The Do-Pro: A Simplistic Stereo-Vision Camera

Timothy Do, Daniel Jilani, Zaya Lazar, Harrison Nguyen
Professor Glenn Healey
Department of Electrical Engineering and Computer Science

Objectives

In this project, a portable stereo-vision (SV) camera, named The Do-Pro, was designed using off-the-shelf components to explore applications of depth perception. The Do-Pro aims to make SV technology more accessible and easy to use for unfamiliar scientists and hobbyists. The Do-Pro also provides a good introduction to computer vision and electrical engineering for K-12 students who are interested in STEM careers.

Background

Humans have evolved with binocular vision to percieve depth [1]. This concept is applied to machines [2] in the form of SV, where two or more cameras take pictures of a scene and compute depth for technological applications. Some practical applications are 3-D scene reconstruction and Advanced Driving Assistance System (ADAS).

A simple SV camera is created by vertically aligning two embedded cameras separated by a baseline distance *b* and computing the disparity $x_L - x_R$ between the two images captured by both cameras and mapping it to depth *z* (**Fig. 1**).

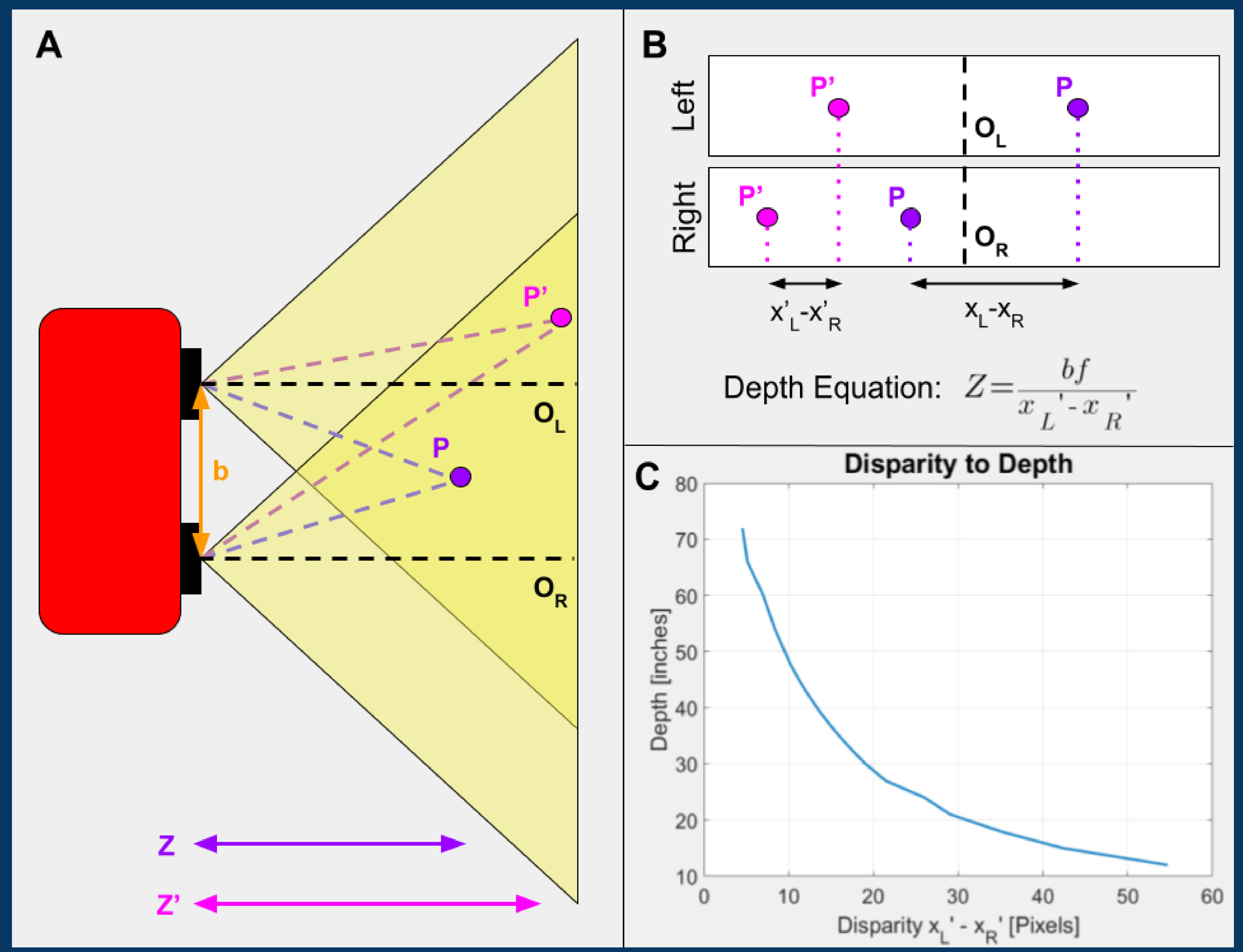

Figure 1. (A) SV camera imaging two scene points P and P' located at depths Z and Z' respectively. (B) Disparity between left and right images; closer scene points present greater disparities. (C) Empirically derived disparity to depth transform for the Do-Pro with a power regression model.

Materials & Methodology

Hardware Design: 3-D Enclosure and Custom PCB

The 3-D enclosure replicates a digital camera for familiarity and ease of use. The custom PCB powers the cameras, buttons, LEDs, & touchscreen to a Raspberry Pi 4 using a boost converter topology with an 18650 battery cell **(Fig. 2)**.

