Technology to Ensure Equitable Access to Automated Vehicles for Rural Areas

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Acknowledgement

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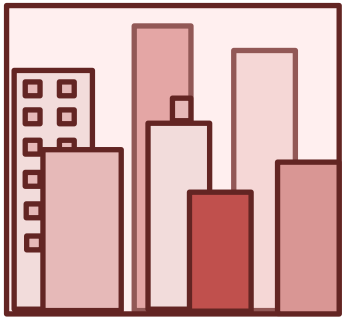
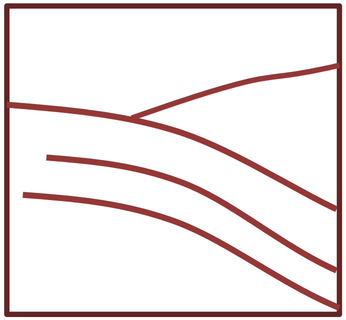
SAFE-D
SAFETY THROUGH DISRUPTION

Motivation

- Rural roads play a significant role in America's transportation system, safely moving people and goods to their destinations
- 19% of Americans live in rural areas but 68% of the roads are in rural areas



Urban
1,059 lane miles
per 100K residents



Rural
9,635 lane miles
per 100K residents

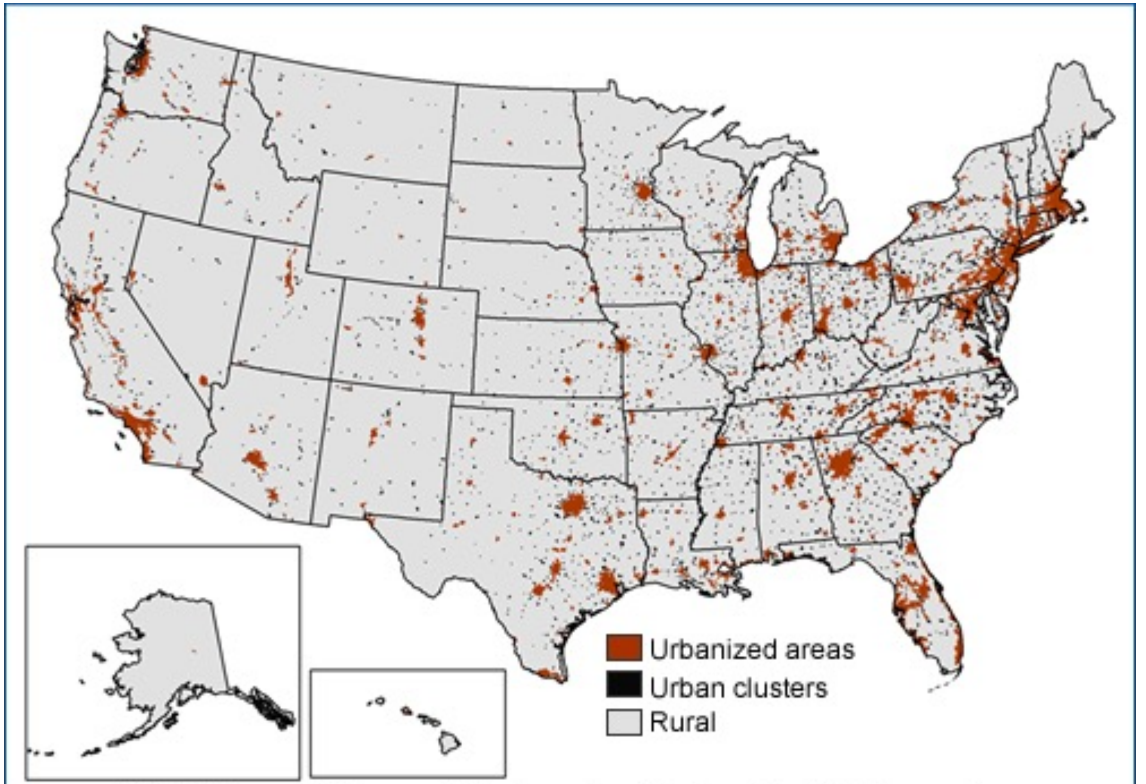
Source: Bureau of Transportation Statistics

Motivation

Usage

Large volumes of freight either originate or are transported through rural areas

46% of Truck VMT* (Vehicle Miles Travelled) occur in rural areas



Source: USDA, Economic Research Service using data from the U.S. Census Bureau.

