Team Projects Overview

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Requirements

1. Projects cannot be implemented in sim-only, **has to be implemented on the actual F1TENTH hardware**.
2. Projects cannot be just running an existing project off github on the car. If you’re not sure, check with us. It should have a **significant portion of creative work and in-depth analysis of the results.**
3. Projects can be topics other than the ones we’ve shown today.

Final Race

- The final project can be your final race strategy but not required.

- The final race will be a single-elimination, head-to-head race against your classmates.

4/19	W		Race Prep		Final Project	
			Module G: F1TENTH Grand Prix!!			
4/24	M	26	**Final Race Day**			
4/26	W	27	Special Topic 4: Guest			
5/8	M	28	Project Demos			Final Project Demo
5/9	T	29	Final Project Documentation Submission Deadline			Project report submission

Your Proposal

1-2 page, LaTeX document. Include references and a timeline/plan. Use the official IEEE conference template.

- What is the problem?
- Why is it important?
- Why is it hard?
- What have others tried to do?
- What you will do? How long will it take?
- How you will measure success?

See examples of past project reports and proposals here - https://tinyurl.com/ESE615-previous-projects

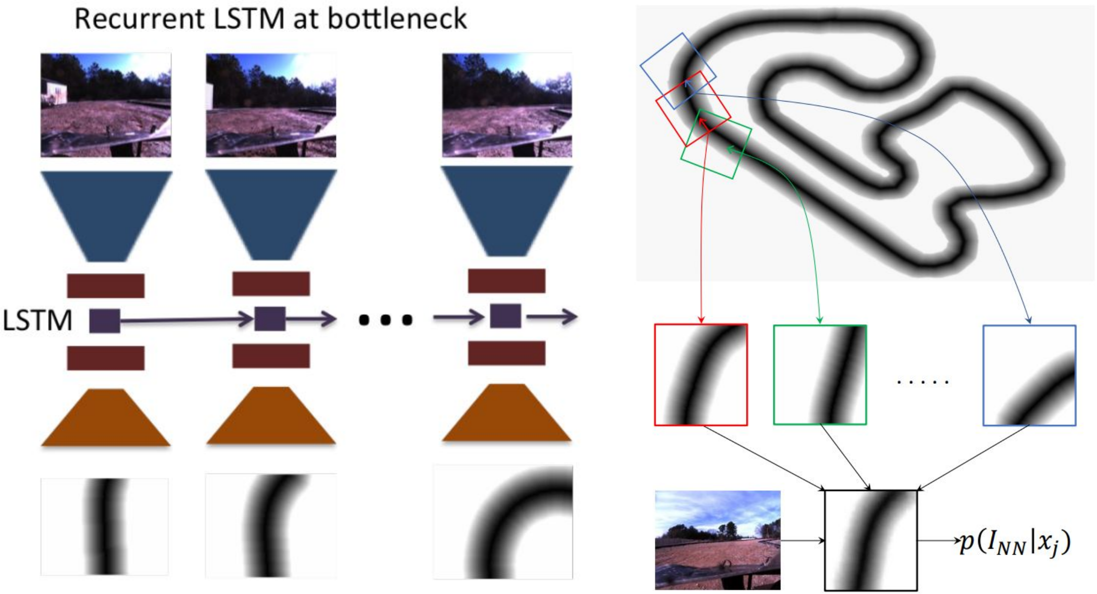
Research Project Ideas

xLAB F1Tenth Research Papers - https://tinyurl.com/xlab-f1tenth-papers23

Perception

Mono-cam Localization

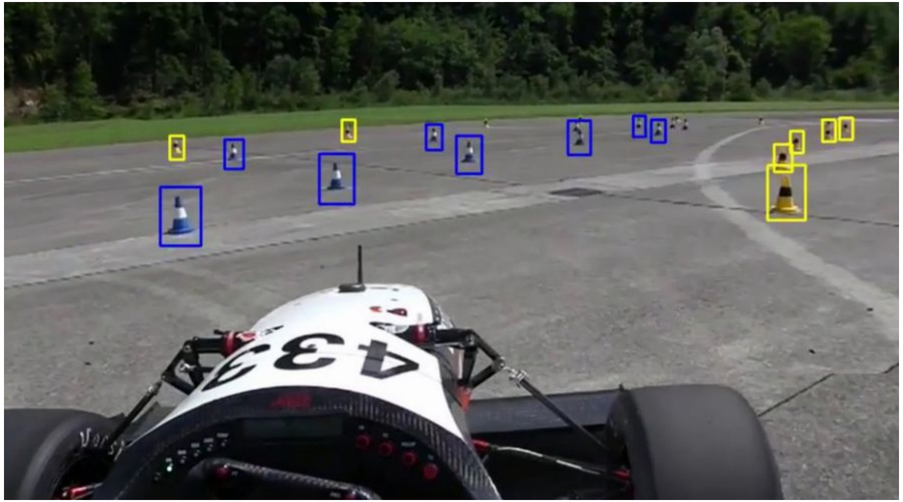
Encoder/Decoder with LSTM at bottleneck to predict local costmap ahead, then use particle filtering for localization.



Reference: https://arxiv.org/pdf/1812.02071.pdf

Cone SLAM

Uses camera for object detection, and fuse with lidar observations to create landmarks. Then implement Graph-SLAM with landmarks.



References:
https://arxiv.org/pdf/2003.05266.pdf
https://www.mrt.kit.edu/z/publ/download/LeLarge_Thesis_SLAM_FormulaStudent.pdf
https://link.springer.com/content/pdf/10.1007/s10846-021-01329-x.pdf

Multi-vehicle Tracker

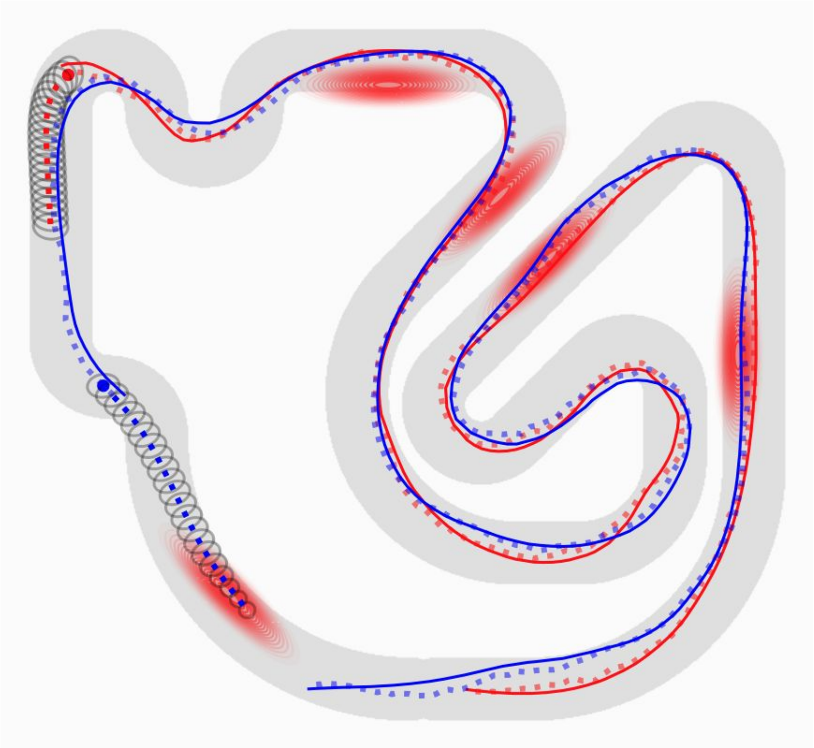
Fusing LiDAR and camera images as observation model, and use an Ackermann steering model as the motion model to perform particle filtering on other vehicles.

References:
https://www-cs-faculty.stanford.edu/group/manips/publications/pdfs/Petrovskaya_2009_AURO.pdf
http://khatib.stanford.edu/publications/pdfs/Petrovskaya_2011_Thesis.pdf
https://ieeexplore.ieee.org/document/7759043

Planning

Opponent prediction

Maintaining a belief on the opponent with uncertainty, and planning in Belief Space.



