Mid-Latitude All-sky-imager Network for Geophysical Observations 2

Atmospheric Imaging

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A Major Qualifying Project (MQP) submitted to
the Faculty of Worcester Polytechnic Institute in partial fulfilment of the requirements for the Degree in Bachelor of Science in Electrical and Computer Engineering submitted by

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Abstract

The ionosphere is a region of Earth's atmosphere comprised of ions, and fluctuates based on factors such as time of day and weather. Disturbances that propagate through this region, called ionospheric waves, were the focus of this project. SRI International has a network of nine imagers scattered throughout the United States that take pictures of the night sky. This project developed two systems that process these images. The first system integrated images from the imaging network and displayed the resulting mosaic over a geographical map projection. The second system enhanced, analyzed, and identified ionospheric wave features in each image. The team also provided SRI with a developer's manual. These tools will be useful in providing a better tool for SRI to understand ionospheric waves.

The full report will be posted under the authorship of Danielle Riccardi.

1 Executive Summary

This project had two goals.

1. Assisting SRI in developing a system that created and displayed a mosaic of images from a network of nine identical sky imagers installed across the continental United States in a geographical map projection.
2. Created a second system that identified the wave feature, frequency, scale size, and direction of ionospheric waves by analyzing images taken by SRI's sky imagers.

To achieve the first goal the group completed the following objectives with its respective tasks:

1. Created a geographic map in a desired projection and scaled it to the continental United States using Python.
2. Displayed the images in the geographic map such that they are correctly plotted with respect to site's latitude and longitude coordinates and scaled to the projection of the map.
3. Displayed a mosaic of images in the US map in a seamless, continuous manner, disregarding overlapping sections and accounted for each all-sky imager's status (online/offline, resolution, etc.).
    a. Developed an algorithm that identified the quality of each image and sorted the images to be displayed in order of quality.
    b. Wrote an automated system that calculates intersection points of images from adjacent sites based on the map projection used.
    c. Based on the intersection points calculated, created image masks that could self-generate based on images whose sites overlapped and the status of the adjacent sky imager's location status (online/offline).
    d. Utilized the masks created to "stitch" images together.

To achieve the second goal the group completed the following objectives through these tasks:

1. Enhanced images taken to highlight and identify wave regions
    a. Researched different image enhancement methods
    b. Created a system that enhanced images by taking the difference between two images and enhancing the overall image.
2. Developed an algorithm to identify wave features.
    a. Defined how wave features can be recognized based on the images.
    b. Quantitatively measured waves

The completion of these tasks and objectives led us to achieve three deliverables.

1. A geographic map of the continental United States with the resulting time-sequence of "stitched-images" mosaics from a network of eight identical sky imagers.
2. A complete system implementing several algorithms that enhanced images and identified wave features, frequency, scale size, and direction by analyzing the images received from sky imagers.
3. A report that documented the design and implementation of the image processing system together with user's and developer's manuals.