*Source: Bureau of Transportation Statistics

Objectives

- Prepare high quality annotated datasets for evaluation and testing of algorithms in Rural Scenes
- Explore the use of topological maps such as Open Street Maps in conjunction with onboard sensors for Autonomous Navigation
- Develop and implement algorithms to localize the vehicle with respect to boundaries of a road in Small and Rural Communities (SRC's) and navigate the vehicle accordingly
- Test developed algorithms and corroborate their performance in real-time

Urban vs Rural Communities

Variance in Rural Road Scenes

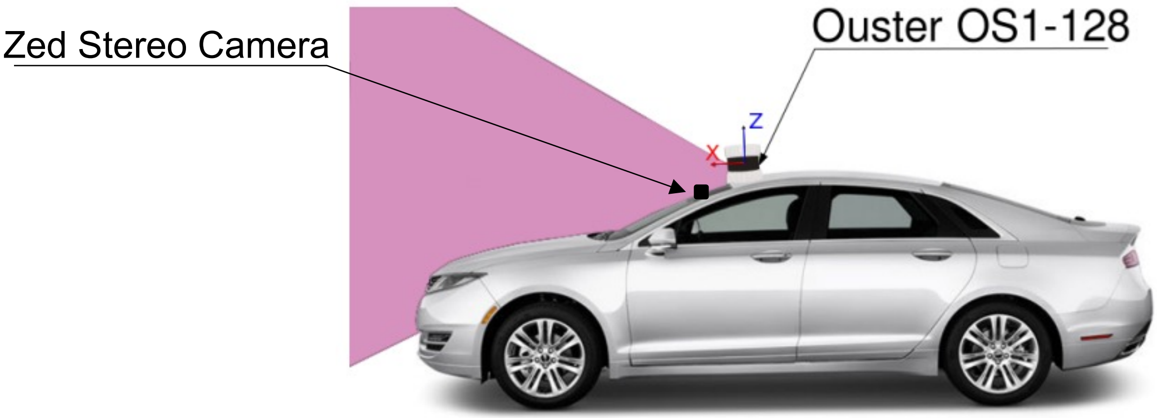
Urban vs Rural Communities

	Urban	Rural
Road Surface	Asphalt, Concrete	Asphalt, Concrete, Gravel, Dirt
Sidewalks/ Curb	Yes	No
Lane Markings	Yes	Inconsistent
Edge Markings	Yes	Lacking/ Inconsistent
Number of Lanes	2-5	2
Vegetation	Minimal	Yes
Road Users	Cars, Pedestrians, Cyclists	Cars, Freight Trucks, Tractors, Pedestrians
	Well Structured	**Less Structured** **Large Variations in road surface, landscape**

Existing Datasets

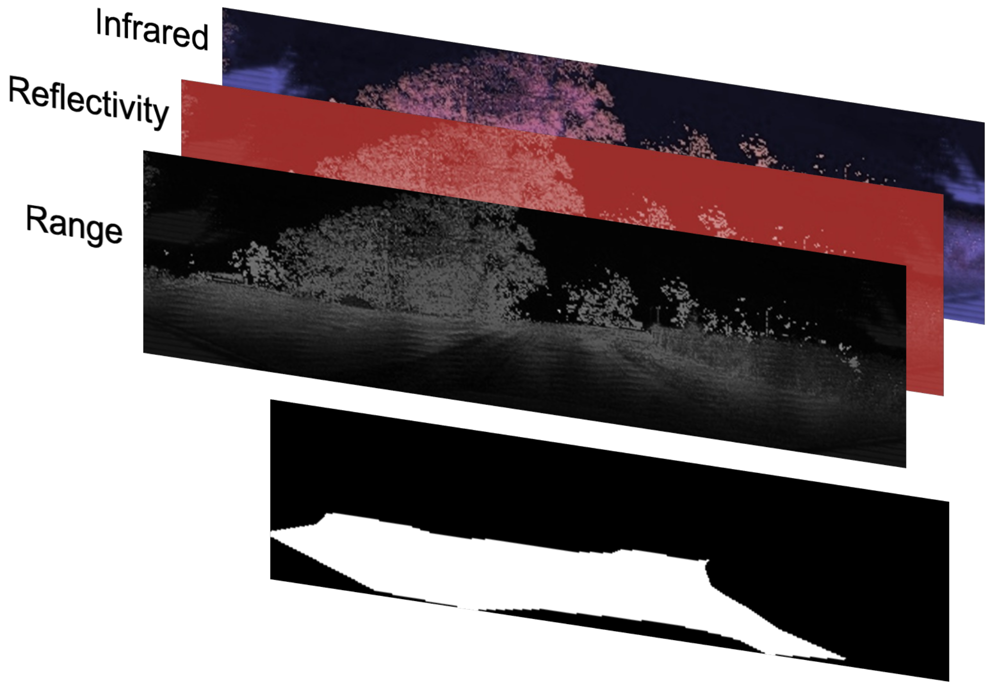
	CamVid	KITTI	CityScapes	NuScenes	Waymo	HSI Road	Ours
Year	2008	2012	2016	2019	2019	2020	**2022**
Landscape	Urban	Urban	Urban	Urban	Urban	Rural	**Rural**
LIDAR Channels	-	64	-	32	130+	-	**128**
Camera	Monocular	Stereo	Monocular	Monocular	Monocular	Monocular (HSI)	**Stereo**
Radar	No	No	No	Yes	Yes	No	**No**
GPS+IMU	No	Yes	GPS	Yes	Yes	No	**Yes**
Image Labels	Semantic	Semantic	Semantic	3D Boxes	3D Boxes	Semantic (only road)	**Semantic**
Point Cloud Labels	-	Semantic*	-	Semantic*	3D Boxes	-	**Semantic**

