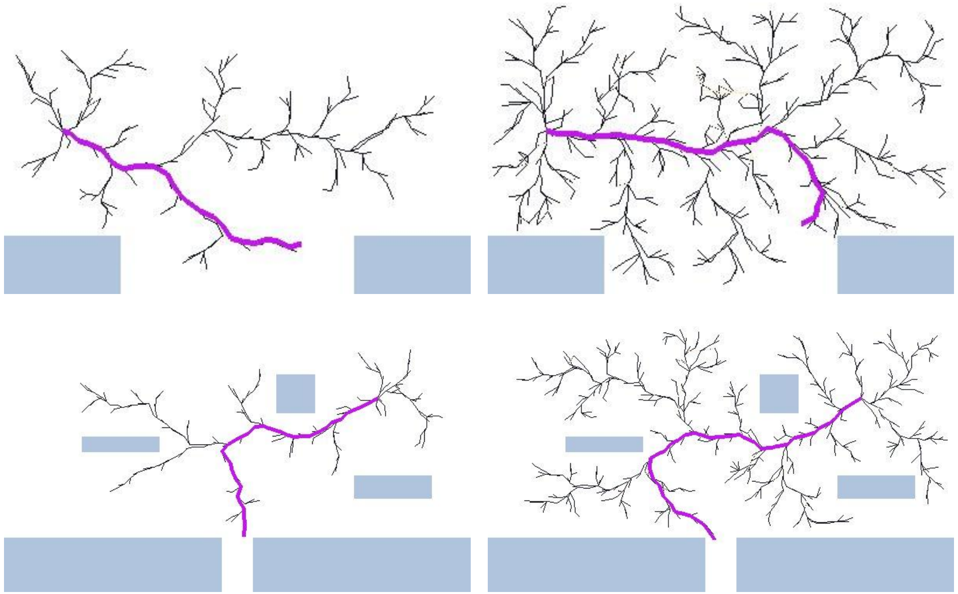
Learning Based Sampling For RRT* Algorithm

EECS 545 - Final Project

Li Chen, Yue Du, Yeyang Fang, Daiyao Yi, Xuran Zhao

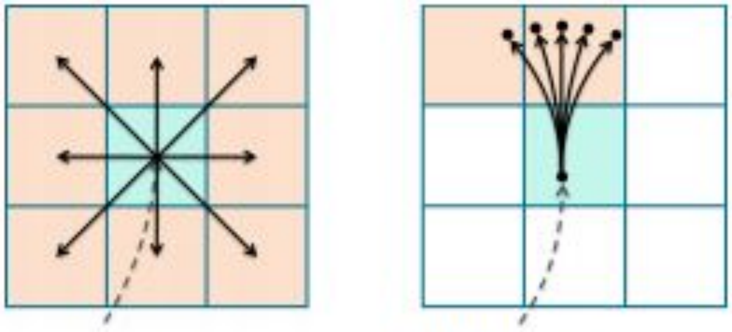
Introduction

- Traditional RRT* path planning includes uniform sample in the planning space. This results in long converge time.
- We proposed a learning based sampling method for RRT* planning to get a faster planning performance.



Data generation

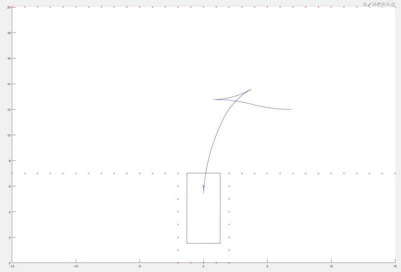
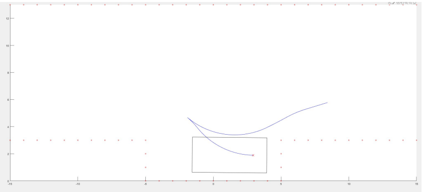
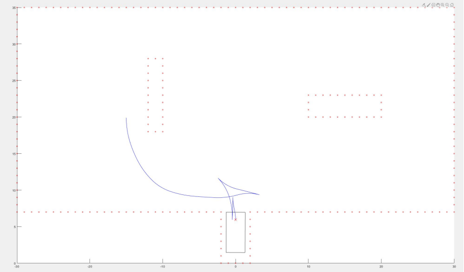
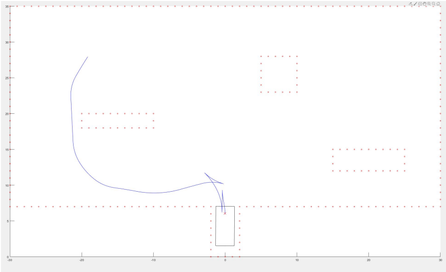
We used hybrid A* to generate the training data. It can generate a smooth path in a given 2-D space for vehicles.