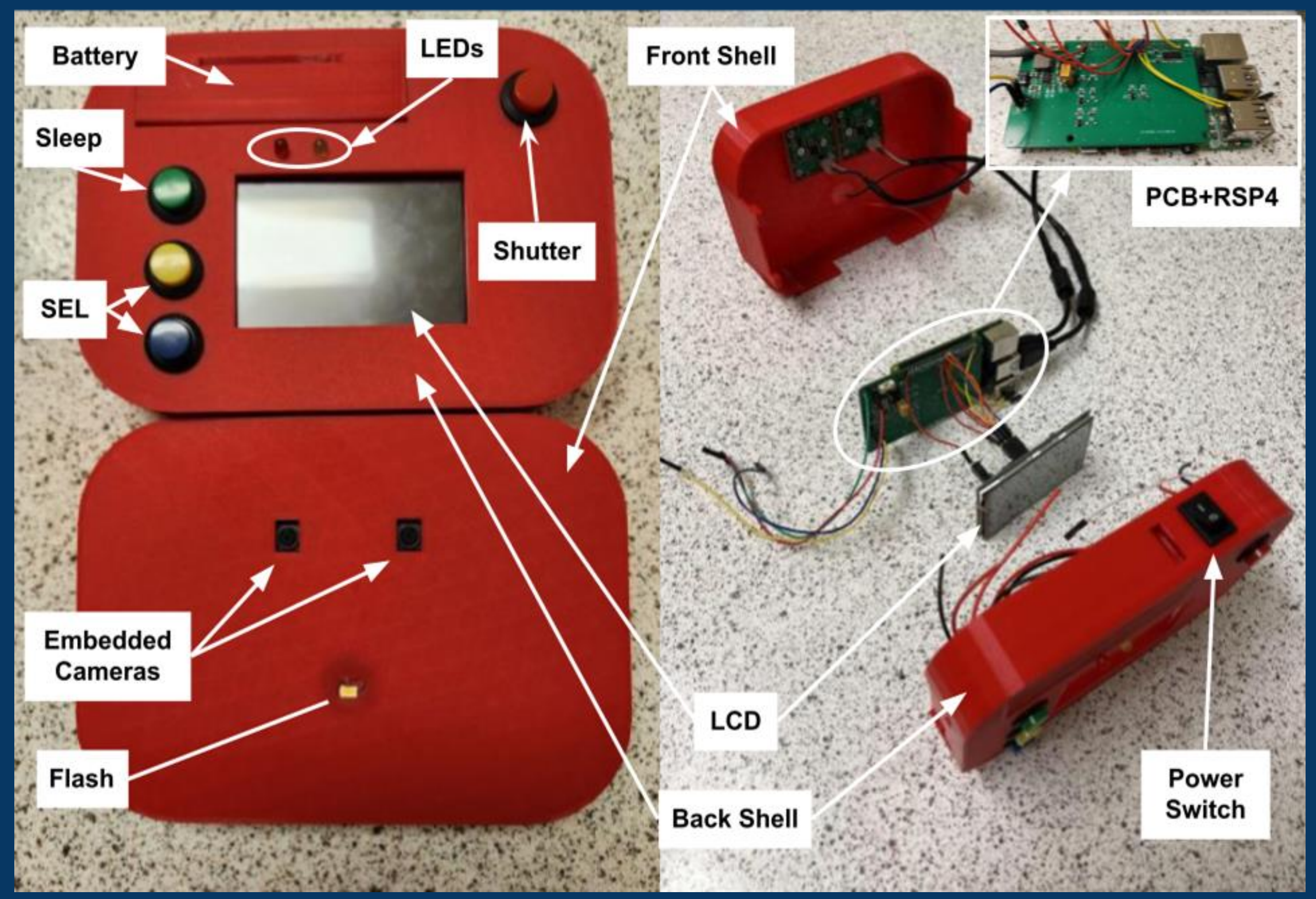

Figure 2. Components and connections of the camera.

Software Design: User-Interface and Algorithms

The user interface (**Fig. 3**) was designed for configuring different visualizations of the disparity output. A specific rectification