Booth Number: 328

GAN Assisted Map Reconstruction for First Responders Using Sensor Fusion

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Problem Definition

First responders are often required to delve head first into dangerous environments to assess the situation. Fires, leaks, underwater/cave rescues, are all examples of situations that can quickly become deadly for those responding to the scene.

Methodology

We aimed to create a multi sensor, GAN assisted, map reconstruction program that can be utilized on any mobile platform to create a virtual 3D twin of any environment.

GAN Map Reconstruction

- We designed multiple generative adversarial network (GAN) models to transcribe as well as improve data collected from each individual sensor.
- 3D point cloud data from the GAN model is then implemented into Unity to visualize environment.

Sensors

- Four sensors were used (RGB-D, LiDAR, Thermal, and RGB) to collect various types of data.

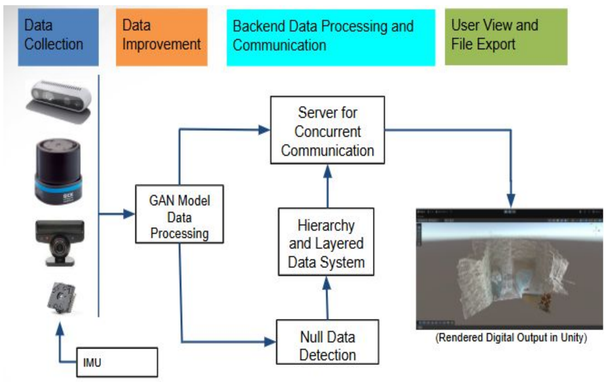


Figure 1. Integrated System Diagram

Engineering Analysis

Testing and validation of results include individual GAN model training losses for each individual sensor, as well as visual analysis of point clouds developed by each sensor

A. RealSense (RGB-D) GAN model focuses on improvement of sensor generated point cloud.
B. 3D LiDAR GAN model focuses on increasing density of points from the generated point cloud of the sensor.
C. RGB sensor GAN model focuses on assuming or interpreting distance values from individual RGB values
D. Infrared sensor GAN model focuses on assuming distance values from heat signature data

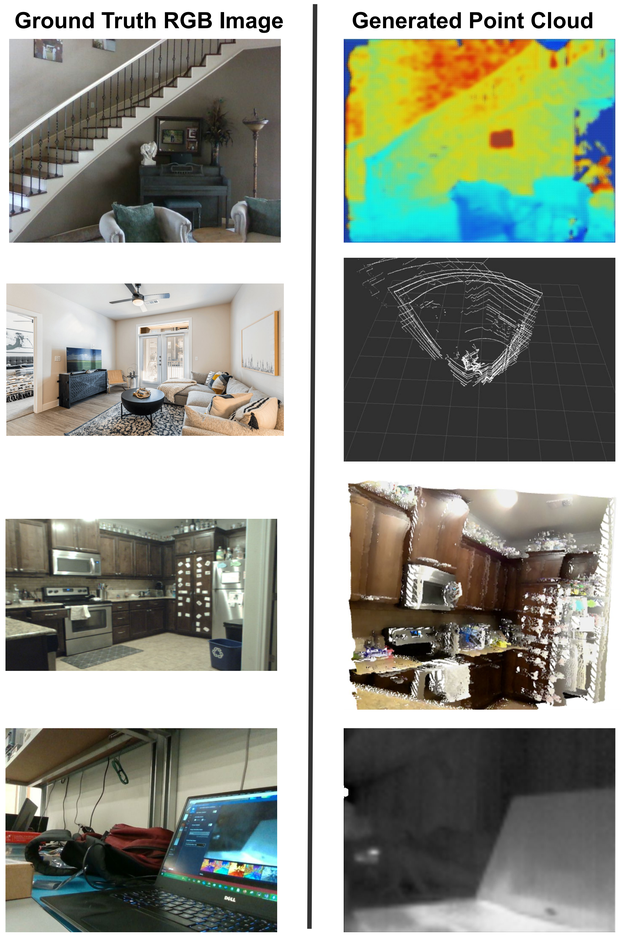
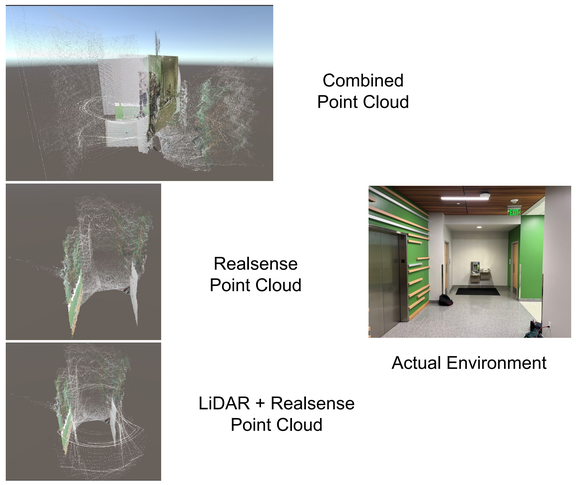


