3D Gaussian Splatting for Learned Drone Navigation

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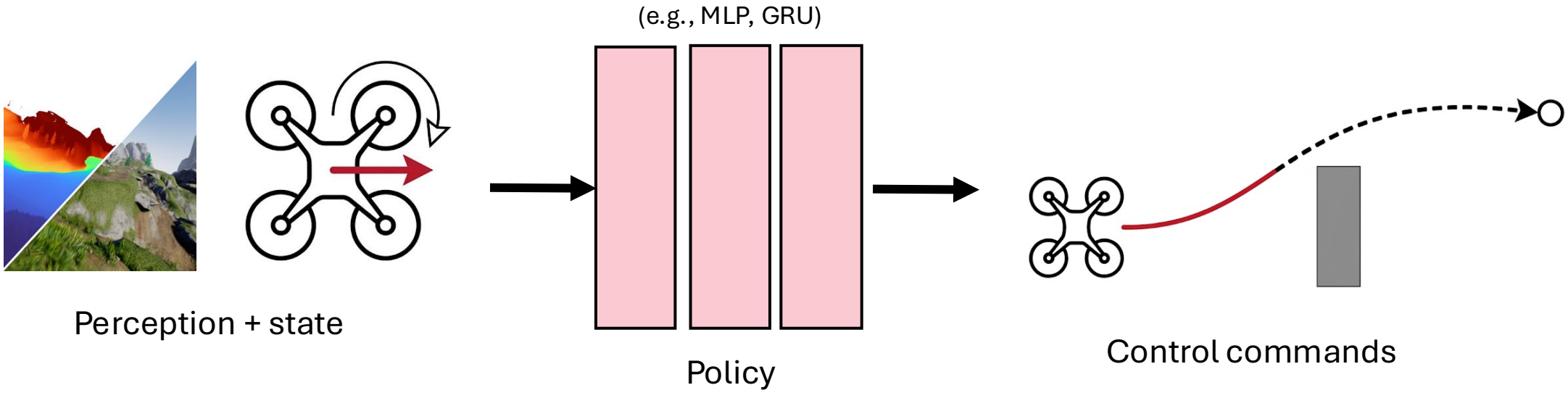
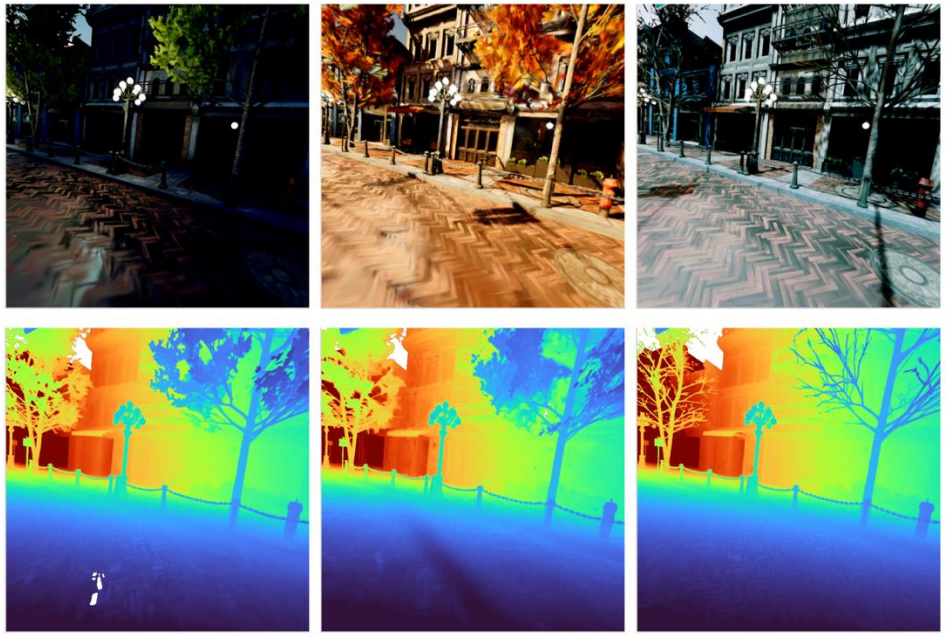
AIRLAB

