Final report for:
Finding the invasive needle in the imagery haystack via sUAS and computer vision

2019

Collaborators:

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Project title: **Finding the invasive needle in the imagery haystack via sUAS and computer vision**

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Award Amount: **$43,795**

Grant Expenditures:

$25,468.90	Salary and Wages
$4,087.48	Fringe
$8,543.72	Purchase of two DJI Mavic Pro Combo Platinum small unmanned aerial systems with extra batteries for BIISC and SDAV laboratories**.** Purchase of high performance image processing computer.
$1,498.33	Travel to Maui to lead a UAS training session for Maui DOFAW (Div of Forestry & Wildlife) and MIISC (Maui Invasive Species Committee) on March 4-5, 2019. Travel to Honolulu to present research results at annual HIGICC Meeting March 21-22, 2019.
$215.11	Miscellaneous
$3,981.46	Indirect costs
$43,795.00	**Total**

Overview

The objectives of this project were to build sUAS capacity at the Big Island Invasive Species Committee and other interested groups, and to refine and validate an automated computer vision (CV) classifier for the detection of *Miconia calvescens* DC within sUAS imagery. We accomplished both of these objectives. Existing imagery datasets were used to generate and refine the computer vision algorithms; no new spatial data were generated by the UH Hilo SDAV laboratory as a result of this project. Therefore, this report will only consist of narrative and figures.

Summary Findings:

- Around Hawaii, Invasive Species Committees and agencies such as the Division of Forestry & Wildlife are increasingly using small unmanned aerial systems (sUAS) as part of routine operations for detection and surveillance of invasive species.
- These sUAS operations are resulting in increased efficiencies, but human analysis of imagery for detecting individual plant targets of concern remains a bottleneck, and automating these tasks via machine learning algorithms that can quickly scan through hundreds of acquired images is a valuable improvement over current methods.
- We have developed a custom convolutional neural network (CNN) to detect individual miconia leaves in a densely forested environment (Figure 1) with performance comparable to human analysts, but with much greater speed (can process ~400 images per hour on our high performance computer).

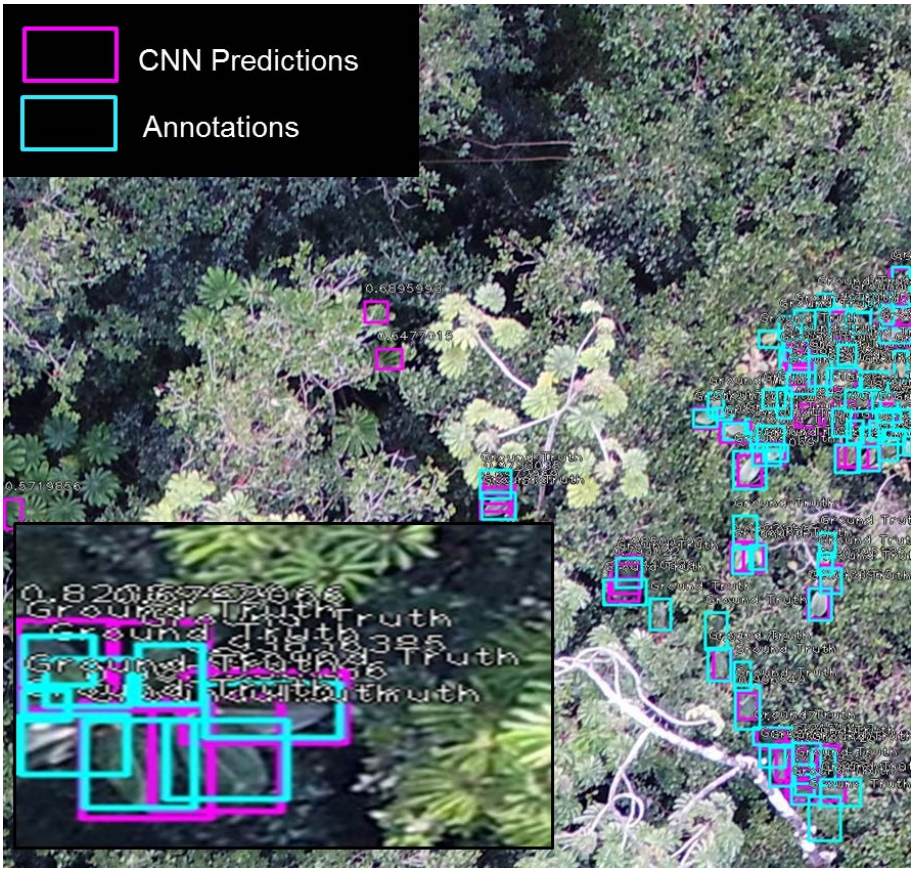

Figure 1. CNN predictions and human annotations for a sample sUAS image

- We are working to further improve the *Miconia calvescens* DC predictor and to expand this work to include other species, including Ohia trees exhibiting suspect rapid ohia death symptoms (Figure 2). Additional species of interest, including *Morella faya* (faya tree), *Megathyrsus maximus* (guinea grass), and *Passiflora tarminiana* (banana poka), are also underway through related work with the National Park Service