Dataset Specifications



- ~ 2 hours of rural road driving data
- 4 Annotated Classes (Vehicle, Pedestrian, Cyclist, Traffic Sign)
- LiDAR: 128 Channel, ~130K points per point cloud, 75m range
- Available LiDAR channels: Range, Reflectivity, Infrared, Intensity
- Camera: Zed Stereo with range 40m
- Rural Scenes recorded at 5 Hz + semantic scene annotations
- Metadata: GPS, IMU data for each frame, Camera intrinsic and extrinsic parameters
- KITTI style data organization for ease of use

Rural Road Dataset



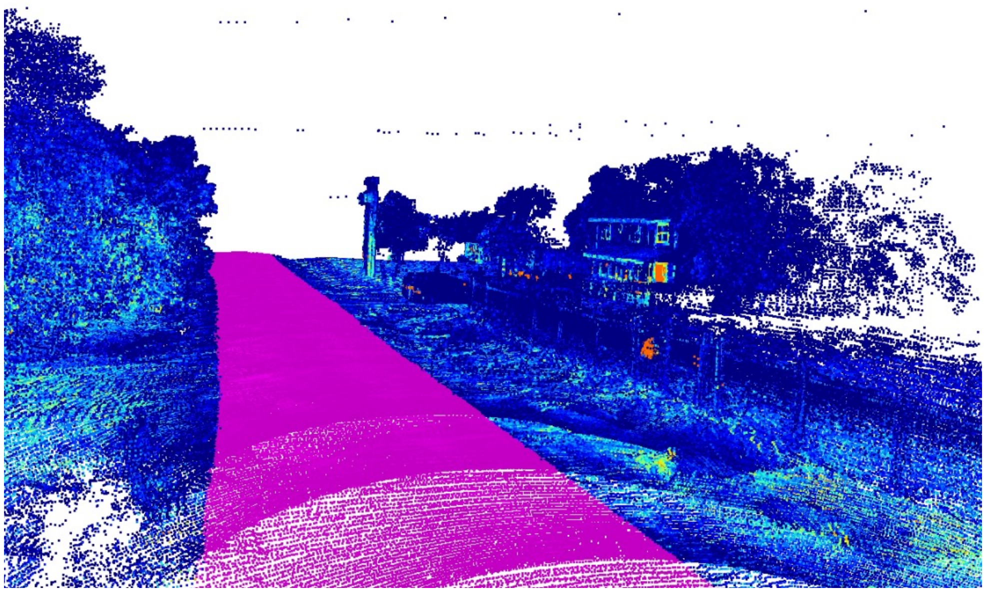
3 Channel LIDAR Range Image

Segmentation Mask

2800 Images + Point Clouds

Available at Safe-D Dataverse : **Autonomous Vehicle Rural Road Dataset (06-004)**

Rural Semantic Scenes



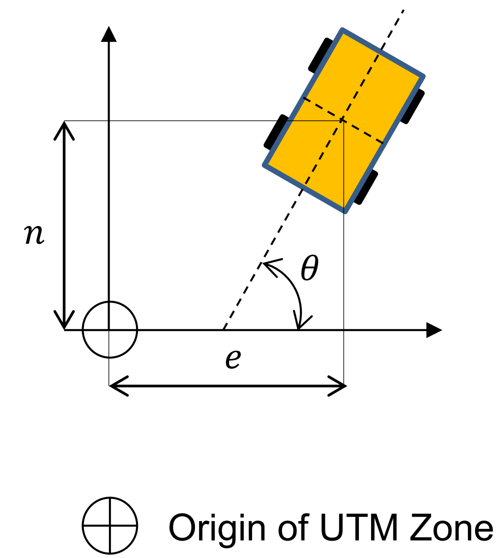
4000+ Samples
4 Annotated Classes (Vehicle, Pedestrian, Cyclist, Traffic Sign)
Semantic Point Cloud Segmentation, Image Segmentation
GPS+IMU

LIDAR aided Localization using Open Street Maps for Rural Roads

Problem Statement

Given sensor readings (LIDAR/Camera) and odometry measurements, estimate the vehicle's pose on a topological map.