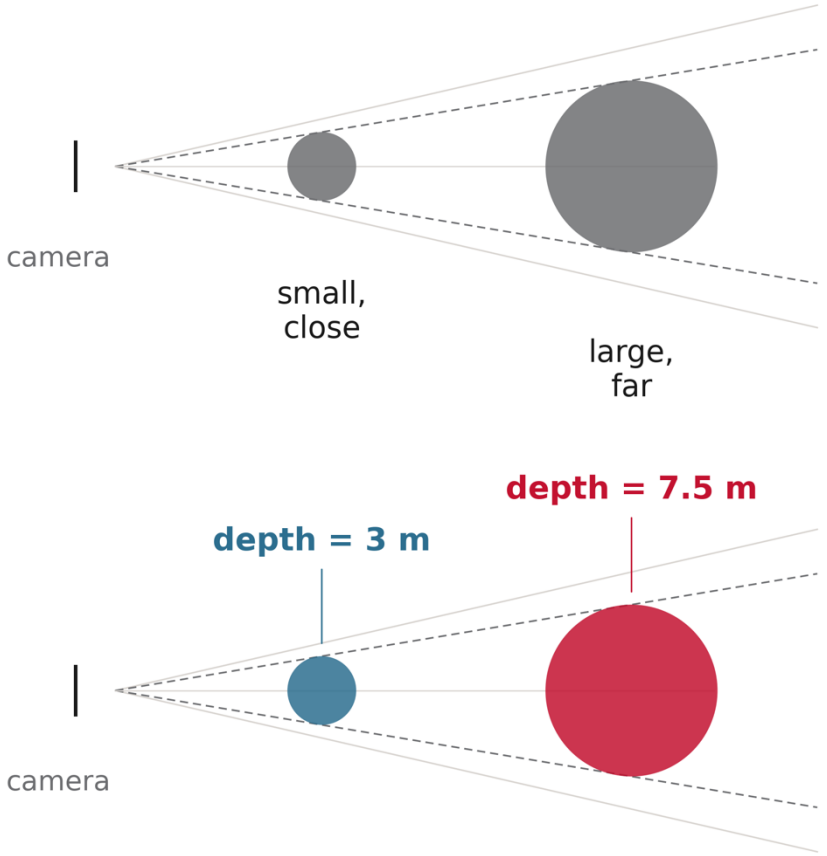
End-to-end drone navigation policies



Depth is appearance-invariant and metrically scaled

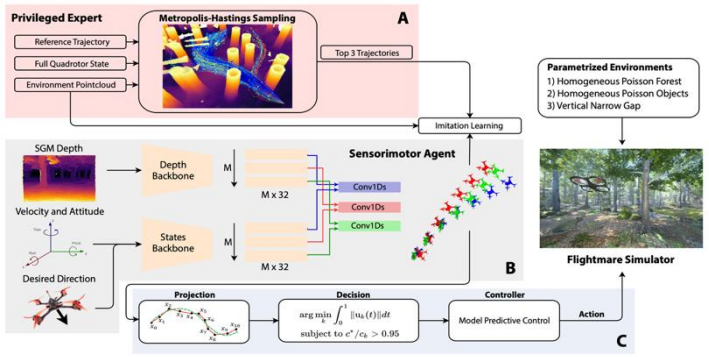


Appearance Invariance

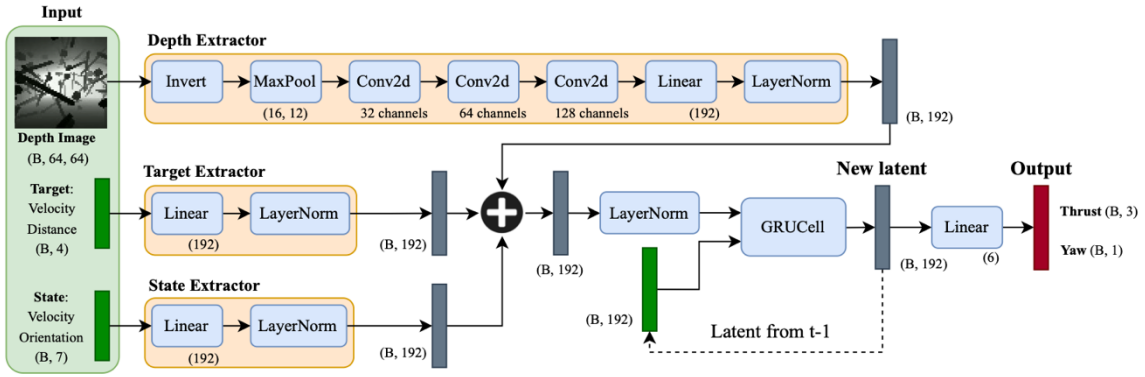


Resolves scale ambiguity

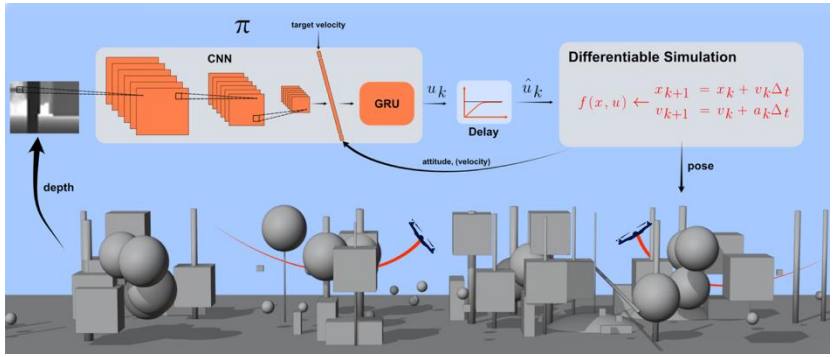
