Internship Project: Determining Snow Depth Using an Automatic Image Processing Algorithm

Kevin Sacca (Junior, Rochester Institute of Technology) Co-Author: Stephanie Cortés (Senior, Universidad de los Andes) Mentors: Michael SanClements, Sarah Elmendorf

National Ecological Observatory Network

Introduction

The amount of snowfall in an ecosystem is important because of the insulating effects of snow cover, snow's effects on surface energy balance, and the amount of water it adds to the environment. Snow water equivalent (SWE) is the product of snow depth and snow density, and represents the amount of water entering the soil if the snowpack melts.

NEON's towers are equipped with static phenology cameras for automatically collecting understory images remotely, but these same images can also be used to determine snow depth through robust image processing techniques. By placing a staff gauge in the understory scene, image processing techniques can analyze the image for the gauge and determine the snow depth. Frequent image collection at multiple sites allows time series datasets for snow depth measurements to be compared across space and time.

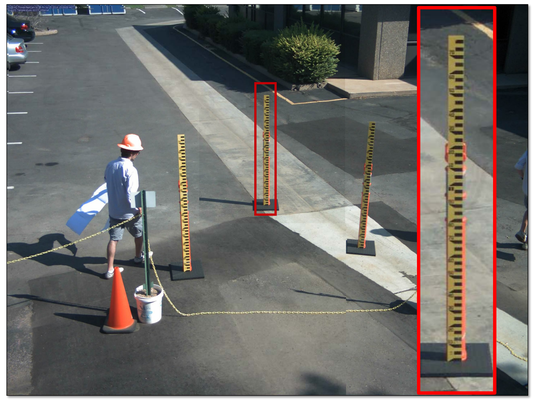


Figure 1. An example image of three staff gauges taken under the given setup parameters with a zoomed view of the region of interest outlined in red.

Phenology Camera (Phenocam)

Figure 2. The StarDot NetCam SC. [1]

The camera system that will be integrated on the site towers is the StarDot NetCam SC 5.0 IR camera. The camera operates with a 5.0 megapixel resolution and has automatic exposure control.

Each tower will have two cameras integrated: one at the top of the tower for canopy phenology and the other at the bottom to collect understory images for snow depth.

Image Processing Method

- For a graduated staff gauge, a line profile is a useful tool for analyzing its features.
- A line profile is a plot of the intensities of the pixels that fall onto a designated line segment.
- Objects and features in an image can be classified from the relative intensity levels of neighboring pixels.
- Pixels that have very high relative intensity levels can be classified and identified as snow.
- These snow pixels can be emphasized through the smoothing of oscillating data.

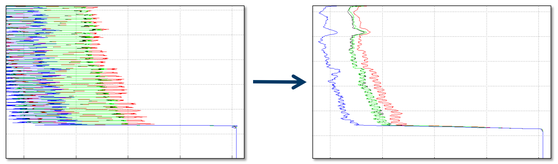


Figure 3. Line profiles of a staff gauge before and after smoothing.

Setup

Setup Specifications:

- Three staff gauges (1.8m) in the Field of View (FOV)
- Measurement error must be ≤ 1cm

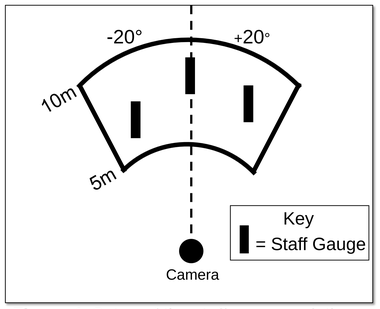
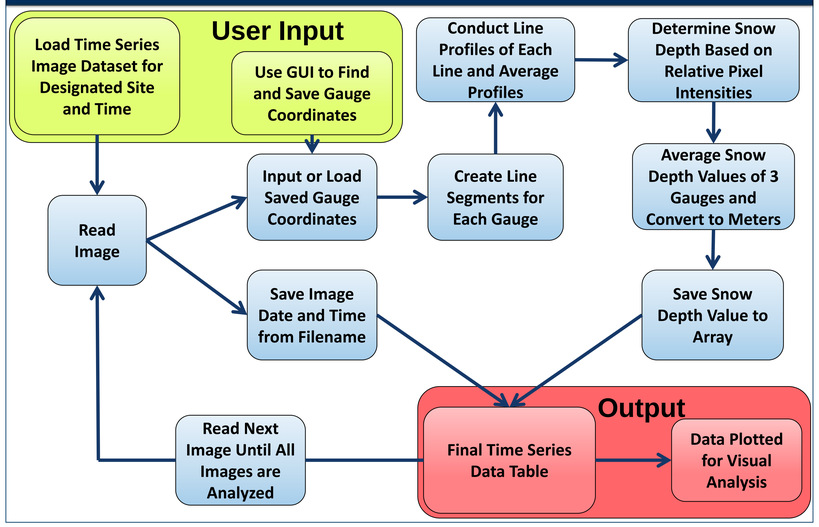
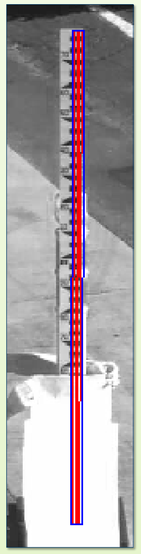


Figure 4. Setup of the staff gauges relative to the camera. The range of distances they can be placed, and the FOV are shown.