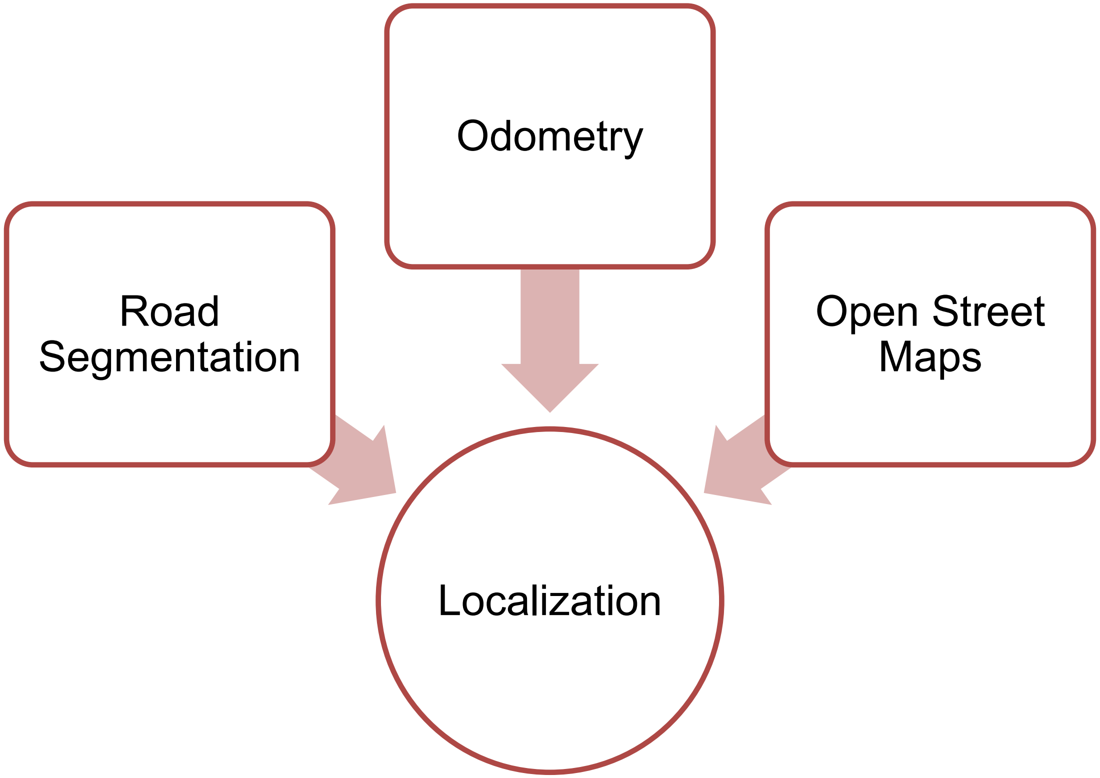
Pose $(x) = [e, n, \theta]$



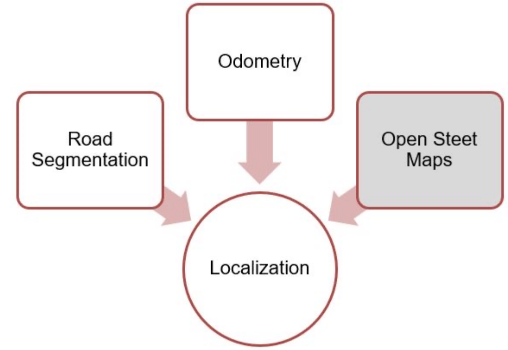
Where,

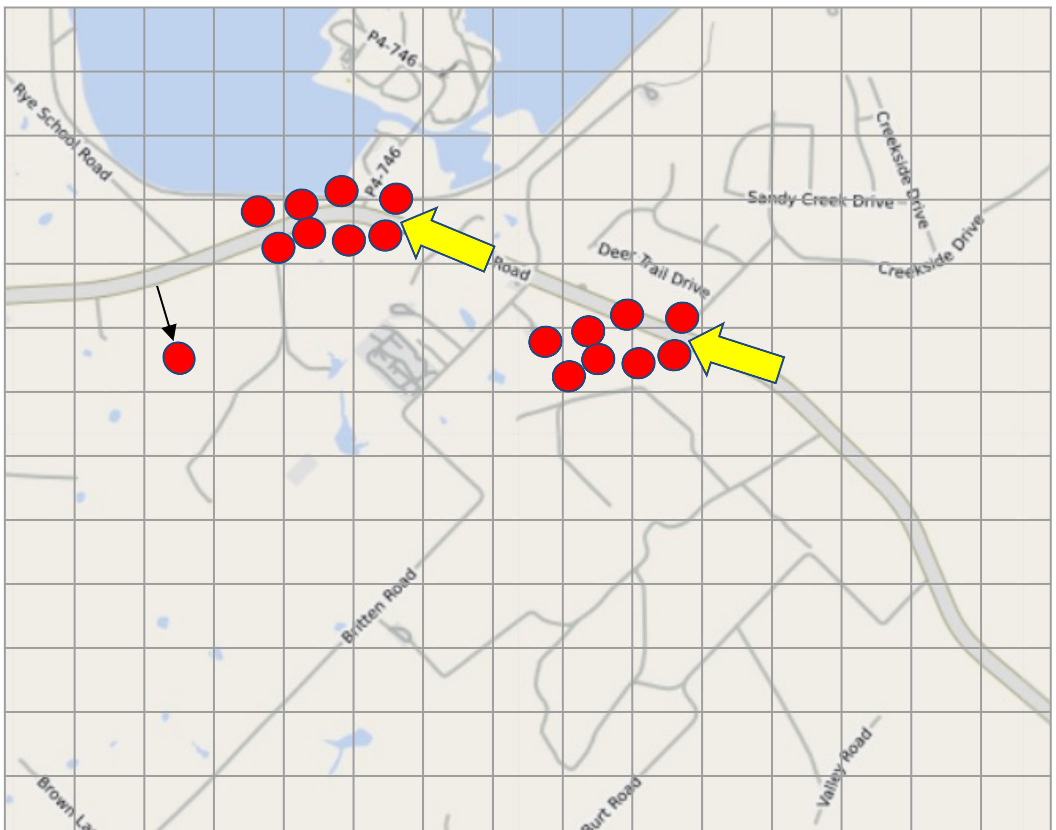
e = Easting Coordinate (UTM)
n = Northing Coordinate (UTM)
θ = Orientation