Depth-based policies generalize well



Loquercio, Antonio et.al., Learning High Speed Flight in the Wild, Science Robotics 2021



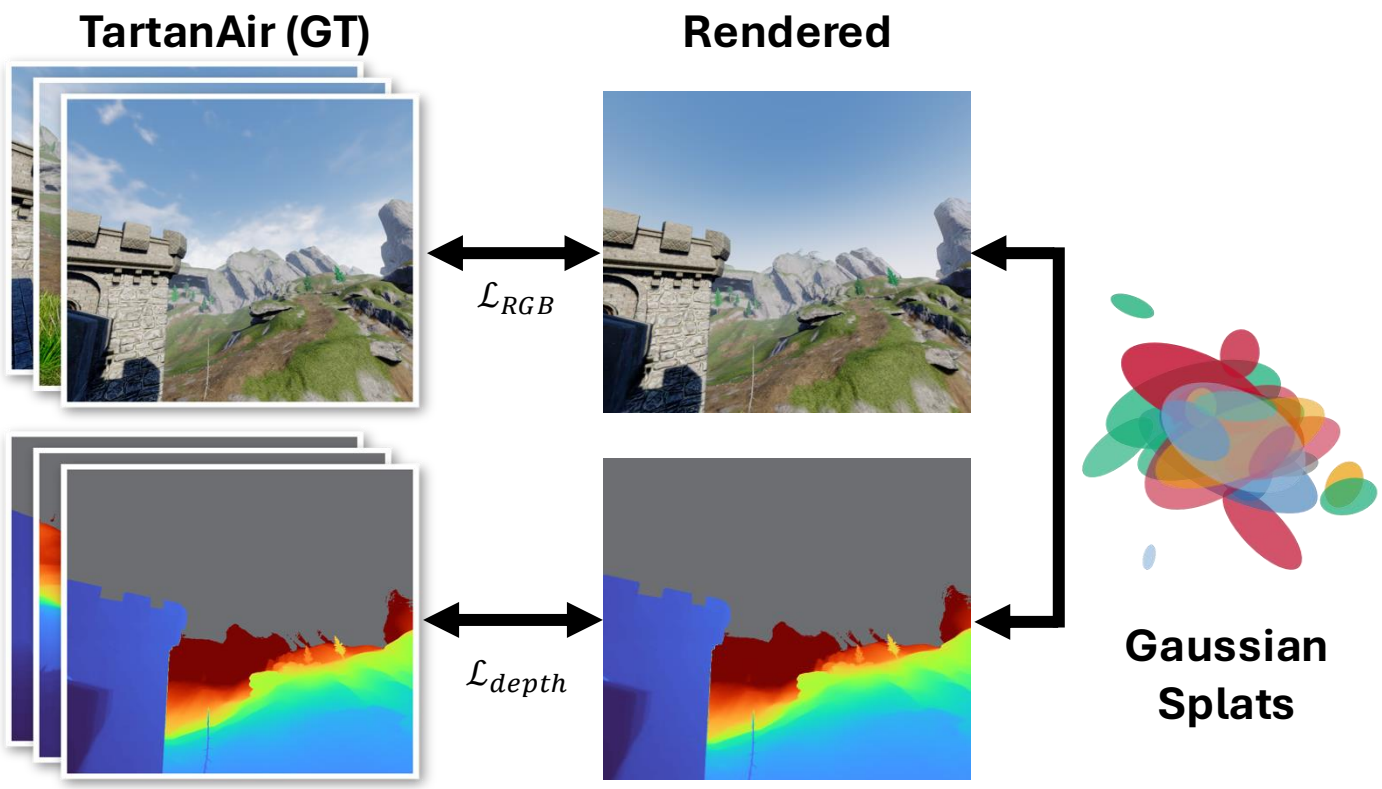
Lee, Jonathan et.al., Quadrotor Navigation using Reinforcement Learning with Privileged Information