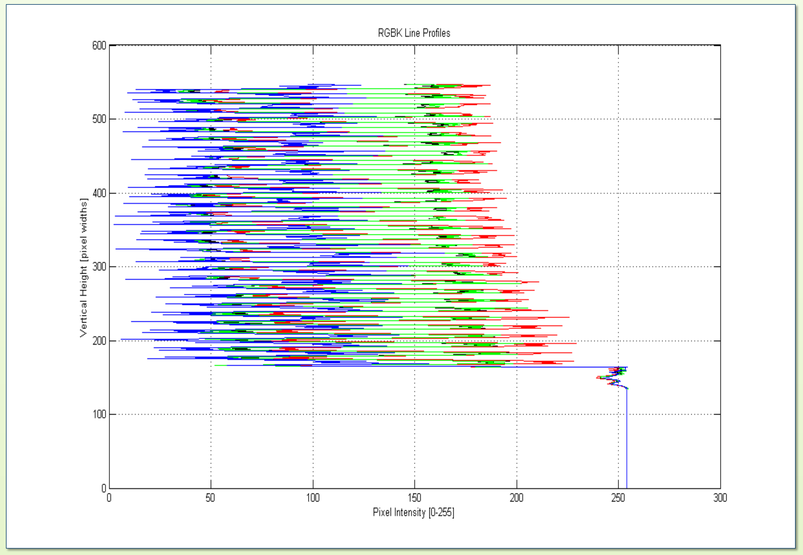
Algorithm Flow Chart



Results and Output



A



B

Day of Year	Snow Depth [m]
1.50	1.26
5.50	1.26
9.50	0.97
13.50	1.26
17.50	1.26
21.50	1.26
25.50	1.26
29.50	1.26
32.50	0.97
36.50	0.97
40.50	0.97
44.50	1.26
48.50	0.97
52.50	0.97
56.50	0.97
60.50	0.97
64.50	0.97
68.50	0.97
72.50	0.61
76.50	0.61
80.50	0.61
.	.
.	.
.	.

C

Figure 5. Image A shows a cropped region of interest in the image around the staff gauge, with the red line segments used for the profiles shown in their respective positions. Figure B is a plot of the average line profile in four channels, R, G, B, and K, of the gauge in Image A. Note the regular oscillations of pixel intensity in the region of the staff gauge not covered by the paper, (paper representing snow). C is a table of snow depth vs. time, with the images taken at noon in four day intervals. Table C is plotted below in the *Time Series Data* section.

Time Series Data

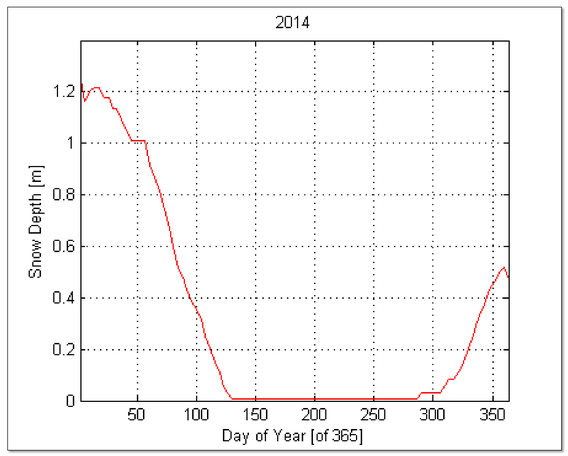


Figure 6. A graph of average snow depth over time. This time series data is the data from Table 5C, and was generated from a simulated dataset of images. The benefit of having long time series datasets is the ability to compare snow depth among different locations and times.

Significance

With the given project requirements, the error of this algorithm in determining the true snow depth is approximately 1 cm, which meets the project goal set to make sure accurate data is obtained.

Using this automated snow depth measurement algorithm has many benefits:

- **Saves massive amounts of time** that would be spent manually going through images. Each site would have ~30,000 images a year.
- **Saves money** since it would be costly to have someone determine snow depth manually.
- **Consistent, accurate, fast, and independent** of site, making it continentally scalable.
- **One-time user input**, with an easy way to recalibrate the system in case of emergency.
- **Easy to use, and easy to modify**. Allows for future improvements of added corner detection and background noise reduction.

Contact Information: kws1850@rit.edu

www.neoninc.org

[1] http://www.stardot-tech.com/ip_cameras.html