Architecture



Road Network Data

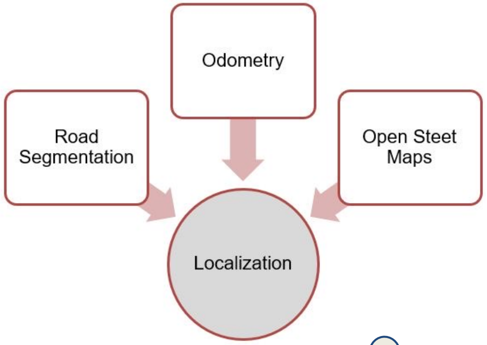




Projected Road Points

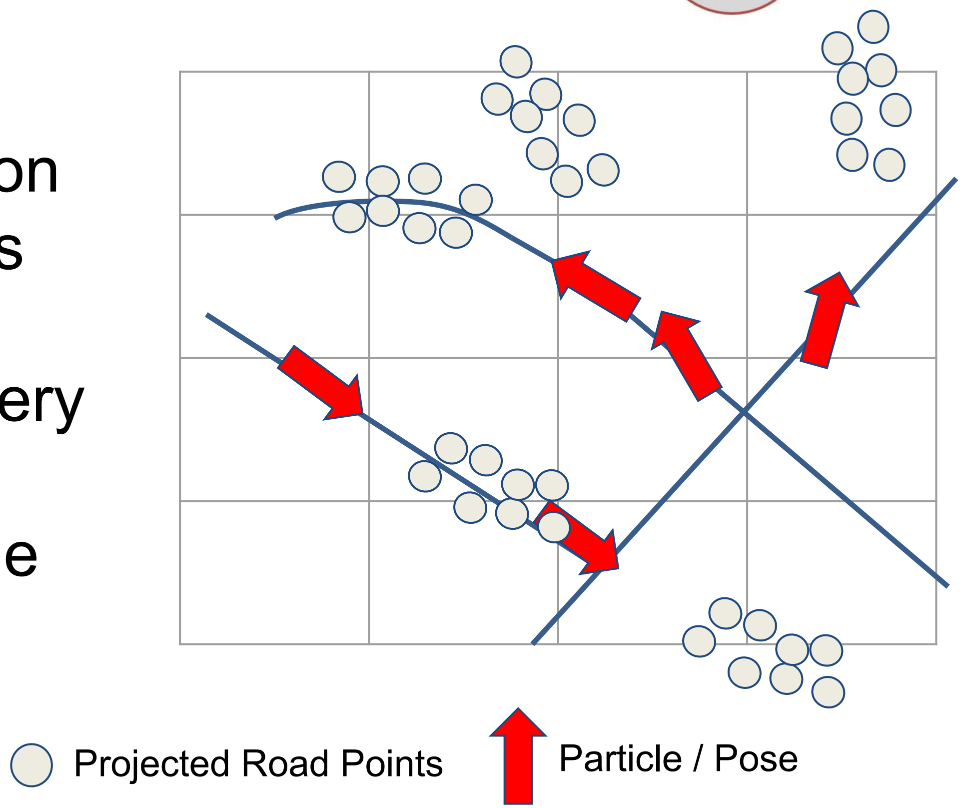
Pose / Particle

Localization Module

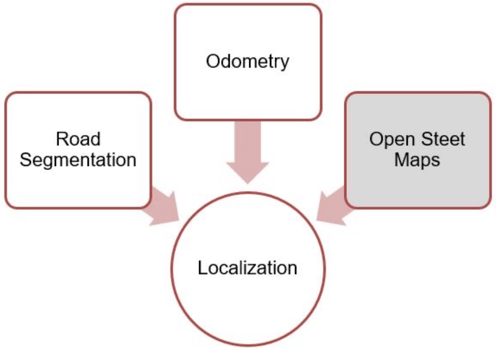