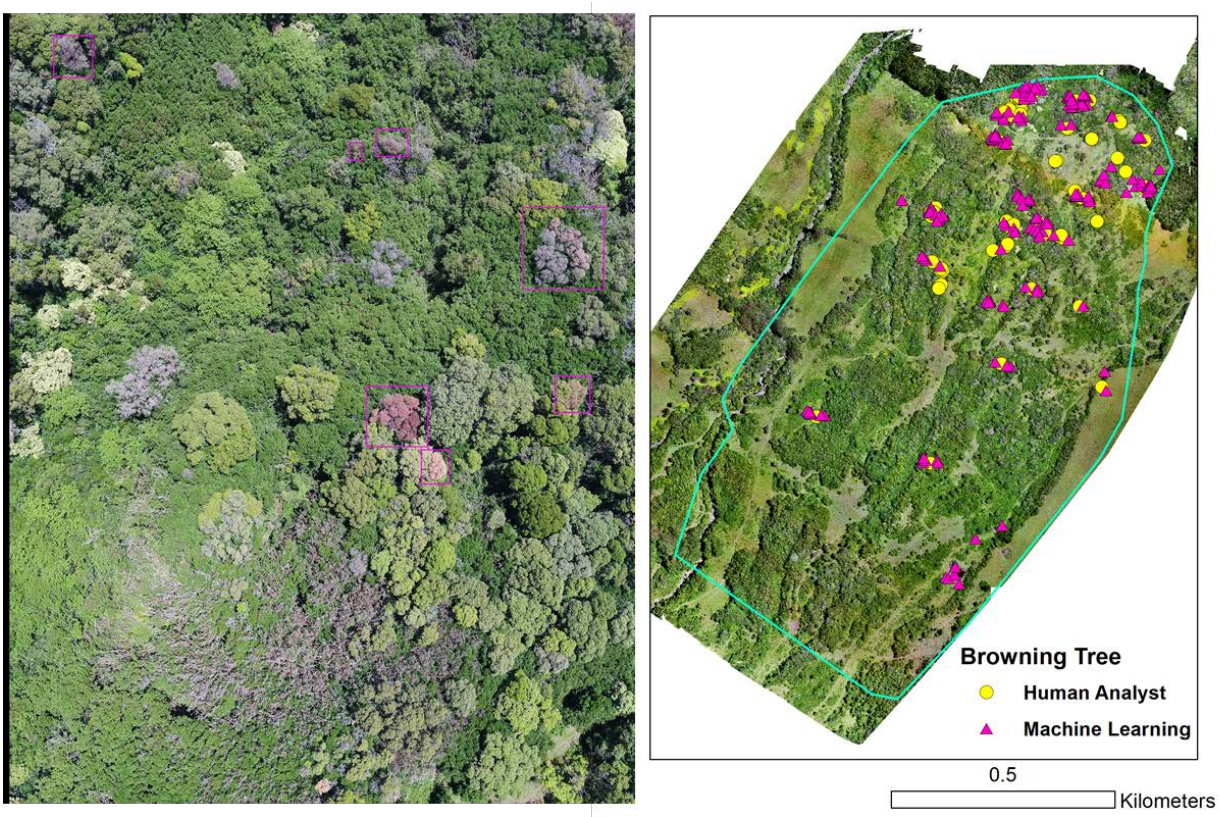

Figure 2. (Left) CNN predictions of suspect ROD trees in raw sUAS imagery, (Right) comparison of CNN predictions (from multiple overlapping images) and human analyst predictions

Deliverables:

- Classification software for identification of *Miconia calvescens* DC
    - Our current version of the *Miconia calvescens* DC classifier, based on ResNet101, is available for download and use by partner agencies from the UH Hilo SDAV laboratory. The next iteration is underway with additional annotation training data that will further improve recall and precision performance (Figure 3)