Zhang, Yuang et.al., Back to Newton's Laws: Learning Vision-based Agile Flight via Differentiable Physics

Can we also achieve similar performance using only monocular RGB?

3DGS gives us diverse photorealistic scenes with metric depth



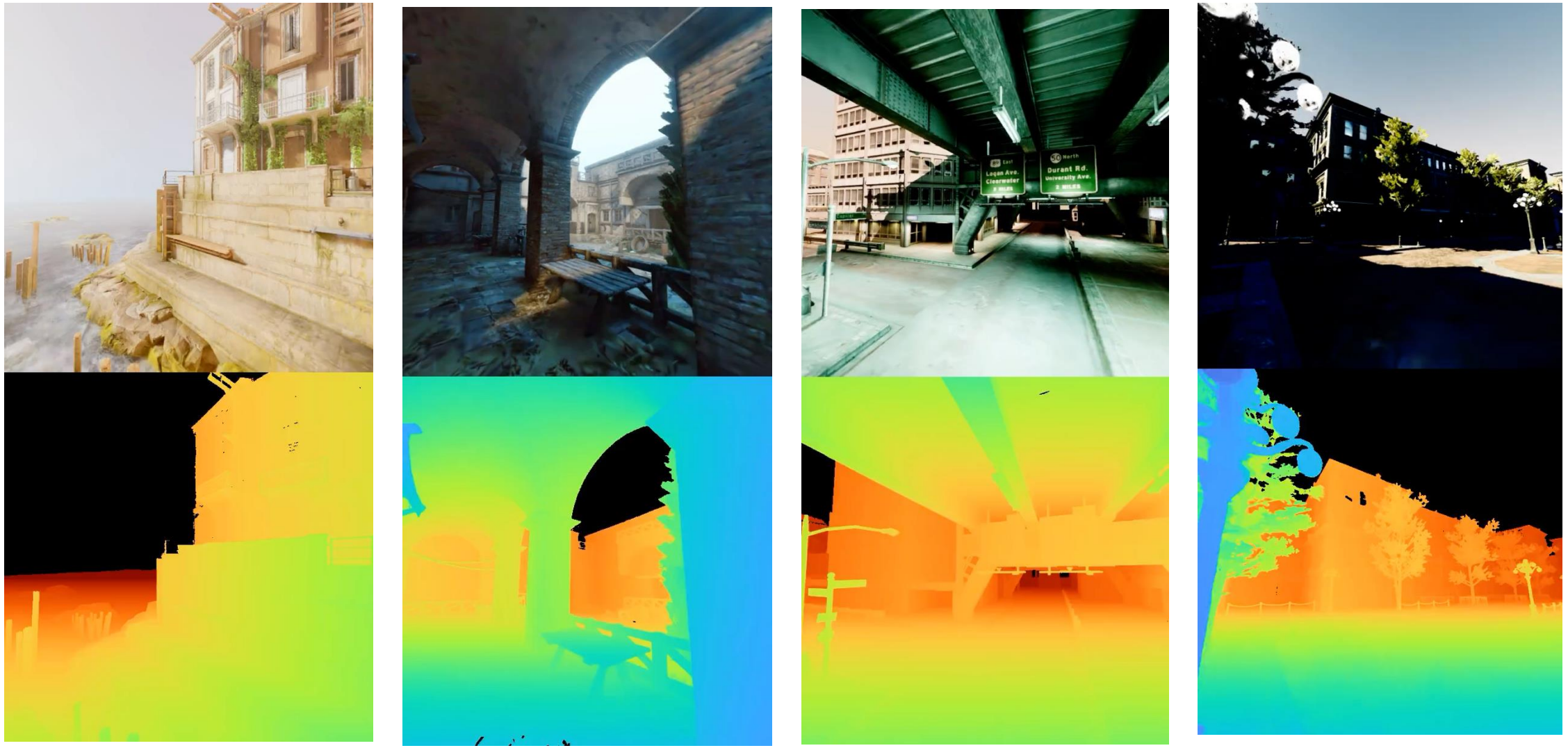
RGB loss

$$\mathcal{L}_{RGB} = (1-\lambda)\left\|\hat{I} - I\right\|_1 + \lambda\left(1 - SSIM\left(\hat{I}, I\right)\right)$$