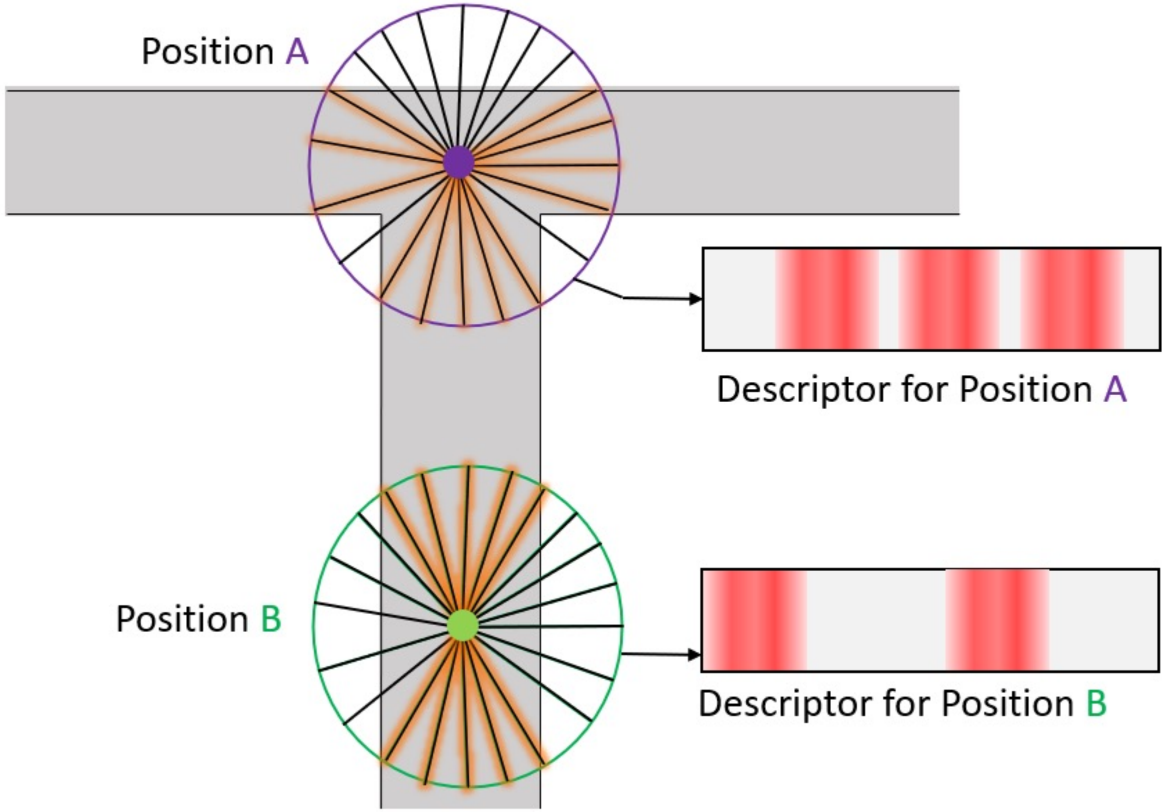
Four step operation:

1. Initialize particles
2. Update particles based on odometry measurements
3. Assign particle weights based on distance to query descriptor
4. Sample based on particle weights

