Quantitative Analysis of Immediate Environmental Problems Using Inexpensive Drone Technology.

Alec Jones, Robert Ferullo, Adriana Noyes and Kayla Pelloni
Department of Environmental and Health Science at Johnson State College
Faculty mentor: Leslie Kanat

The Problem

Landslides, rockfalls, and soil erosion become more severe with increased rainfall. Climate change is a major contributor to the increase in heavy precipitation events (USGCRP 2017). Precautions should be taken to reduce the risk of slope failure on vulnerable land due to environmental factors. Vermont also has very active rock chutes neighboring mountain trails and roads. These chutes can be monitored by using drone technology. Areas with high erosion rates or land movement can be found using digital elevation models, from which it possible to calculate volumes. Land loss may also be calculated with subsequent models.

Use of ArcGIS

Using the DJI Phantom 4 Pro drone, high resolution photos are taken at precise altitudes and angles. These photos are imported into ArcGIS and geolocated. Coordinates are embedded in the photos and used by ArcGIS to place the images on a basemap. This allows for a set of photos of a survey area to be accurately placed and geolocated on a digital map (Figure 1). These photos are also layered over one another to create a seamless overlay of the area being photographed (Figure 2). These methods are used to observe areas of land loss associated with landslides, rockfalls and soil erosion.

Figure 1. A georeferenced photo of Johnson State College's Campus.

Figure 2. Stitched photographs

Use of Agisoft Photoscan

Agisoft Photoscan software enables users to create three-dimensional models of objects or landscape. The rock on the Johnson Quad (Figure 3a) was modeled by flying the drone around it and capturing 38 images with at least 50 percent overlap.

Agisoft Photoscan interprets the GPS data from the drone. This allows the program to replicate the rock in 3D space. Irrelevant portions of the images, such as the lawn, are masked accordingly. The images are automatically aligned and fine details may be added if desired. Using the "close holes" feature in Agisoft, allows the object's volume to be calculated. This is especially useful in a case such as this, where it is impossible to obtain images of the underside of the rock (Figure 3b). Using this method, the calculated volume of the rock is approximately 8.3 m^3, which is surprisingly close to its true volume.

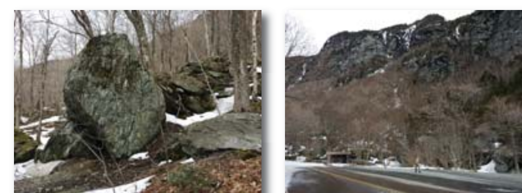
Figure 3. Volumetric calculations for the rock on the campus of JSC. Image 'a' is a photograph taken above the rock and has limits marked. Images 'b–f' are processed. Image 'b' depicts the bottom of rock (never photographed). Images 'c–f' are model representations of the rock rotated ≈90˚ to the left in each subsequent image (shadows are due to sun angle).

Use of 3D Printing

After obtaining accurate volumetric calculations of the landforms using Agisoft Photoscan and drone imagery, 3D models are created with the Prusa i3 MK2.5 Multi-Material printer. Printing a 3D model of the rock on the central campus of the Johnson State College can be done using the volumetric calculation. This printer will also be used to print 3D models of rock chutes at Smuggler's Notch–also derived from drone imagery. Volume loss and soil erosion models can also be printed using this approach.

Future Work

The drone will be taken to Smuggler's Notch (Figure 4) to construct a model of the landscape in the same way the rock on the JSC Quad was built. The following year, another model will be created at the same location. By comparing the volume of the landscape at each point in time, total loss or movement of material may be quantified. The drone will also be used to analyze soil erosion volumes and rates in the gullies found on crop fields at Joneslan Farm in Hyde Park, Vermont.



a b

Figure 4. Rock falls (a) and a rock chute (b) at Smuggler's Notch, VT.

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Reference

US Global Climate Change Research Program (USGCRP) (2017). *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. Washington, DC, USA, 470 pp., doi: 10.7930/J0J964J6.