References:
https://arxiv.org/pdf/1909.06963.pdf
https://arxiv.org/pdf/2102.09812.pdf
http://proceedings.mlr.press/v119/sinha20a/sinha20a.pdf

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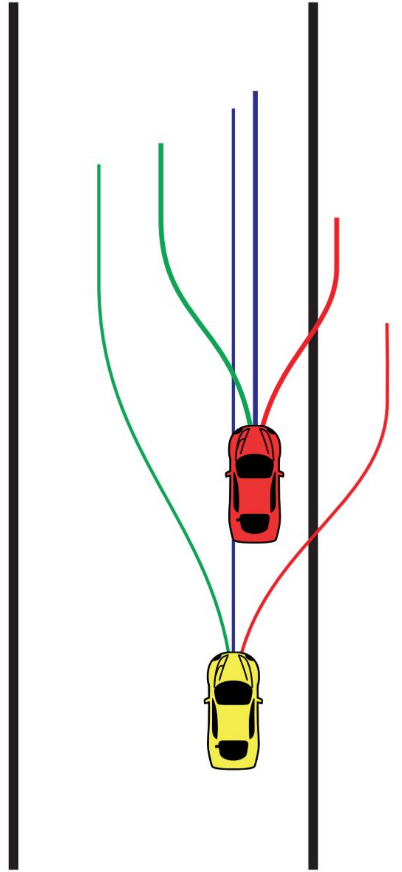
Game Theoretic Planners

Model the interaction between agents as a non-cooperative game, and apply game theoretic approaches to find the best response.



References:
https://arxiv.org/pdf/1707.04540.pdf
https://ieeexplore.ieee.org/document/9196757
https://msl.stanford.edu/papers/wang_game_2020.pdf
https://arxiv.org/pdf/1712.03913.pdf
https://arxiv.org/pdf/2209.07758.pdf

References

https://www.ri.cmu.edu/pub_files/pub4/shin_dong_hun_1990_1/shin_dong_hun_1990_1.pdf

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.637.356&rep=rep1&type=pdf

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.88.8908&rep=rep1&type=pdf

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.375.9234&rep=rep1&type=pdf

https://www.ri.cmu.edu/pub_files/pub4/howard_thomas_2008_1/howard_thomas_2008_1.pdf

https://www.ri.cmu.edu/pub_files/2011/7/mcnaughton-thesis.pdf

https://courses.cs.washington.edu/courses/cse571/16au/slides/Ferguson_et_al-2008-Journal_of_Field_Robotics.pdf

Control

Drifting MPC / Controller

Create a controller for the slip angle, or create a drift-aware MPC for the vehicle.

Reference:
https://asmedigitalcollection.asme.org/dynamicsystems/article/142/2/021004/1066044/Toward-Automated-Vehicle-Control-Beyond-the

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Drifting Aware Learning

Learn a controller to perform drifting.

Reference:
https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7487756

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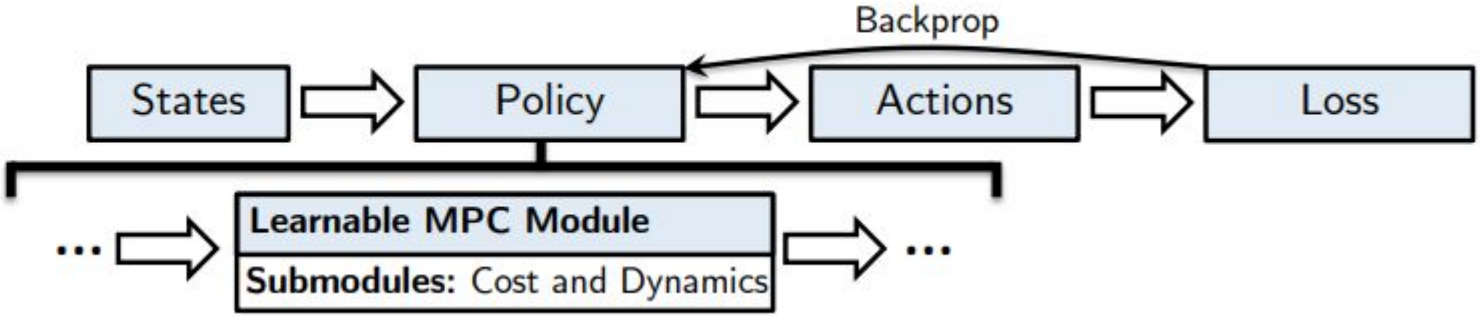
Differentiable MPC

