Using Photogrammetry and Laser Scanning to Create 3D Models for Botanical Collections

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Introduction

3D Morphology:
Traditionally, data on plant morphology has been preserved and collected from pressed and dried botanical samples, a method which allows for only simple structural data to be analyzed. 3D models offer a valuable to way to quantify and analyze the complex structures of flowers, specifically that of *Pedicularis*, a group of flowers that display extreme morphological diversity.

Photogrammetry:
Photogrammetry is a method for creating 3 Dimensional models from many photographs that have been stitched together using various kinds of open source or commercial software. However, traditional photogrammetry is time consuming, labor intensive and expensive. We collected data through a new photogrammetry setup, consisting of a Raspberry Pi that controlled four cameras in order to automate the data collection process.

Goals:
To create a more efficient and practical method for creating 3 dimensional models using two different methods: a modified raspberry pi setup and a blue light scanner. to allow for flower morphology to be studied at the population level.

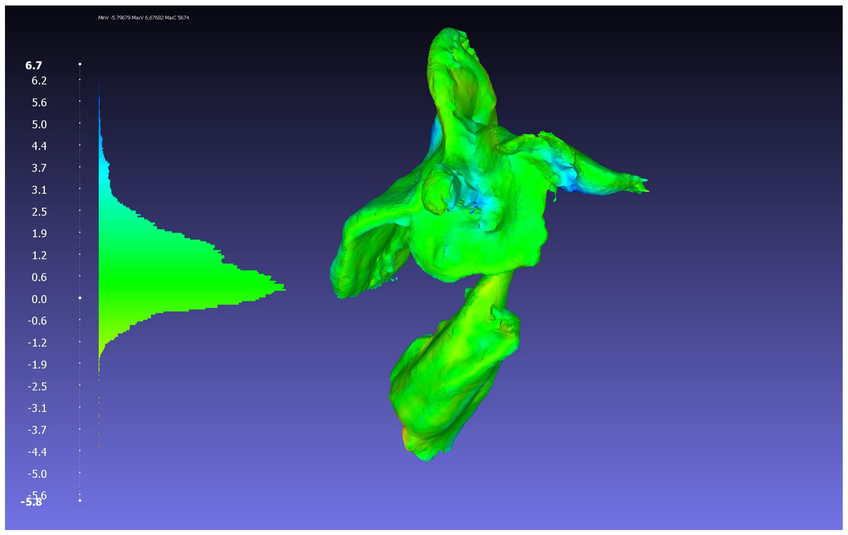


Fig. 1. Vertex distance from original mesh, photogrammetry pipeline

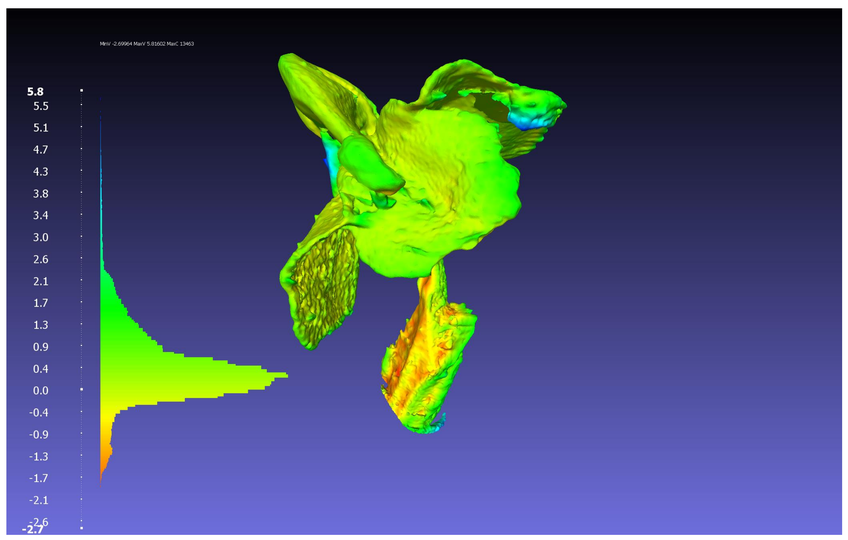


Fig. 2. Vertex distance from original mesh, laser scan pipeline

Methods

Raspberry Pi Pipeline

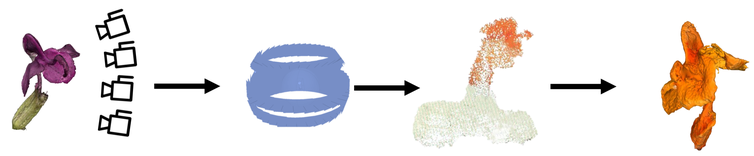


Fig.3 Setup and Workflow of Photogrammetry

Revoscan Mini Pipeline

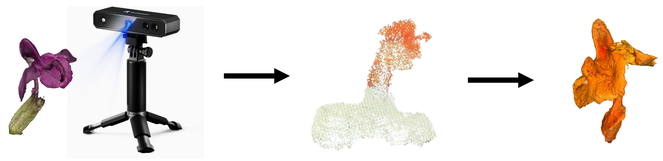
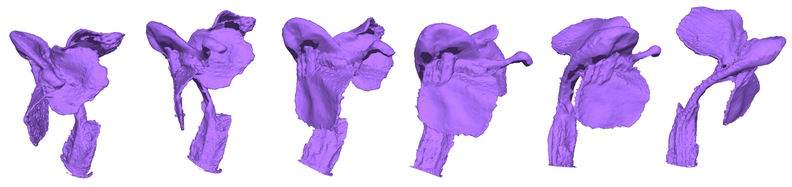


Fig.4 Setup and Workflow of Laser scan



Software
Agisoft Metashape, a commercial software for image processing, was used for masking and aligning photographs, creating point clouds, meshes and texturing. Meshlab was used to clean and compare meshes

Conclusion

The modified Raspberry Pi photogrammetry setup has increased efficiency for creating models, although the software process can still be automated. This new method has the potential to create 3D models on much larger scales.

Next Steps

There are various ways to analyze models, the most common of which is GPA. However since GPA is based off of arbitrary models and not biological ones, it often does not reflect the real biological changing structure. In order to solve this issue, the Eaton lab is developing a landmarking system in order to create ancestral 3D reconstructions that do not have the same draw backs as GPA based reconstructions. Additionally, these methods have many other uses, such as modeling flower development through time.

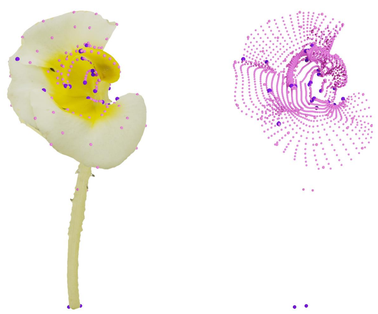


Fig. 5 Landmarked *P. cranolopha*

3D Models:
https://sketchfab.com/eatonlab

Acknowledgments

Leménager, M., Burkiewicz, J., Schoen, D.J. and Joly, S. (2023), Studying flowers in 3D using photogrammetry. New Phytol, 237: 1922-1933. https://doi.org/10.1111/nph.18553