Flatbed 3D Scanning

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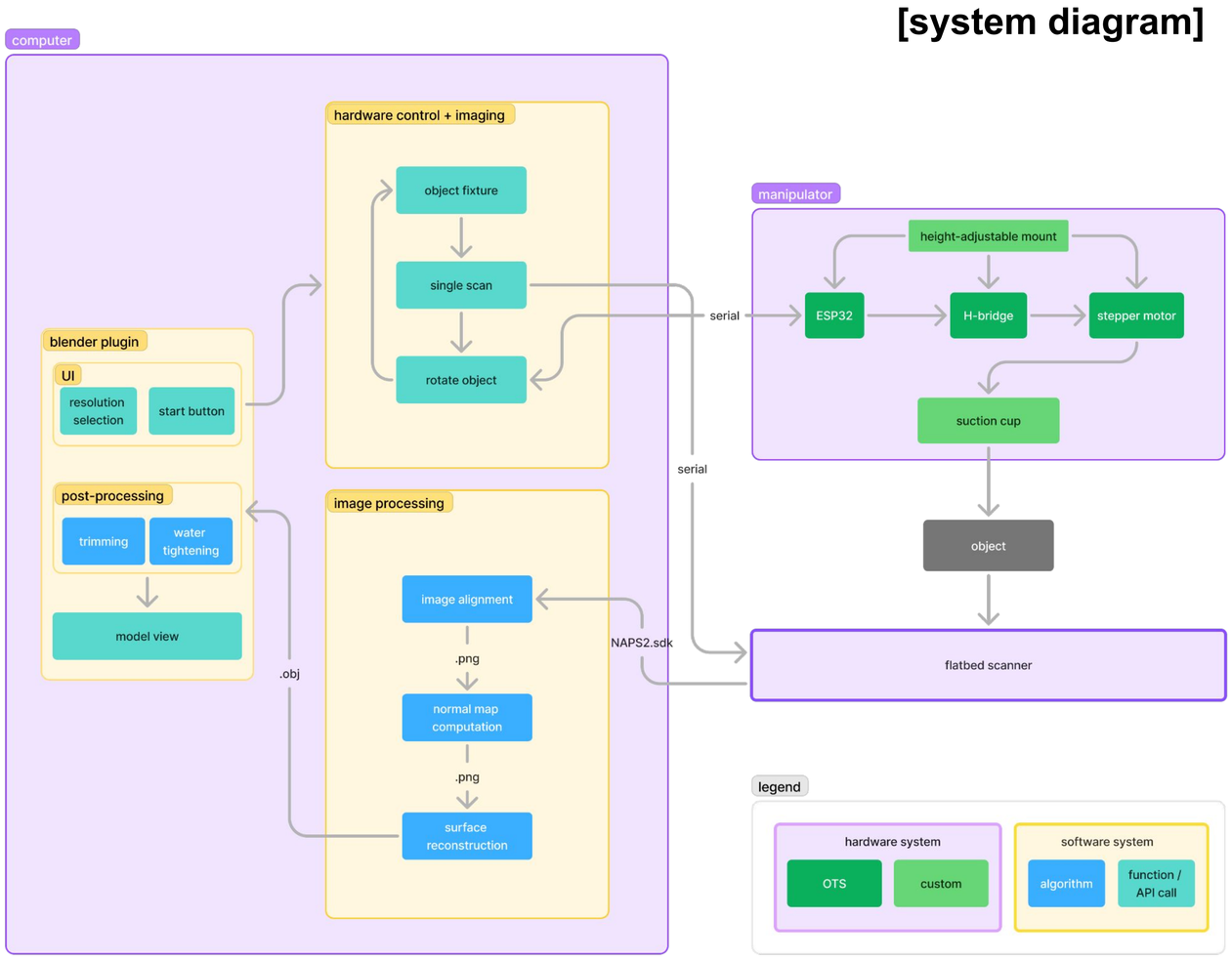
Product Pitch

3D scanning is a developing technology that already sees plenty of use in commercial quality control, art and history research, and hobbyist projects. Current state of the art falls short of an accessible price point and at scanning small features. This 3D scanning process utilizes off-the-shelf flatbed scanners with our open source hardware and software to perform a photometric-stereo-based scanning approach. This offers a less expensive, detail-focused alternative to existing 3D scanning solutions. Initial tests show very high quality scans at a variety of different resolutions, and within an acceptable scan time.