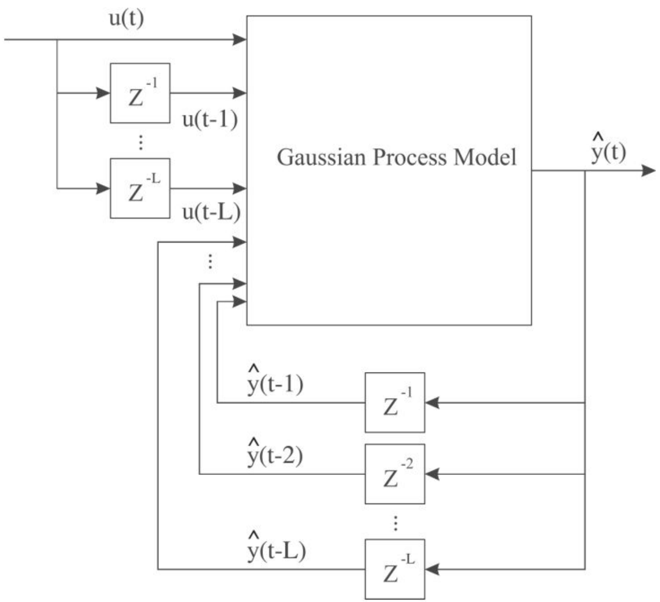


Create a learnable MPC module that can be integrated into a larger end-to-end reinforcement learning pipeline.

Reference:
https://proceedings.neurips.cc/paper/2018/file/ba6d843eb4251a4526ce65d1807a9309-Paper.pdf

System ID

Identify a nonlinear dynamic system with a Gaussian process (GP) prior model.

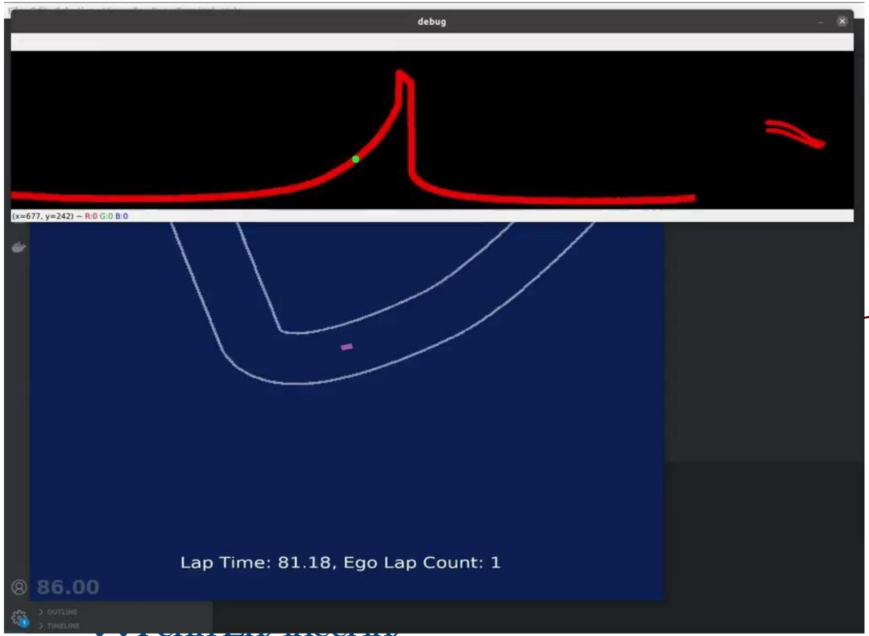


References:
https://www.tandfonline.com/doi/pdf/10.1080/13873950500068567
https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.211.9464&rep=rep1&type=pdf