(a) regular A*   (b) Hybrid A*

Data generation

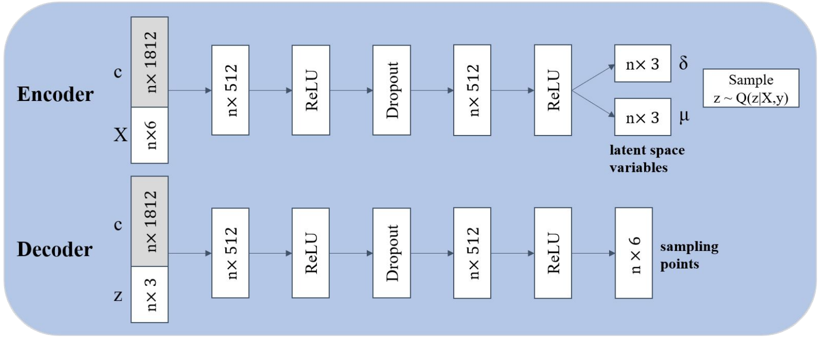
We considered four scenarios to generate the training dataset of the network.

No.	Obstacle?	Dimension	Scenario	Trajectory Generated	Data Generated
1	No	20m x 30m	Reverse Parking	154	2310
2	No	13m x 30m	Parallel Parking	138	2055
3	Yes	35m x 60m	Reverse Parking	1001	15015
4	Yes	35m x 60m	Reverse Parking	507	7605

Conditional Variational Autoencoder (CVAE)

- Contains encoder Q(z|X,c) and decoder P(X,z|c)
  - z - latent space variables
  - X - sampling points ($X = \begin{bmatrix} x & y & \theta & \dot{x} & \dot{y} & \dot{\theta} \end{bmatrix}$)
  - c - conditions, in our case maps and initial/end points



- Maximizing:

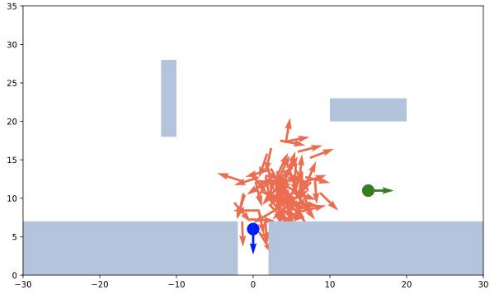
$$\|x - f(z,y)\|^2 - D_{KL}(\mathcal{N}(\mu(x,y), \Sigma(x,y)) \,\|\, \mathcal{N}(0,I))$$

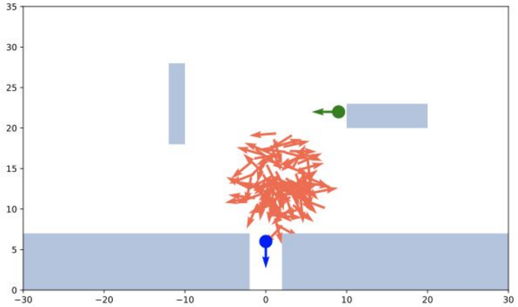
- Loss Function: $L = L_{recon} + \omega L_{KL}$ (ω - weighting parameter)

UNIVERSITY OF MICHIGAN

Sampling Learning - Orientation Improvements

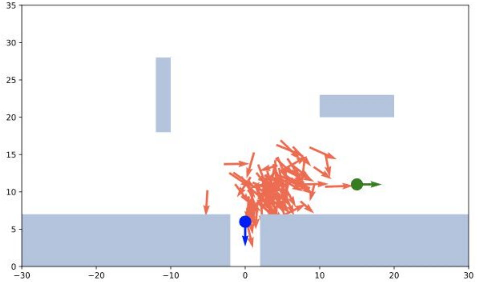
$$X = [x \quad y \quad \theta \quad 0 \quad 0 \quad 0]$$