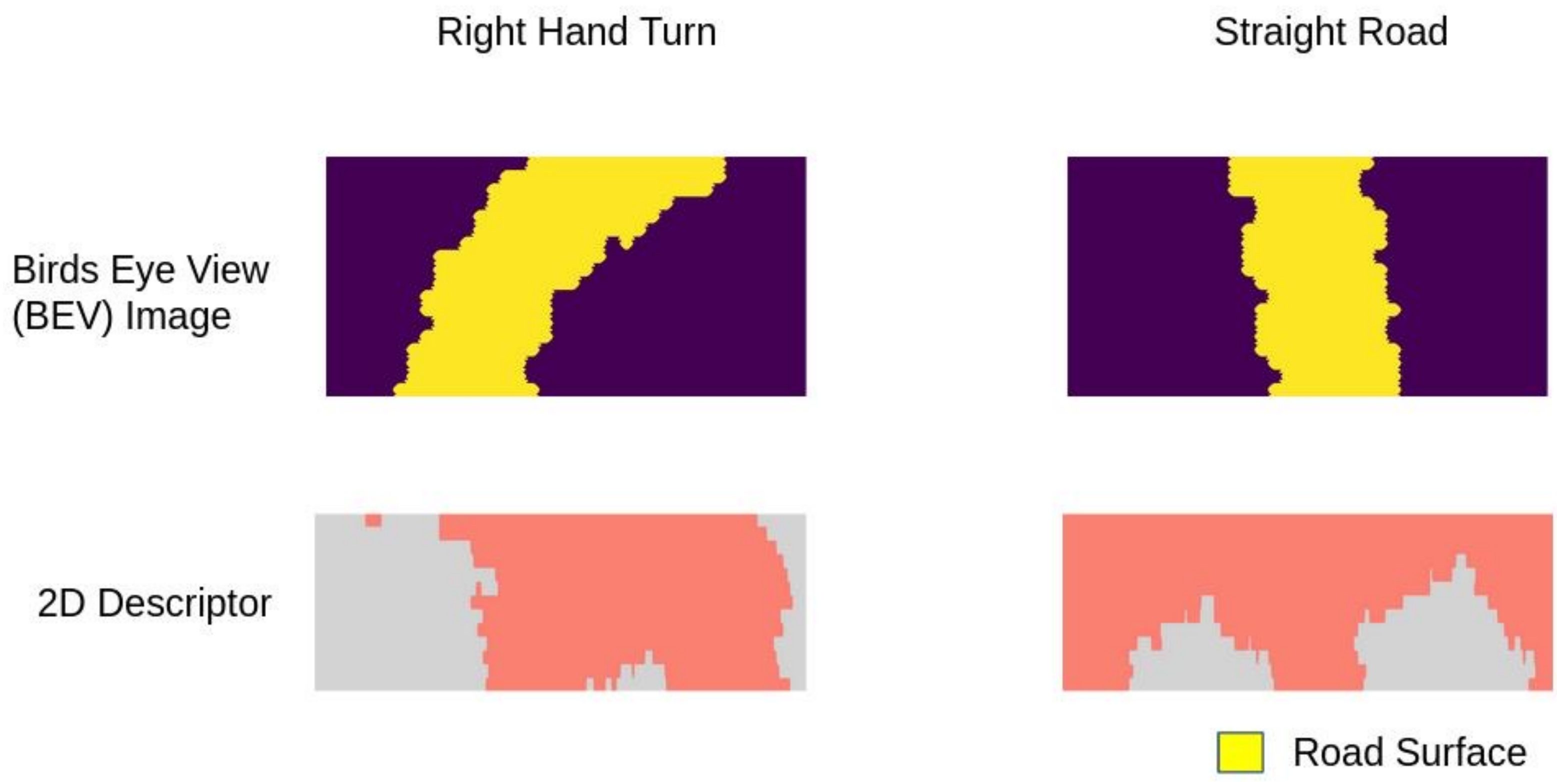


Road Descriptors

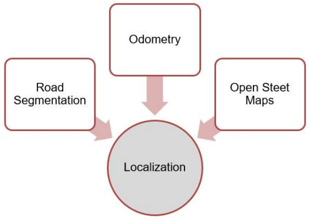


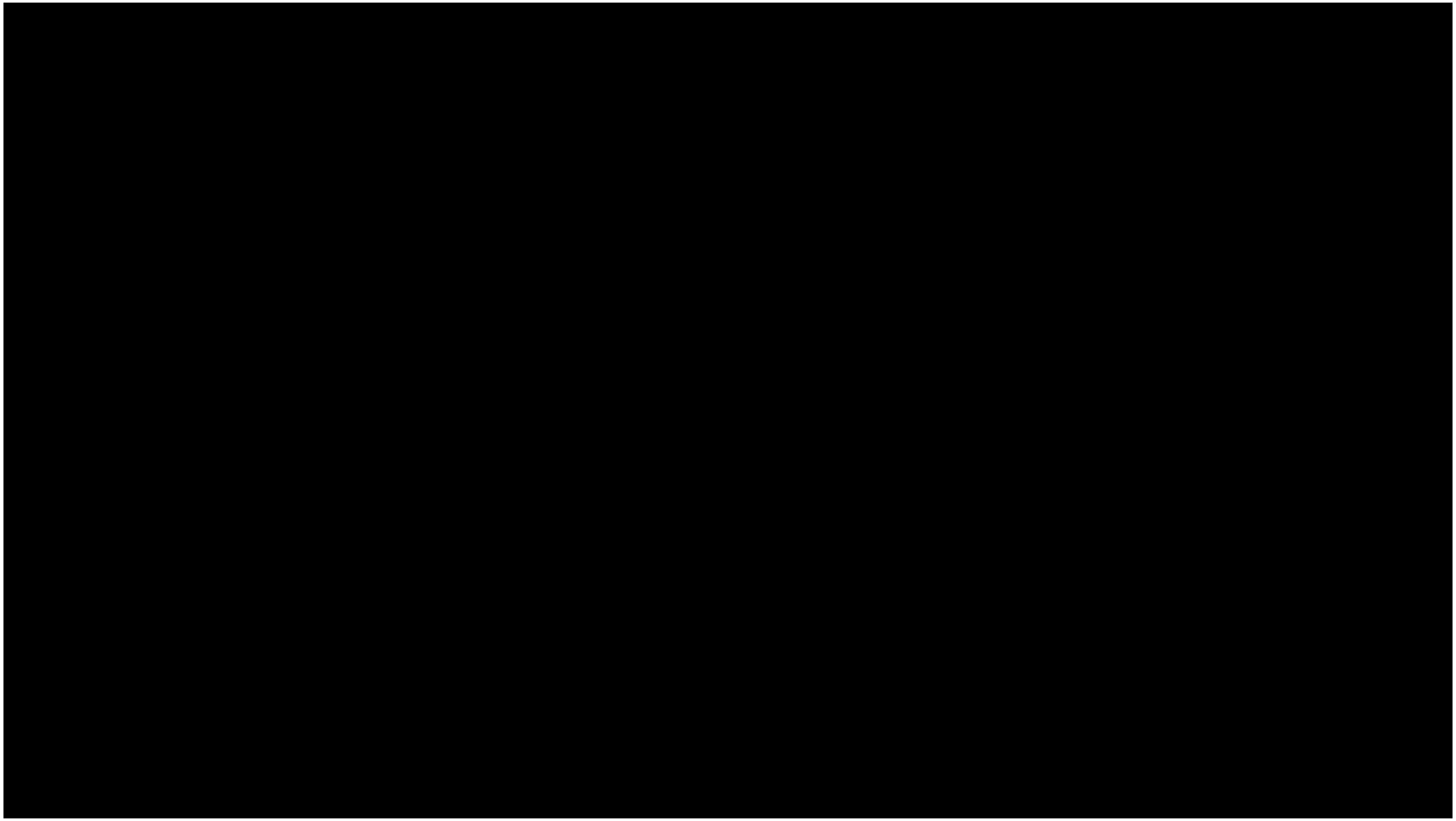


Road Descriptors

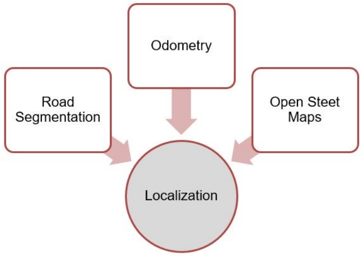


Localization





Future Work



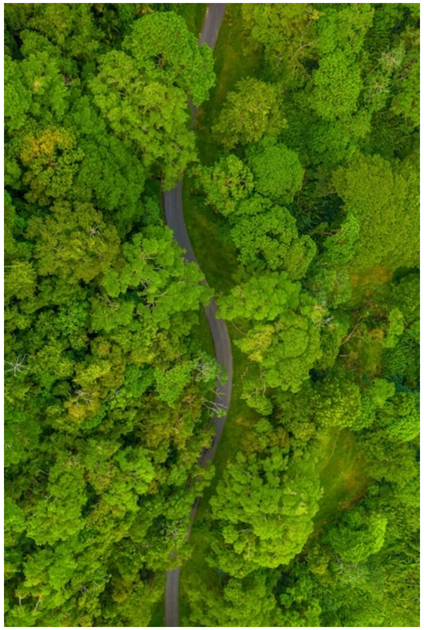
- Release of Semantic Rural Road Dataset