Learning

Model-free RL

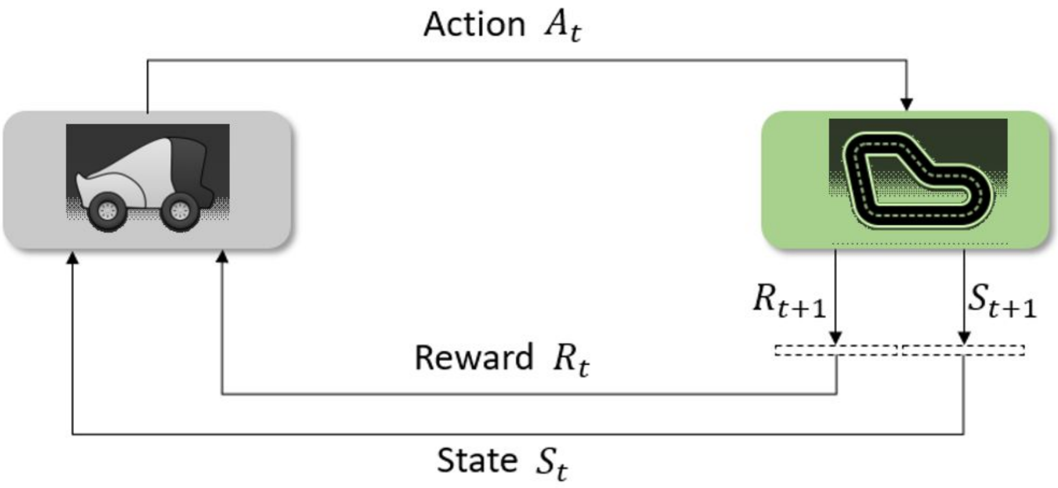
Create an RL agent that can be trained in the simulation and deployed in the car.



Sim2Real Gap

Model-free RL

- Markov Decision Process (MDP)