model was developed for calibrating the stereo pair. Multiple disparity algorithms [3] have been incorporated so users can tailor to their specific needs.

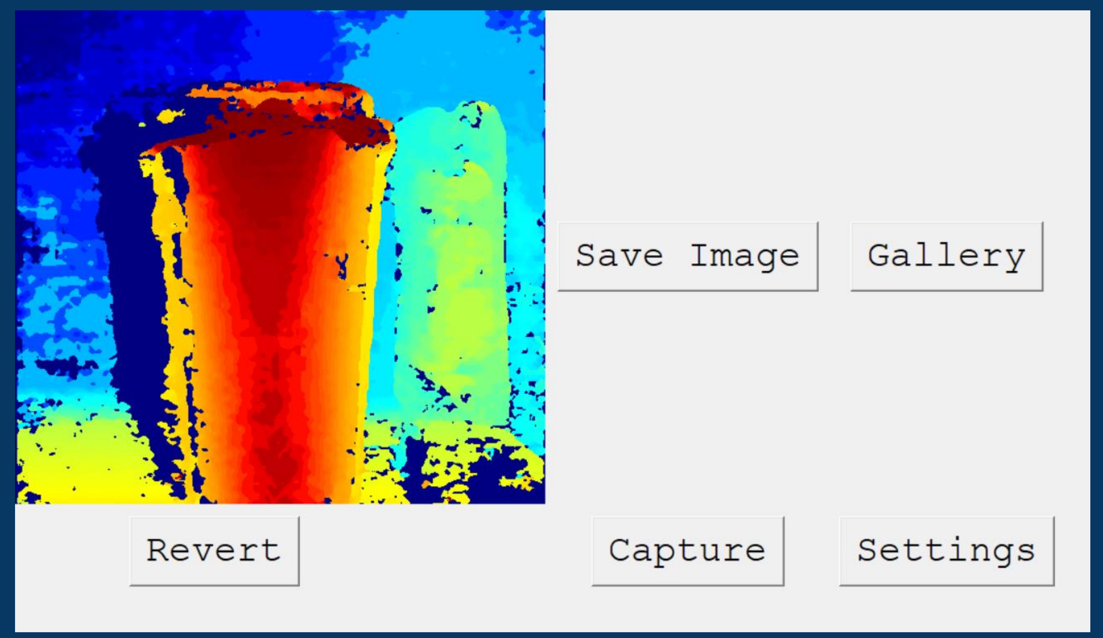

Figure 3. Touchscreen user interface and disparity of a coffee cup.