- Object Detection and Tracking
- Motion Planning and Autonomous Navigation using Open Street Maps

Thankyou!

Appendix

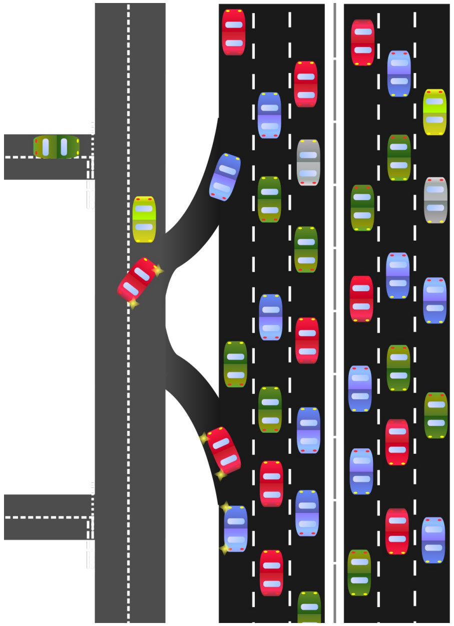
TEXAS A&M UNIVERSITY

Use Cases for Localization Algorithm



Roads with overhead vegetation

Limited visibility of the sky



Frontage Roads

Urban vs Rural