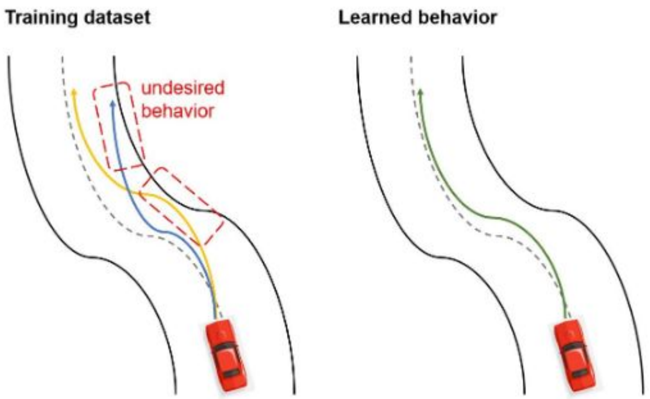
State: sensor input

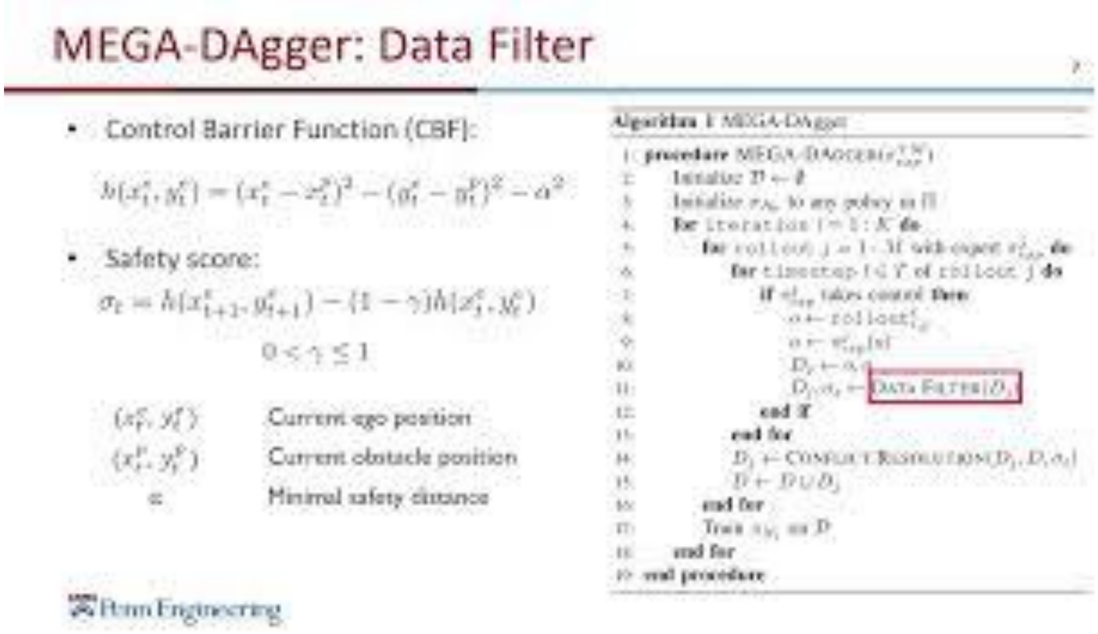
Reward: Longevity

Action: Steering angle, Speed

Imitation Learning

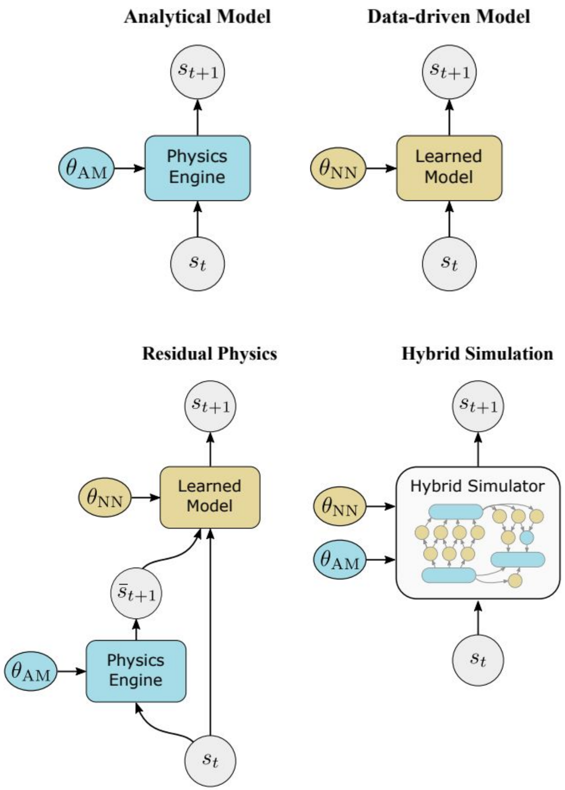
Learning from the "Expert": Your own pure pursuit/RRT agent





Differentiable/Neural System Dynamics

Implement a data-driven, residual learning, or hybrid dynamic simulation of the vehicle. Implement learning-based systemID pipeline.



References:
https://ieeexplore.ieee.org/iel7/9560720/9560666/09560935.pdf?casa_token=w3Jth7zPCp8AAAAA:2VrupjA-aVLISHxNJ30kD6GVet3Y34OGwGqLouyJlxITiHkPF0POvYI3VKmZmMUD5tePIbyqJA

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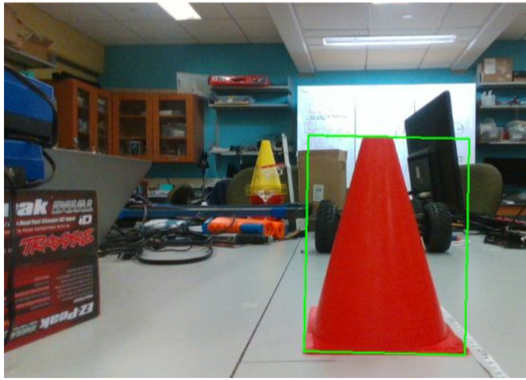
Vision-based SLAM for F1tenth

Can you run F1tenth without LiDAR?

Solution strongly needed!



- Option 1: Visual SLAM, accelerated for Jetson platform.
- Option 2: Cone-base SLAM,
- Option 3: Lane marker-based SLAM.

Use your imagination,

Build A robust system,

Contribute to the F1TENTH Project!

NeRF-based Visual simulator for F1tenth

- Visual simulation for F1tenth.
- Challenges:
  - Accurate training
  - Fast rendering
  - Integration with F1tenth Sim

Levine Hall rendered with NeRF