MC3 - A Web-Based Interactive Image Explorer for Temporal Analysis of Satellite Images (Honorable Mention - Good Interactive Image Explorer)

Vijayraj Mahida* Bartosz Kupiec* Andrew Burks* Timothy Luciani* G.Elisabeta Marai*

Electronic Visualization Laboratory, University of Illinois at Chicago

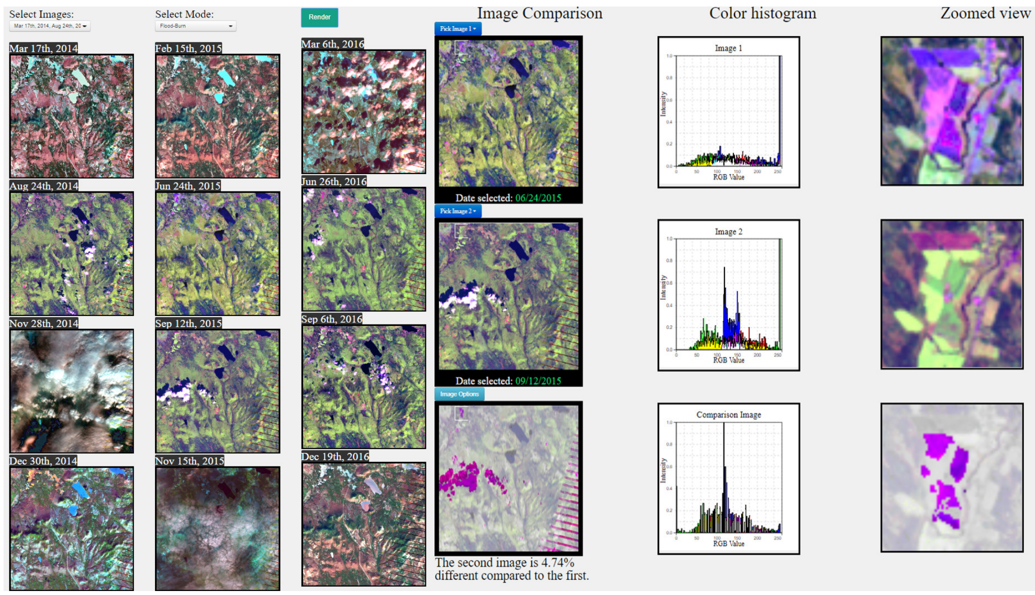

Figure 1: Image comparison tool, with overview (left) and detail analysis (right) of satellite images, showing possible trends in the upper-left region of the image set. Our web-based image analysis tool combines small multiple views of satellite images, linked semantic zooming and image intensity histograms, along with filter controls.

Abstract

Our web-based image analysis tool for the VAST 2017 Mini-Challenge 3 combines small multiple views of satellite images, linked semantic zooming and image intensity histograms, along with filter controls. The resulting tool allow users to interactively analyze spatio-temporal changes in the preserve area.

1 Introduction

The overall goal of the VAST 2017 Mini-Challenge 3 was to find correlations between satellite images and the concerning plight of the Rose-crested Blue Pipit. The provided dataset included twelve six-band satellite images which ranged from visible light to short-wave infrared. Along with these images a single RGB image was provided to show the length of the lake; the relation of the lake image relative to the satellite images was not given. Finding the scale and orientation of the lake, via pixel analysis or through other image analysis techniques, must be performed. Distinctive features in the preserve area, i.e. town full of houses, farms, factories, parking lots, and additional features in the area may help in finding possible causes for the problem of the Pipit bird.

*{vmahida2,kupie2,aburks3,tlucia2,gmarai}@uic.edu

2 Approach

We have designed and implemented a web-based image analysis tool that combines small multiple views of satellite images, linked semantic zooming and image intensity histograms, along with filter controls. The resulting tool allows users to visualize changes in the preserve area. The tool is implemented using the D3 library and javascript.

The six-band satellite images, provided in both TIF and CSV format, can be converted to match specific criteria set by the user. The small multiples view allows users to see the changes in the lake across seasons. Users can explore those changes in more detail in the zoomed semantic view. The detail view further provides image intensity histograms and filters, to aid the analysis process. This coupled approach allows trends across two satellite images in different modes to become more apparent. For example, specific information of the Boonsong Lake area, such as the suspected farmlands (which could be seen clearly when looking at both plant health and RGB modes), can be classified. Using this tool as a baseline, further exploration of the preserve can be done to find anomalies that may link-up with the other mini-challenges.

3 Scale and Orientation of the Boonsong Lake

To find the scale and orientation of the lake, we used the converted RGB images to find the Boonsong Lakes position. We started with the picture with information about the lake (whose orientation was north-south and 3,000 ft. long). The clearest image (i.e. the one with minimal cloud cover and visible roads) seemed to be from data image02_2014_08_24. We scaled the satellite image to 7812 x 7812 pixels, then we took the original lake image and overlaid it on top of the satellite image. We computed that the lake images length is 347 pixels, which is about how much the lake takes vertically (where 347 pixels is 3,000 ft). By overlaying the original image on top of the satellite images we then tentatively computed the scale (1 px = 74.745 ft squared) and orientation of satellite images (north-south).

