EE367 Proposal: Jetson TX1 and Lightcrafter-based Projection Mapping

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1 Motivation

The ability to turn any scene or object into an augmented reality space creates a new medium for anyone interested to work with: the world at large. With advances in computing technology in both form and power, it has become possible to create a smaller projection system with the capabilities normally associated with desktop or laptop machines. Combining a camera, projector, and compute system, the scene can be augmented using image processing techniques. This technique can be extended to perform any number of tasks, such as outlining, re-texturing, user interaction, and identification.

2 Related Work

Citations at the end of the proposal. [1] provides a description of spatially augmented reality systems. [2] contains examples of tracking an object through illumination changes with projection mapping. [3] discusses trends in SAR technology, with an overview of its various components.

3 Project Overview

The goal of the project is to get hands-on experience using the Lightcrafter, ideally in conjunction with the Jetson TX1. To that end, the exact specification can be tuned to better fit the time remaining in the class.

As envisioned, the project consists of a system utilizing the Jetson TX1 as the computation center, an Intel RealSense camera as the sensor, and the Lightcrafter as the projector. Depending on the intended complexity (and the capability of the Lightcrafter's light source), the application can change, ranging from edge detection to painting a target on a movable object in the scene.

Figure 1: Example of Edge Detection. The car's edges are highlighted in a different color and projected back onto the car.

4 Augmented Reality Applications

4.1 Edge Detection

In the edge detection application, a scene is captured, and the edges present in the scene are projected back on to the scene using the projector. This application, while simplistic, can be built up into more complicated AR applications by changing the conditions by which an edge is projected. For example, one could decide to project only those edges that belong to a class of objects, such as a license plate or even a vein. This project will focus on the simple case for proof of concepts, starting with a simple high-pass filter to grab the edges, and iterating upon this method.

4.2 Target Tracking

As time permits, one other interesting application involves tracking an object as it moves through the scene by projecting only onto that object. For example, in tracking a small car as it moves through the scene, the application can "highlight" the car's edges, or simply project a single color onto the boundary of that car.

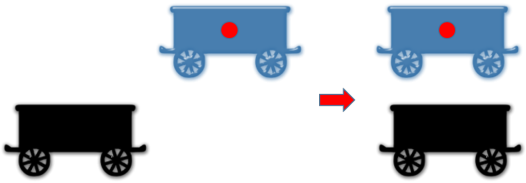

Figure 2: "Painting" a moving target. The blue car moves, and is tracked with a red dot.

5 Milestones, Timeline, and Goals

The first step is to get the RealSense camera working on the Jetson TX1. There exist several tutorials on connecting the two. Then, the camera and projector need to be aligned. To reduce complexity, the project will assume the user and camera will be at the same point in space, and that the camera and projector are fixed (no dynamic alignment). Finally, the last step is to build the application that will be used to demo the technology and ultimately achieve the augmented reality effect. Most likely, this will start with the simplest application of edge detection and painting the edges of objects in the scene, until the latency of the system is calibrated. Given that the Jetson TX1 is a powerful GPU-based system, the goal would be to reduce latency as much as possible to allow for near-realtime scene changes. However, the system is latency limited, which might change the feasibility of the chosen applications.

A rough list of goals for the project is as follows, and subject to change:

5.1 Integrate Sensor with Jetson

1. Connect RealSense Camera (or use on-board camera if this fails) to Jetson and take simple image
2. Build streaming functionality to capture multiple sequences of images

5.2 Sensor-Projector Alignment

1. Ensure that sensor and camera can "see" the same scene physically
2. Design projection frames (on board) to use projector as primary display output
3. Construct simple example scene to use for demonstration purposes

5.3 Edge Detection

1. Implement edge detection scheme (starting with high pass filtering)
2. Project edges back onto scene, ensuring that scene is covered by projector
3. Reduce latency of implementation to approach real-time

5.4 Deliverables

1. Create poster, presentation, and demonstration

References

[1] R. Raskar, G. Welch, and H. Fuchs, "Spatially augmented reality," in *First IEEE Workshop on Augmented Reality (IWAR'98)*, pp. 11–20, Citeseer, 1998.

[2] T. Sueishi, H. Oku, and M. Ishikawa, "Robust high-speed tracking against illumination changes for dynamic projection mapping," in *2015 IEEE Virtual Reality (VR)*, pp. 97–104, March 2015.

[3] F. Zhou, H. B.-L. Duh, and M. Billinghurst, "Trends in augmented reality tracking, interaction and display: A review of ten years of ismar," in *Proceedings of the 7th IEEE/ACM International Symposium on Mixed and Augmented Reality*, pp. 193–202, IEEE Computer Society, 2008.