Anieesh Saravanan
2025asaravan@tjhsst.edu

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Period 3
Mentor: Dr. Yilmaz

simulair

Procedural Terrain Generation for Drone Obstacle Avoidance

Introduction

Drones operating in the real world must navigate around both **static obstacles** (trees, buildings, terrain) and **dynamic obstacles** (vehicles, other drones). Traditional field testing is expensive, time-consuming, and limited in diversity. We propose a fully automated, **headless simulation pipeline** that utilizes procedural terrain generation to create rich, varied virtual environments for scalable and cost-effective training/testing of obstacle avoidance, including end-to-end headless automation and obstacle synthesis. There are currently no existing pipelines for text-based natural terrain generation in drone training scenarios.

Methods

As shown in **Figure 1**, the pipeline utilizes Infinigen, Stable Diffusion 3.5 Large Turbo (SD3.5), and Stable Point Aware 3D (SPAR3D) to generate photorealistic base landscapes and create 3D meshes for simulator insertion. NVIDIA IsaacSim runs parallelized headless drone simulations, with the Pegasus Platform (**Figure 2**) managing motor controllers and monocular camera sensors. Pipelines were tested with an Intel Ultra 9 285K, RTX 5090 (32GB VRAM), and 64 GB RAM.

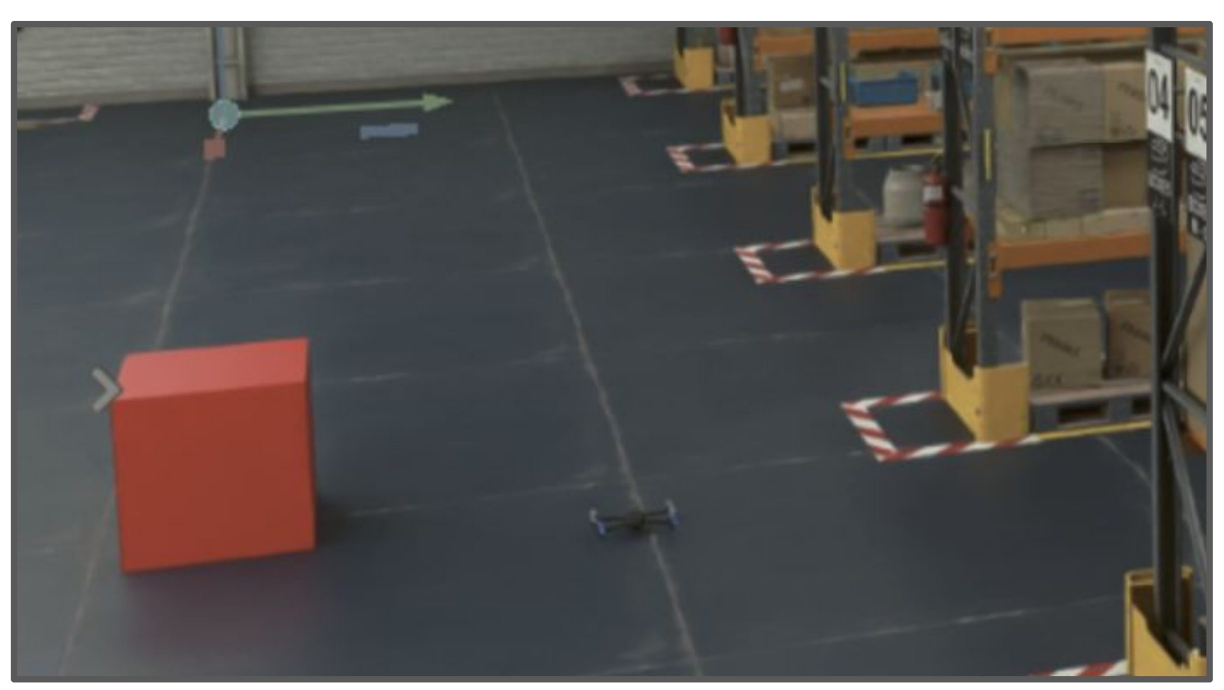

Figure 2: Pegasus and IsaacSim platform

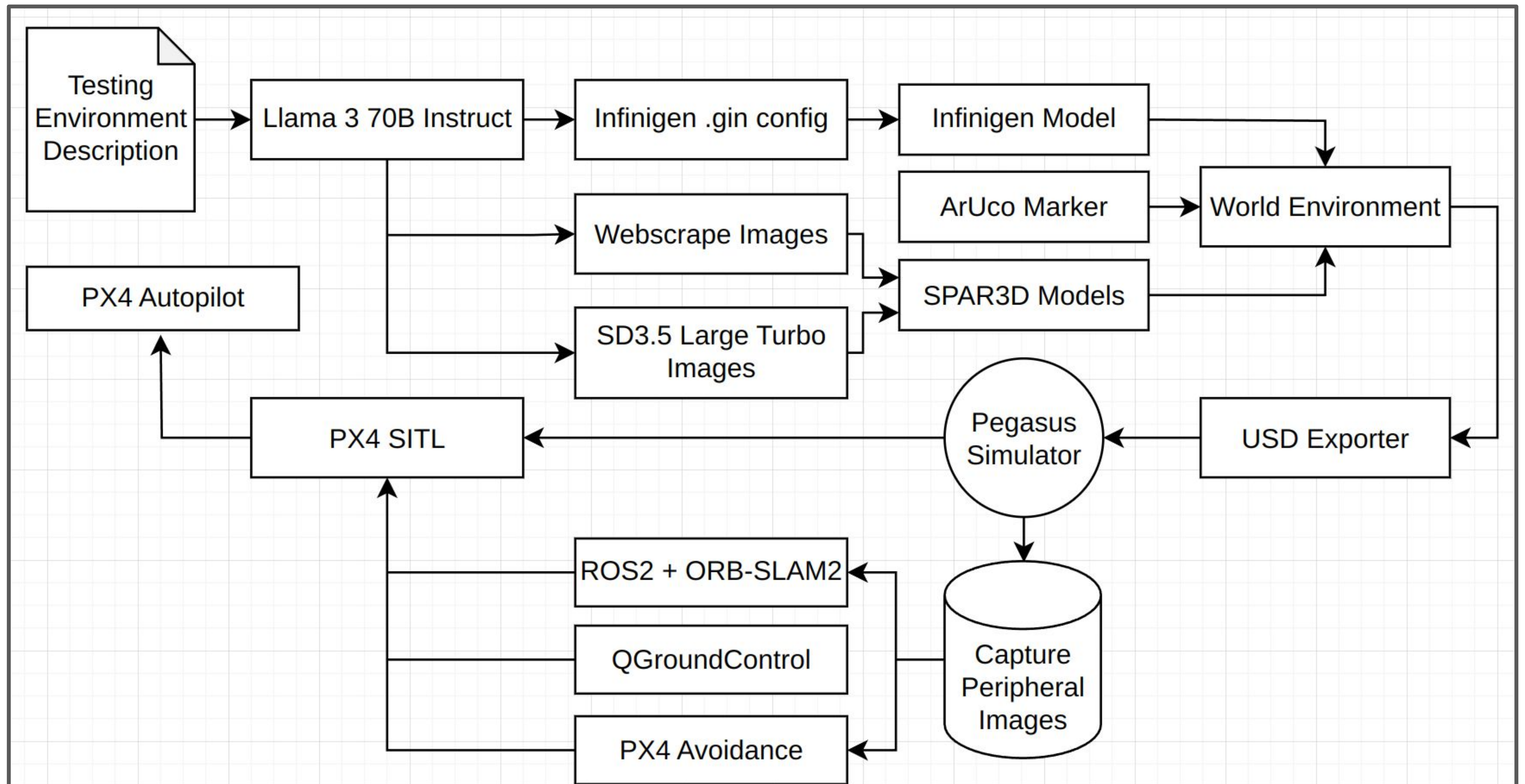

Figure 1: Systems Architecture

Figure 4: Generated Testing Environments

Results

Prompts are successfully registered and influence the terrain generated with .gin configuration files (**Figure 4**). ArUco marker landing pads are randomly generated and placed in the environment at open locations. The drone is able to recognize the depth of peripheral objects within the populated environment (**Figure 3**), and update the PX4 Autopilot configuration. However, the drone is unable to recognize the actual object, due to resolution and lighting constraints within the simulation. ORB-SLAM2 is successfully able to interface with the PX4 SITL in conjunction with QGroundControl and the deprecated PX4 Avoidance module to direct the controller. Through the pipeline, obstacle avoidance models on simulated quadcopters can successfully be trained and tested within the environment for applications in the real world.