Applications: ADAS and 3-D Reconstruction

The Do-Pro can be used as an ADAS sysytem by K-Means clustering & segmenting the disparity output for detecting nearby objects. It can also be used for 3-D reconstruction by converting the disparity into depth to transform the scene into a point cloud.

Results

Hardware:

The Do-Pro was successfully assembled in its portable form factor. The battery life of the Do-Pro has a maximum expectancy of about 77 minutes (i.e., when the 3200 mAh battery drops from 4.2 V to 3.2 V).

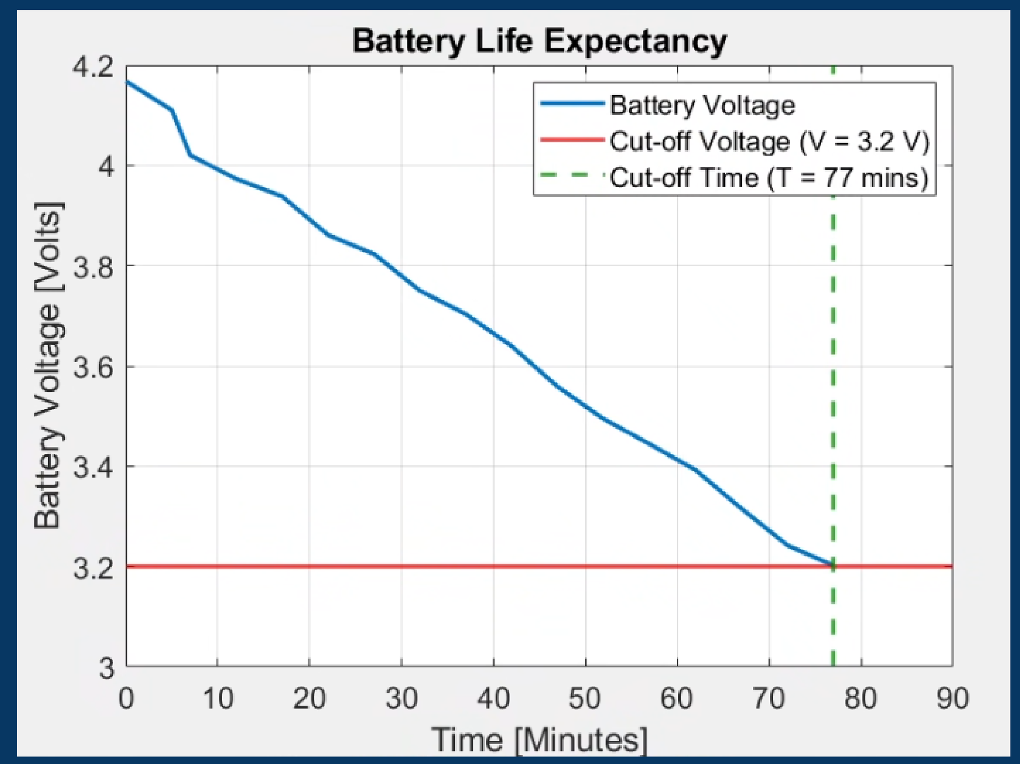

Figure 4. Battery voltage under disparity computation load (~10 W).

Software:

The Do-Pro can generate relative visualizations of depth (**Fig. 5).** It was able to accurately measure depth from 1-4 feet with an accuracy of +/- 1.5 inches (6% error). It can accurately reconstruct a 3-D point cloud and detect close-up objects around 1 feet away with 90% accuracy.