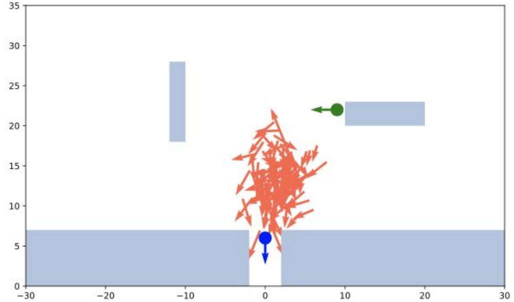




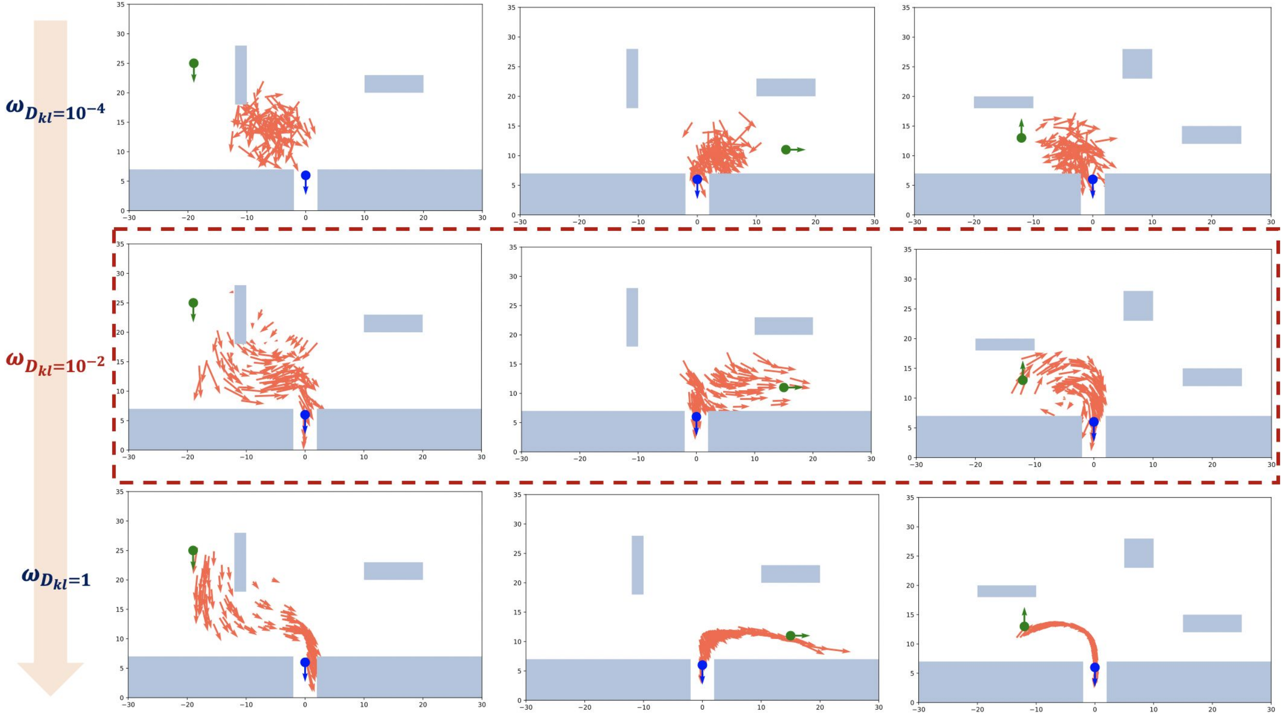
Include angle training

$$X = [x \quad y \quad 0 \quad cos(\theta) \quad sin(\theta) \quad 0]$$

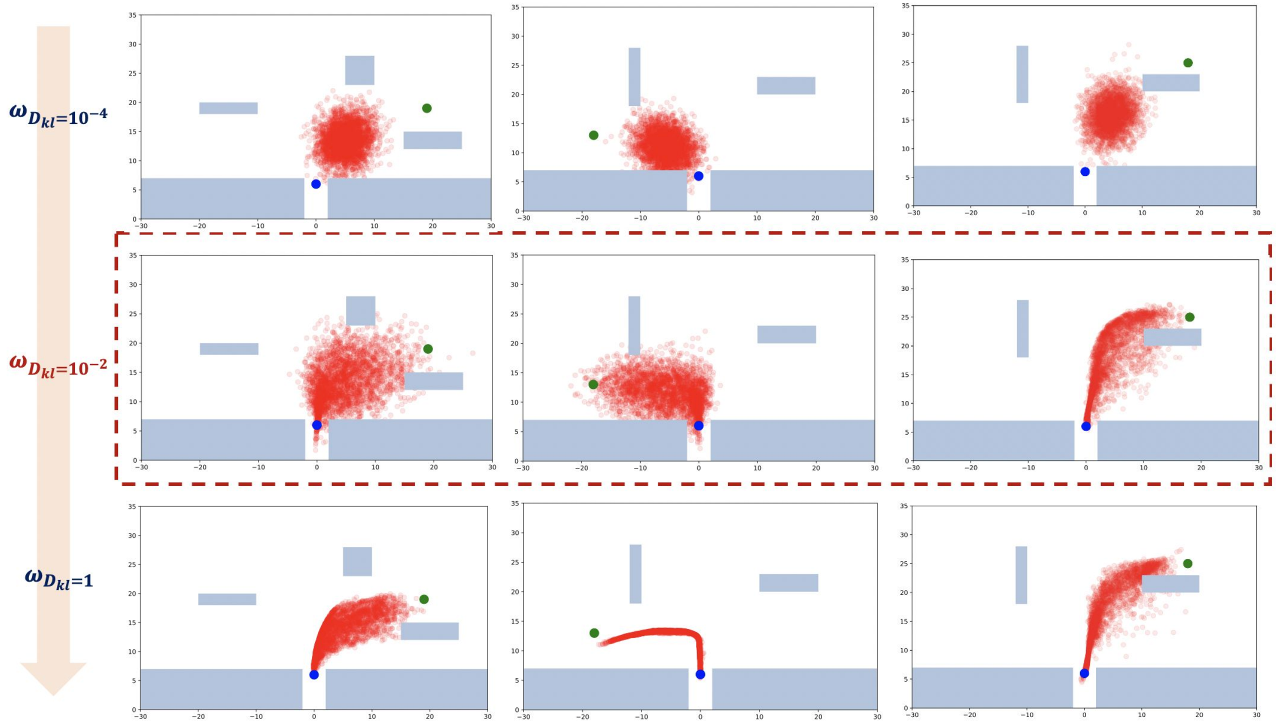




Sampling Learning - Weighted Loss

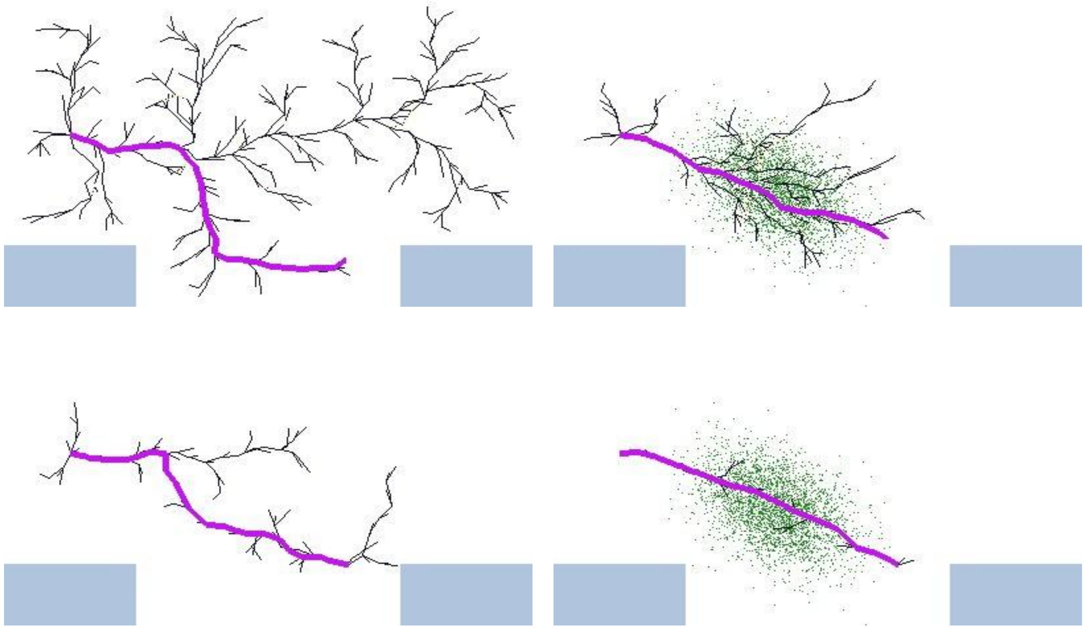


Sampling Learning - Weighted Loss



Simple map

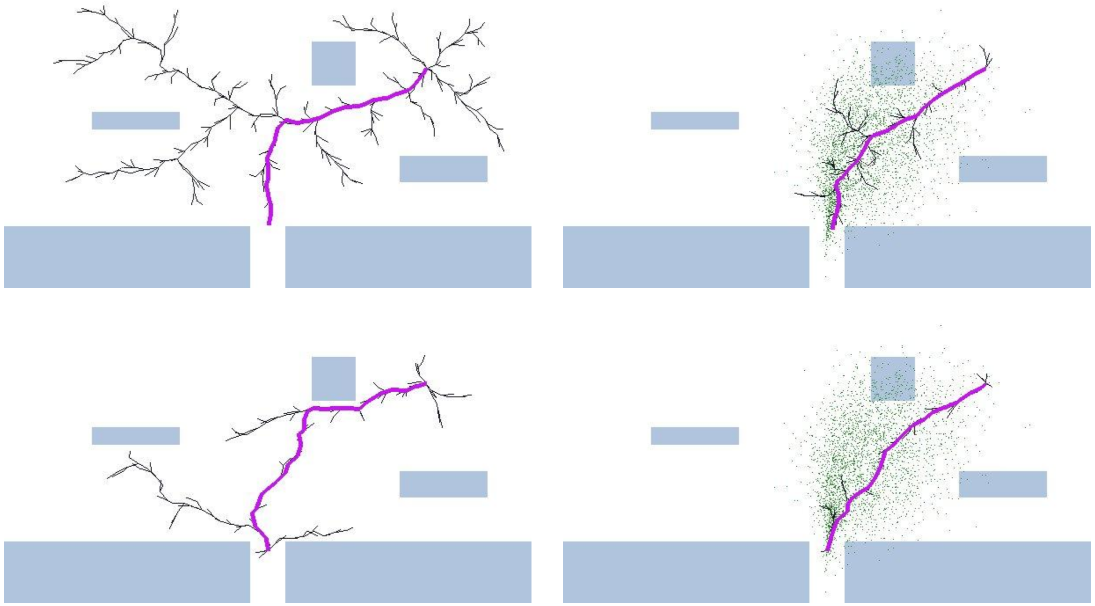
- CVAE