Figure 2. GAN Map Reconstruction for Each Sensor (Top to Bottom) A - Realsense B - LiDAR C - RGB D - Infrared



The “Combined Point Cloud” (shown above) is an example of all 4 sensor data outputs visualized in Unity. Due to scaling issues in the Unity Engine, individual sensor distance measurements began to visually diverge at distances greater than 5 meters.

Limitations

Training Generative AI models often require 10,000 - 50,000 dataset images to be sufficiently successful. No available training datasets tailored to our sensor’s data types could be found, thus requiring us to develop our own training data by sensor output data. This limitation caused the GAN models to have a few shortcomings:

- improvements in the depth map data also resulted in over-smoothening
- difficulty interpreting depth from the Infrared and RGB

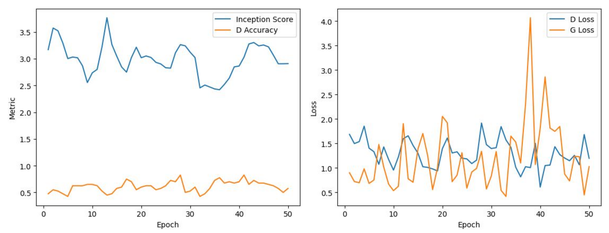


Figure 3. (Left) Inception Score compared to accuracy of discriminator; (Right) Generator loss compared to discriminator loss over 50 epochs

Outcomes

Overall, the results demonstrated the combining of each individual point cloud in Unity utilizing sensor fusion. Some sensors may not work in specific environments (infrared and RGB cannot collect data in a large fire), so data collection of each sensor can be manually turned off/on in Unity. Combining sensors allows us to combat multiple errors and malfunctions so we are capable of scanning various environments. While a robotic device was not part of this project, the sensors and IMU can be mounted and aligned to any robot that moves to scan environments from a safe distance.

Impact

While this project and device was designed to increase safety for first responders, it is not limited to only those uses. With improvement this device has the capability of providing a high quality scan of any environment which can be useful for various scenarios.

- **Cross-Industry Applications:** Quality environment models can be developed for autonomous vehicles, infrastructure inspection, and construction surveying.
- **Safety and Sustainability:** Minimize human exposure to environments with chemical spills, collapsed buildings, etc.
- **Remote monitoring:** Rapid production of 3D maps provides remote monitoring of facilities, warehouses, or other structures enabling faster decision making and assessments in various scenarios.

Project References

1.H. Lin et al., “UNeR3D: Versatile and Scalable 3D RGB Point Cloud Generation from 2D Images in Unsupervised Reconstruction,” arXiv:2312.06706v1, 2023.

2.I. J. Goodfellow et al., “Generative Adversarial Networks,” arXiv:1406.2661, 2014.

3.LeddarTech, “Sensor Fusion and Perception Technology Fundamentals – FAQ,” 2025. Available: https://leddartech.com/sensor-fusion-perception-technology-fundamentals-faq/ (Accessed Apr. 22, 2025)