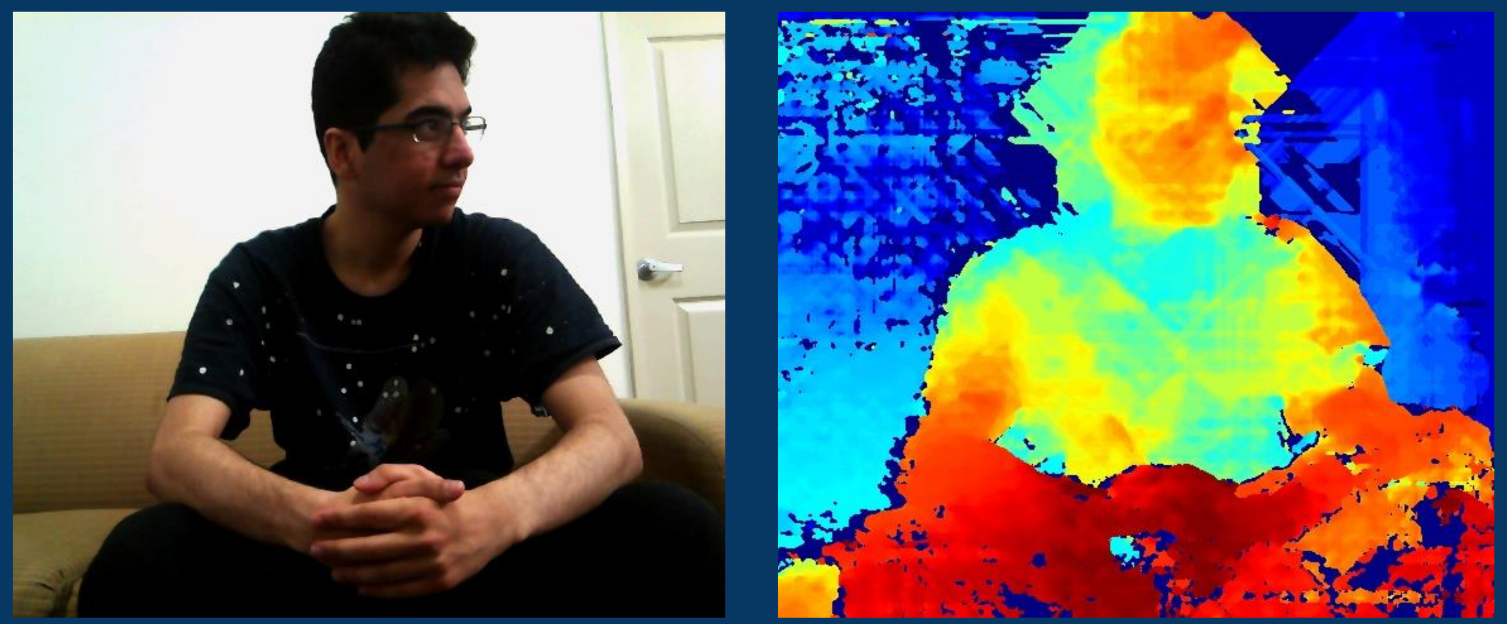

Figure 5. Original image (left) vs. relative disparity map (right).

References

[1] F. Li (2014). Lecture 9 & 10: Stereo Vision. [PowerPoint]. Available: http://vision.stanford.edu/teaching/cs131_fall1415/lectures/lecture9_10_stereo_cs131.pdf

[2] B.K.P. Horn,, "Robot Vision", Cambridge, MA: MIT Press, 1986, ch. 13.

[3] D. Scharstein, R. Szeliski and R. Zabih, "A taxonomy and evaluation of dense two-frame stereo correspondence algorithms," Proceedings IEEE Workshop on Stereo and Multi-Baseline Vision (SMBV 2001), 2001, pp. 131-140, doi: 10.1109/SMBV.2001.988771.