Depth loss

$$\mathcal{L}_{depth} = \left\|\log \widehat{D} - \log D\right\|_1$$

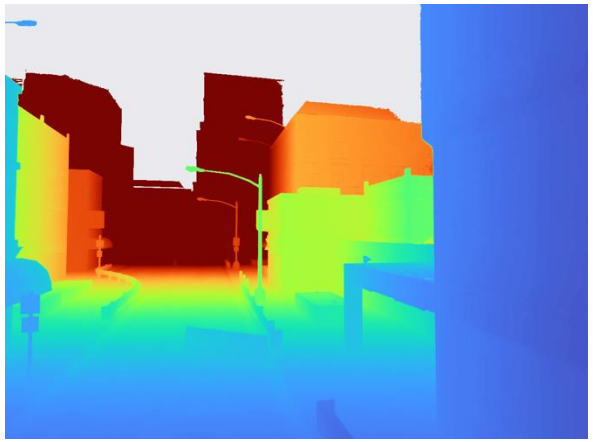
Trained on 20 diverse scenes from the TartanAir dataset



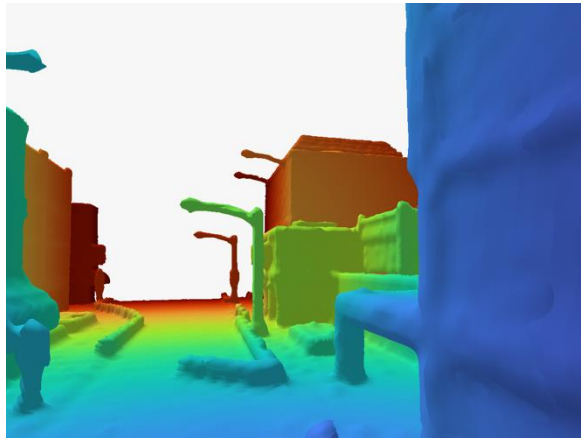
Simulator provides RGB, metric depth, collision geometry, and insertable obstacles