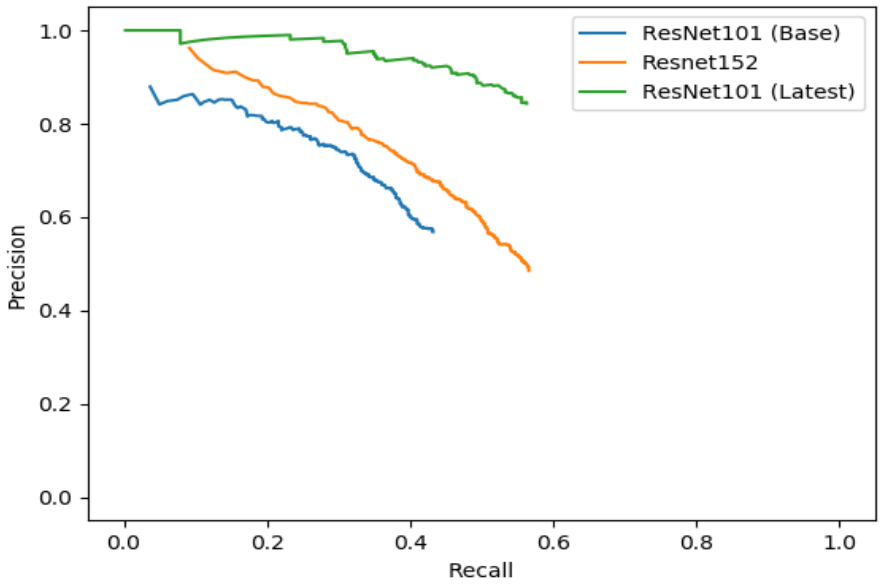

Figure 3. Improvements in *Miconia calvescens* DC classifier over time with improvements in CNN architecture and number of training annotations.

- Performance metrics, including time estimates for desired detection probabilities, on field crew effort in miconia surveillance using aerial imagery
    - Human analyst performance experiments have been completed (n=26) and collected data, including annotation performance, vision tests, and personnel surveys are being processed and prepared for publication
- Standard operating procedures and training materials for image collection, classification, and validation of decision support products
    - Training materials have been developed and shared with workshop participants and partner agencies through multi-day workshops in New Zealand at the Society for Conservation Biology 5th Oceania Congress, 2-6 July, 2018, and on Maui for Maui DOFAW (Div of Forestry & Wildlife) and MIISC (Maui Invasive Species Committee) on March 4-5, 2019. In addition, BIISC and UH Hilo SDAV work together in close cooperation on a monthly basis.
- Centralized library of collected imagery across test sites
    - This library of >1,000 images is held in the UH Hilo SDAV laboratory archives

Products:

Peer-reviewed papers (in-preparation)

- Rodriguez, R., Jenkins, D., Leary, J., and Perroy, R., Automated Direct Geolocation of Features in Unmanned Aerial System Acquired Imagery.
- Perroy, R. Rodriguez, R., Mandel, T., Panoff, M., Benitez, D., Detection of invasive plant species in Hawaii via Convolutional Neural Networks.
- Parker, J. L., et al. The benefits of sUAS integration into early detection of invasive species, Pacific Cooperative Studies Unit Technical Report

Conference Presentations

Perroy, R. (2019), Increasing the availability and utility of high-resolution imagery for invasive species detection in Hawai‘i, *EMAPi 2019 Conference*, September 11, Prague, Czech Republic

- Perroy, R., Parker, J., Benitez, D., Knox, A., Sullivan, T., Radford, A., Leary, J., Mahnken, B., Kaye, S., Rodriguez, R., You CAN try this at home: Breakthroughs in aerial operations for invasive species management, *Hawaii Conservation Conference*, July 11, Honolulu, HI. (Symposium session)
- Rodriguez, R., Leary, J., Jenkins, D., and R. Perroy (2019) Detection of Miconia calvescens DC in Hawaiian Forests with Convolutional Neural Networks, Poster session, *American Society of Agricultural and Biological Engineers Annual International Meeting*, July 9, Boston, MA.
  Perroy, R. (2019), Overview of remote sensing projects at the UH Hilo SDAV Laboratory, *Hawaii Geographic Information Coordinating Council Annual Meeting*, March 21, Honolulu, HI

Training Workshops

- Parker, J., and Sullivan. T. (2019) sUAS training workshop for Maui DOFAW (Div of Forestry & Wildlife) and MIISC (Maui Invasive Species Committee), March 4-5, Maui, Hawaii.
  Parker, J., and Perroy, R. (2018), sUAS Workshop for Conservation Biology, *Society for Conservation Biology 5th Oceania Congress*, July 2-6, Wellington, NZ.

Datasets

- Library of >1,000 raw images from sUAS flights under different lighting conditions over areas in Hawaii containing Miconia calvescens DC
- >5,500 annotations of individual miconia leaves for algorithm training and validation
- Downloadable software for detecting Miconia calvescens DC from a folder of raw sUAS imagery