  - Average forward time: 0.0127s



	# nodes		elapsed(s)		path_len (x0.1m)	
	random	**learnt**	**random**	**learnt**	**random**	**learnt**
RRT* (σ)	251.5629 (119.9123)	244.4267 (90.5567)	3.6873 (3.8788)	3.5150 (2.5824)	265.2073 (28.8045)	221.5089 (10.4951)
biRRT* (σ)	93.03 (23.6036)	48.57 (5.2093)	0.2290 (0.1084)	0.0819 (0.01397)	257.7198 (20.3302)	228.9368 (6.8773)

Complex map

- CVAE
  - Average forward time: 0.0127s



	# nodes		elapsed(s)		path_len (x0.1m)	
	random	learnt	random	learnt	random	learnt
RRT* (σ)	492.23 (137.0647)	135.2 (28.8119)	28.0249 (16.4521)	2.4032 (0.9523)	317.2249 (37.1870)	260.7166 (9.1753)
biRRT* (σ)	156.32 (45.5480)	70.56 (11.7760)	1.7625 (0.9827)	0.5296 (0.1635)	340.8630 (55.2340)	280.5843 (11.2468)

Thank you !
Q & A

EECS 545 - Final Project

Li Chen, Yue Du, Yeyang Fang, Daiyao Yi, Xuran Zhao