RGB

Obstacle Insertion



Metric Depth

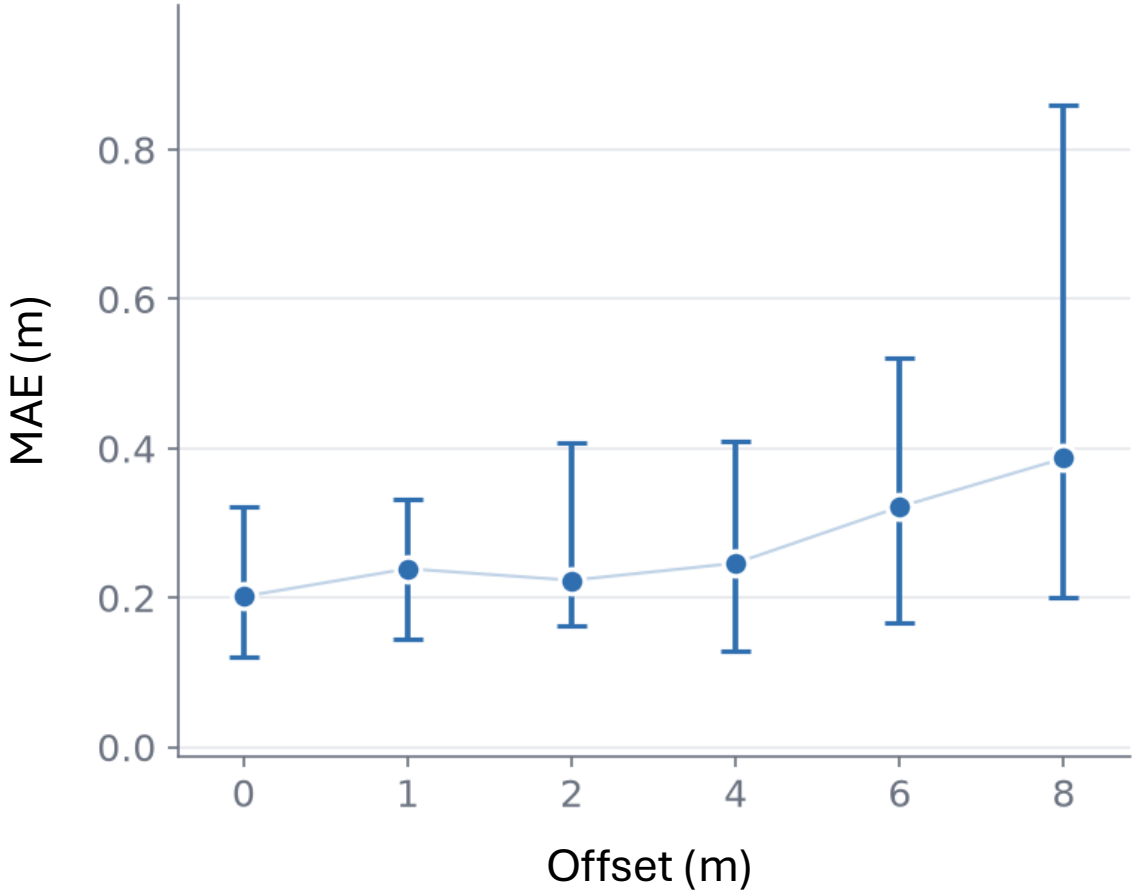


Collision Mesh

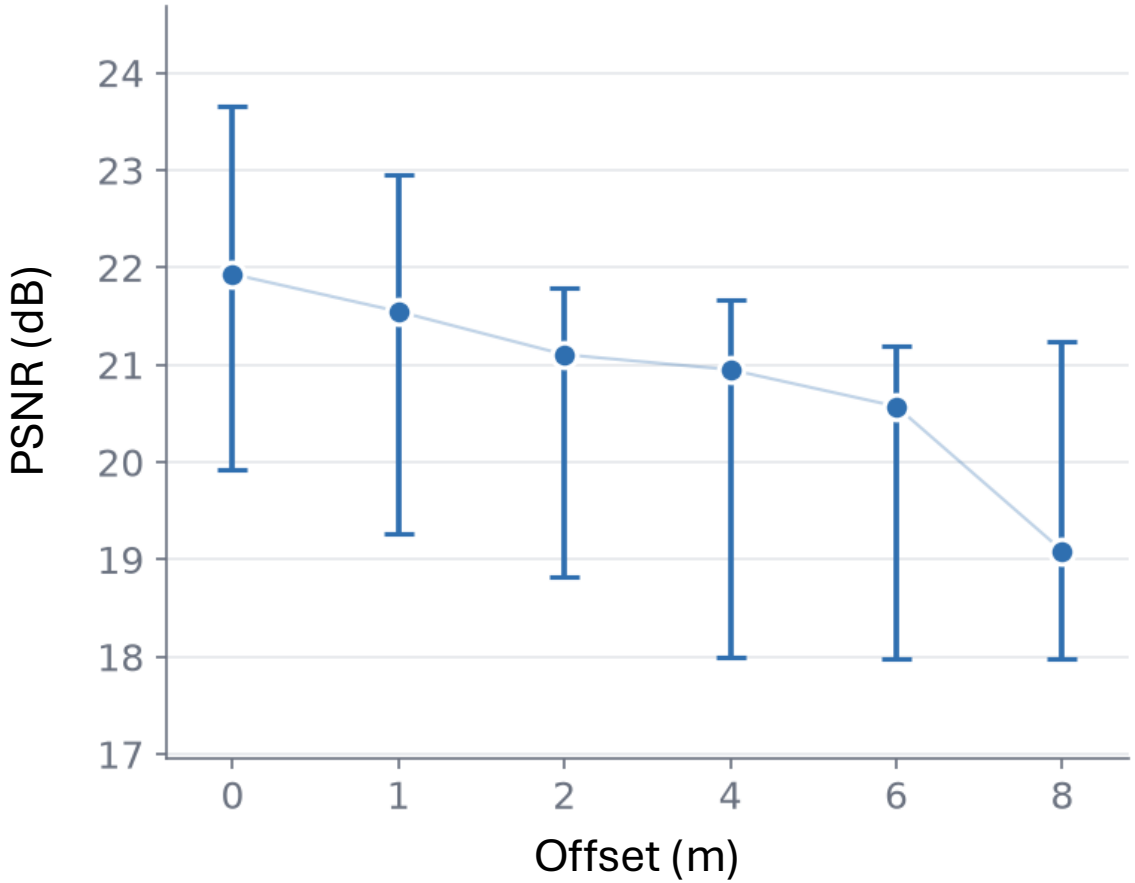
Result: Renders stay faithful in novel-views

2300 novel-views evaluated at increasing distances from training trajectory.