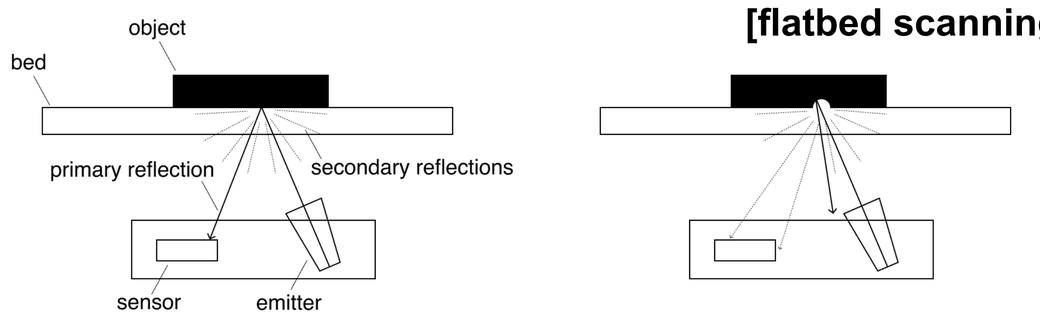
System Architecture

[system diagram]



System Description

[flatbed scanning physics]

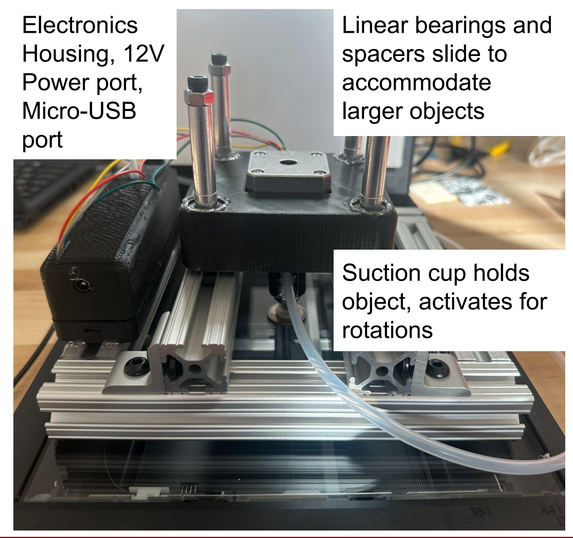


scanning a flat object

scanning a contoured object

Our custom hardware uses an ESP32 to control a stepper motor and suction cup that precisely rotate the object 4 times. At each rotation, a scan is taken. The four scans are aligned and used to compute a normal map, which is then used to generate a height map. This height map is then automatically imported into Blender.

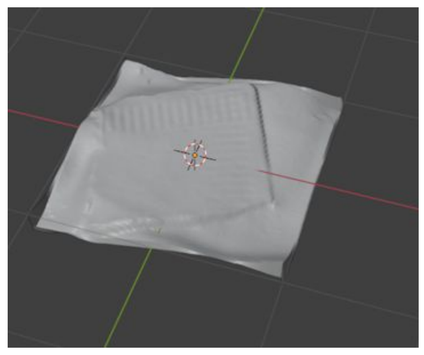
[The Manipulator on a Scanner]



System Evaluation

We had planned on evaluating the scanner using 3D object similarity metrics, but were unable to follow through due to several technical challenges. Instead, we evaluate the scans by inspection.

[An Object and its Scanned Model]



Use-Case Requirements:

Metric	Target	Actual
Scan Time	≤ 5 minutes	≤ 2 minutes
Scan Area	6in. x 6in.	6in. diameter

Conclusions & Additional Information

The system implementation is similar to our initial ideation. It is low-budget, relatively easy to set up, fully automated, generates small detailed 3D scans, fast, and has three distinct subsystems of hardware, software control, and signal processing.

Due to technical difficulties, we were unable to generate scans until later than expected and so couldn't do official metrics of our scanner compared to available commercial 3D scanners. Creating tasks that are modular and do not depend on other subsystems being completed was a valuable lesson, as we bottlenecked the rest of our feature development while trying to get the scan generation working.

Features that could be implemented to extend our project would be automatic post-processing of the model (trimming extra space and watertight the model), allowing variable number of scans, and quantifying our scans' quality with metrics comparing the models from different scanners.

https://course.ece.cmu.edu/~ece500/projects/s25-team5/

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