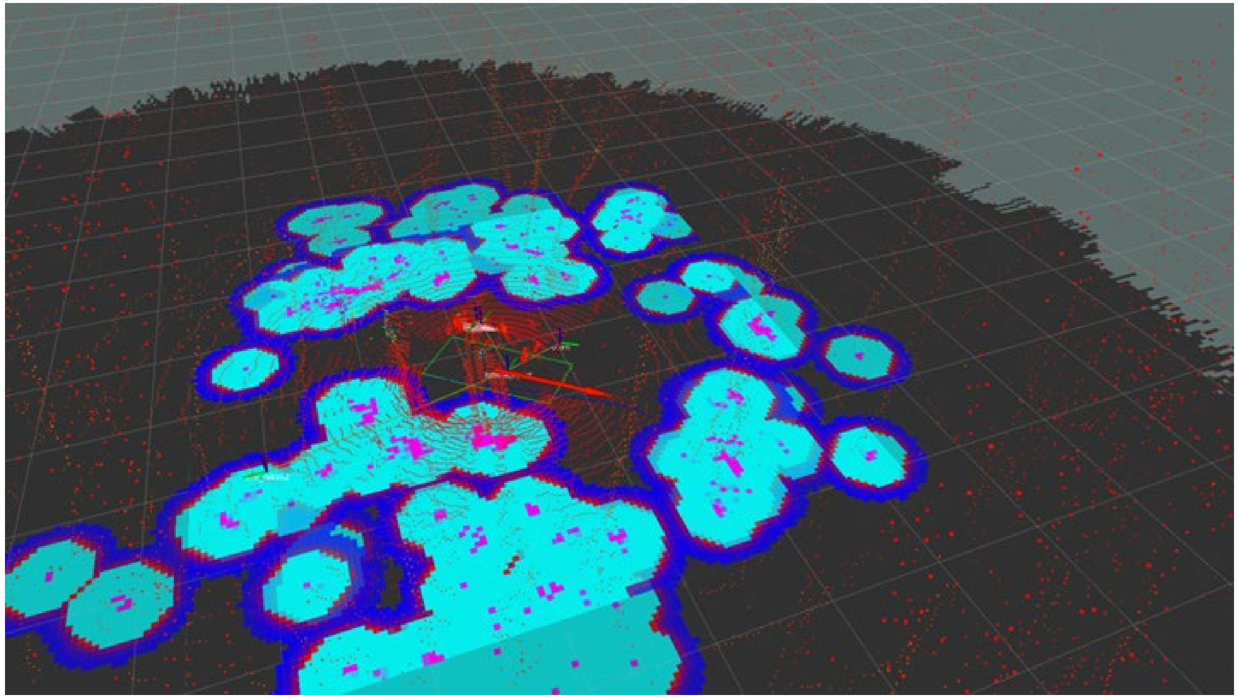
- Point clouds are a collection of points that represent surfaces in 3D space.
- Mostly used in urban or indoor environments where surfaces are clearly defined.



Different maps are created depending on the environment

- Obstacles in point clouds are assigned a cost for the robot to avoid.
- Cost maps show where the robot cannot go.





Outer Exclusion Zone
Inner Exclusion Zone
Obstacle

Outdoor environments have different vegetation densities

What are the takeaways?

Robots can navigate the outdoors while autonomously characterizing analytes in real time!

We are working to continue to improve robot adaptability for a greater number of environments!

Thank you!
Questions?