Depth Accuracy



Reconstruction Accuracy

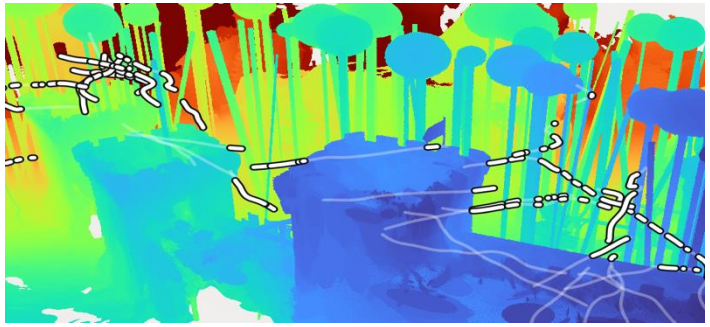


Training a policy

Expert Teacher

Goal position

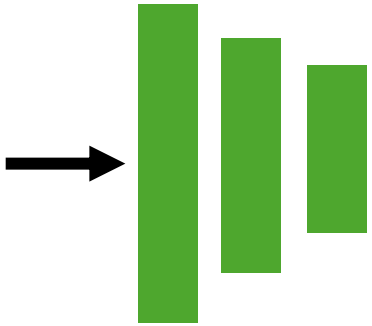
Full 3D Environment



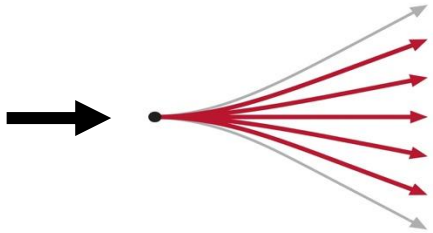
Trajectory Sampling

Student

RGB + state

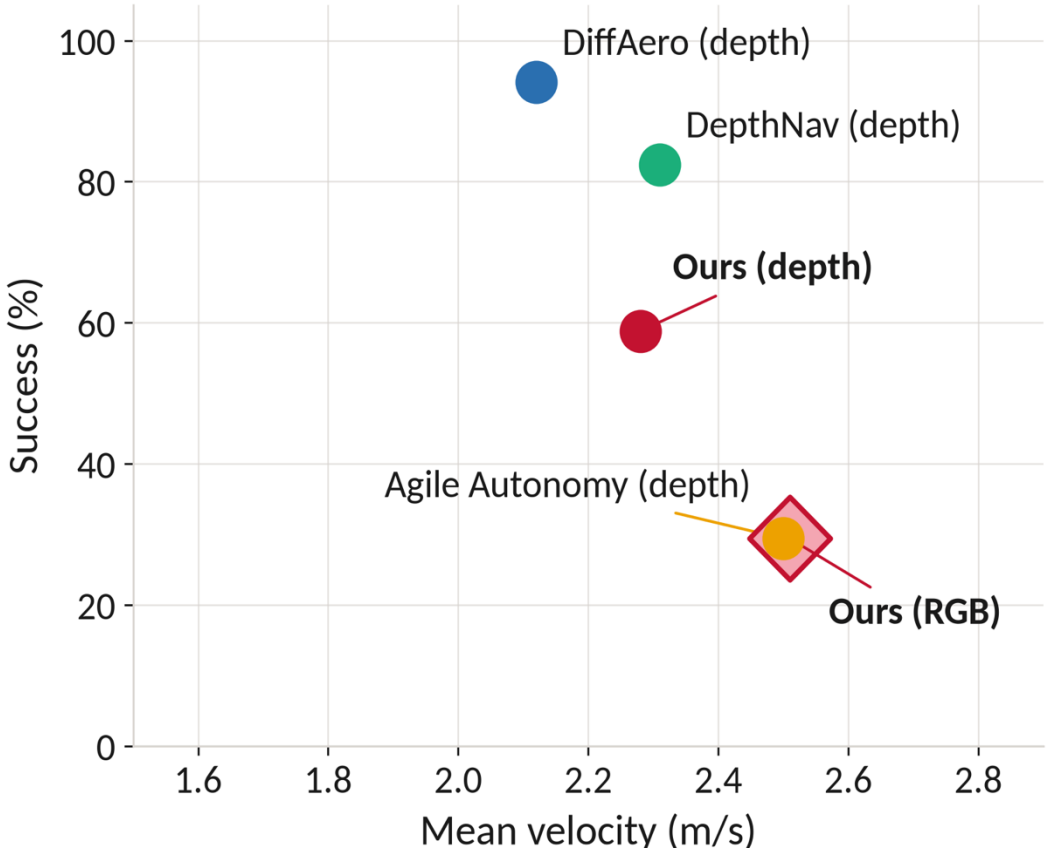


Policy



Rollouts

Preliminary results of the RGB-based policy



Future work

- Evaluate **sim-to-real transfer** by deploying a trained RGB policy.
- Extend 3DGS scene reconstruction beyond TartanAir to **broader, real-world data.**
- Continue improving policy training and close gap between RGB and depth.

Acknowledgements

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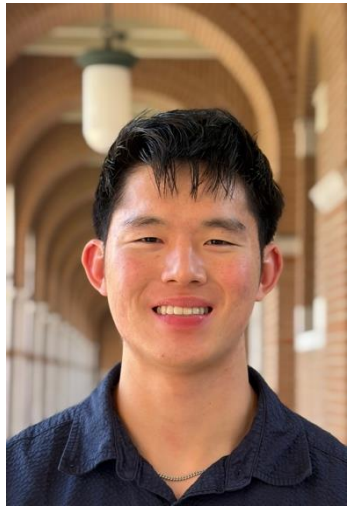

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