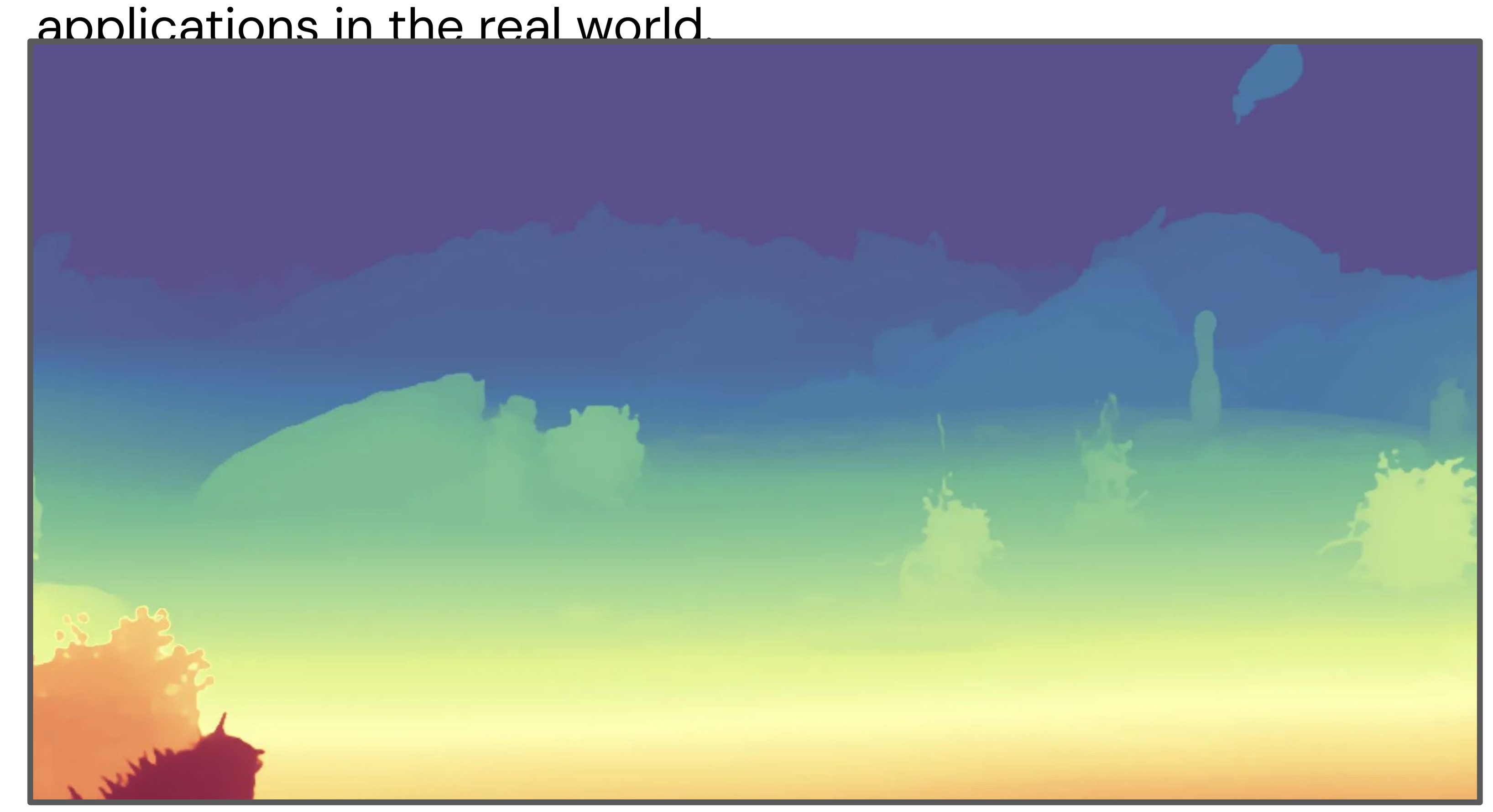

Figure 3: Populated Terrain with Depth Mapping

Conclusion

Procedural terrain-based simulation significantly improves obstacle-avoidance performance while reducing development cost and risk. The headless and parallelized architecture used enables diverse and thorough training, accelerating research cycles. Further studies can investigate performance optimizations and upcoming SLAM systems for monocular detection. Additionally, models can be evaluated on OpenStreetMap elevation data to gauge applicability to real-world terrain.