However, our assumption regarding the scale of the satellite image was incorrect. A better approach would be to retain the original satellite image and rescale the provided lake image to estimate the pixels covered by the lake image in reference to the satellite image. Overall, our pixel size was not determined correctly. We think the reason is that we measured the height of the lake as 347 pixels instead of 30 pixels. In short, we forgot to apply the scale factor used when upscaling the satellite image from 650 to 7812 (about a factor of 12) to the estimate for the distance covered by a pixel. The true size of the pixel was approximately 100 by 100 feet instead of our 8.645 by 8.645 feet estimate.

4 Feature Analysis

Once we identified the estimated size of the preserve lake, we used the interactive tool we have developed to find distinctive features. With the created web-based image analysis tool we were able to identify specific unique trends in the area. There are several features that we identified by analyzing these images. The main features are five lakes, farmland (possibly campgrounds), parking lots, and roads (see Figure 2 for a summary). Our analysis tool was successfully used to identify clouds, snow, plant cover changes, man-made features, and imaging artifacts.

Using image processing and the September 2016 image as reference, we were further able to trace roads, based on pixel value similarity across 12 rendered images. The September 2016 image was used for road tracing (or at least as a backdrop for showing the results). Unfortunately, the image differencing threshold was set too high and it did not highlight the sludge dumping site. The tracing actually interprets the drainage path from the sludge dumping site as the continuation of a road. The power line that cut roughly north to south through the middle of the map was misidentified as a road, yet was successfully traced by the tool along with the actual roads. However, our analysis was focused on the correct temporal comparison and location.

With the multiple views we can see changes in Lake D over the same season between 2014-2016: plant health, cloud cover, and snow-ice become readily apparent. The zoomed view tool under the image comparison feature of our software enabled us to see that on 9/6/2016 and 12/19/2016 there was snow cover present in the area where the two major roads intersect, but the overall shape of that area remains the same. We can observe this because during September 2016 and December 2016 the shape of the roads and lot are roughly the same. Some sort of structure must be there, most likely camping grounds or parking. There appear to be sensor errors on the right side of the images across all bands except on 9/6/2016 bands.

5 Changes Over Time

Using the small multiples view to see the changes of the preserve over time and combining the image comparison tool we are able to see clear plant health changes over the time from 06/24/2015 to 09/12/2015 (Fig. 3). In the RGB images the shadows of the clouds can be observed. In November (of year 2016 and 2015) the area is very cloudy, which would make sense since its close to winter time. In the flood-burn mode the differences in the area of interest (second image) become apparent as well. The percent difference between images is displayed on the bottom of our interface.

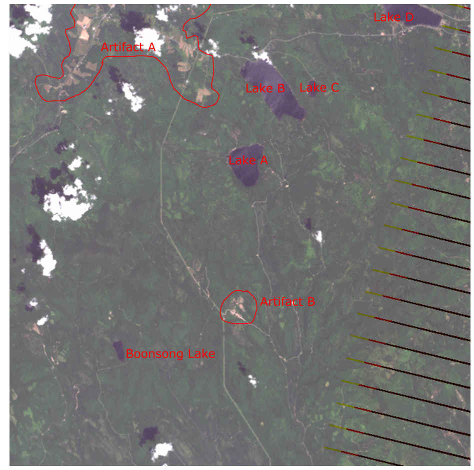

Figure 2: A satellite image from June 26th 2016 is shown in RGB above to highlight identifiable natural features in a lake area. The power line that cut roughly north to south through the middle of the map was misidentified as a road.

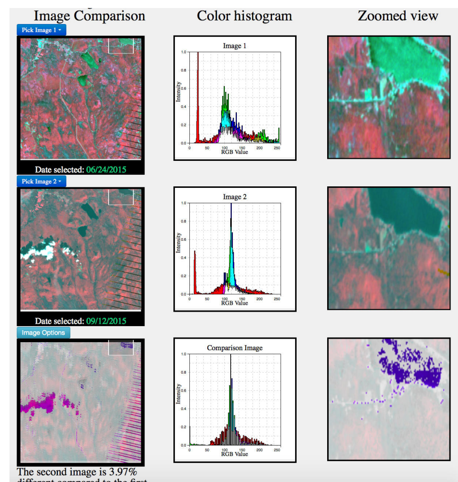

Figure 3: Lake D was our suspected chemical pollution site due to plant health changes, as shown by the zooming tool in the lake over three months, specifically from June 2015 to September 2015.

6 Conclusion

Overall, we were able to identify vegetation changes near the lake in the northeast corner of the image data as a potential pollution site, although not the location of the true sludge dumping site or vegetation changes occurring near it. Additional observations about icy roads and variance in how the lakes freeze over show that our tool is capable of supporting in-depth exploration.

Acknowledgments

We thank the anonymous reviewers for their generous and supportive feedback. We thank everyone at the Electronic Visualization Laboratory for their support. This work was supported in part by NSF awards CNS-1456638 and IIS-0952720, and by the NSF GRF program.