A Mobile App to Estimate Sky View Factor

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Abstract

Assessing the sky view factor or the intensity of solar radiation that a place receives is valuable to various walks of life. A solar engineer would want to know the intensity a place can garner to decide whether or not to place a solar panel. On another track, a person maintaining a small garden would also benefit from the intensity information to help the plants grow well. Instantly reporting the light intensity levels is the key to help users achieve their respective goals. The approach that this project aims to employ involves building an intuitive iOS mobile app, which users can use on their iPhones and get the results promptly.

Introduction

Sky View Factor (SVF) is the the percentage of light under the canopy. It helps in determining the snow melt rate, soil moisture, and the stream temperature. The SVF is also significant in urban areas in cases such as estimating the radiation a street receives. Clearly SVF is an important factor in many fields.

Traditional Approach

Currently, SVF is estimated using a device called Densiometer. It is a wooden device with a metal plate embedded into it.

Using this device poses multiple challenges as detailed below

1. Instructions – A close look at the instructions sheet reveals that the device expects user to rely on his guess work in estimating data, which is further used in calculating the SVF.
2. Cost – This device is priced at $150 on Amazon making it an expensive product.
3. Location – Since this is a standalone device. It doesn't have the ability to store the location details i.e. latitude and longitude, where the data points are noted.
4. Time – It doesn't store a timestamp when the details are collected.

5. Direction – Noting the magnetic directions such a North, North East could be of significant importance to the projects. However, it is not possible with this device.
6. Leveler – This tiny unit placed in one corner of the device demands user's attention to level it. Since the device will be held at shoulder height and at arm's length, it adds burden to the user. Over all this product with its challenges doesn't offer an amazing user experience. A Spherical Densiometer is shown in figure 1 below.

Figure 1 - Image of a Spherical Densiometer[1]

Mobile App as a solution

To overcome the challenges posed by the Densiometer, we have worked towards building an iOS mobile app. To replicate the functionality of the device, we need to produce an image that captures the surroundings with a wide angle. For this purpose, we procured a fish eye lens, which offers a 180 degrees' view.

[1] Densiometer image http://www.amazon.com/Forestry-Suppliers-Spherical-Densiometer-Convex/dp/B0096EOF20/

Figure 2 - Fish eye lens[2]

Figure 3 – Lens mounted on smart phone[3]

Pictures of a fish eye lens and how that can be used with a smart phone are provided in figures 2 and 3 above. In figures 4 and 5 below, we can notice the difference between the images captured using a normal vs fish eye lens.

Figure 4 – Normal lens image

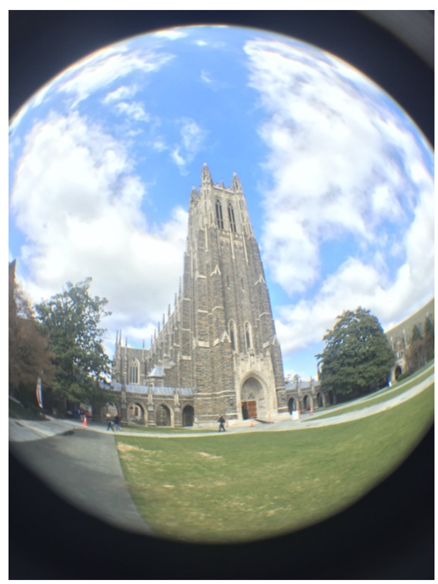

Figure 5 – Fish eye lens image

[2] http://www.walimex-webshop.com/en/walimex-walimex-fisheye-lens-180-for-iphone.html
[3] http://www.amazon.com/gp/product/B00G33BZ2A

The plan is to click a hemispherical picture, using a fish eye lens and an iPhone, at a location and process that image to estimate the SVF.

App Framework

The flow of the mobile app is presented below. It starts with the initial screen as shown in figure 6. The user is promoted to do three actions – choose the theta and phi values and capture the image. Tapping on the button 'Capture Image' segues the user to screen two shown in figure 7. Here the user gets the opportunity to view the captured hemispherical image. Now the user can tap the button 'Process Image'

Figure 6 – Initial screen with 3 possible actions

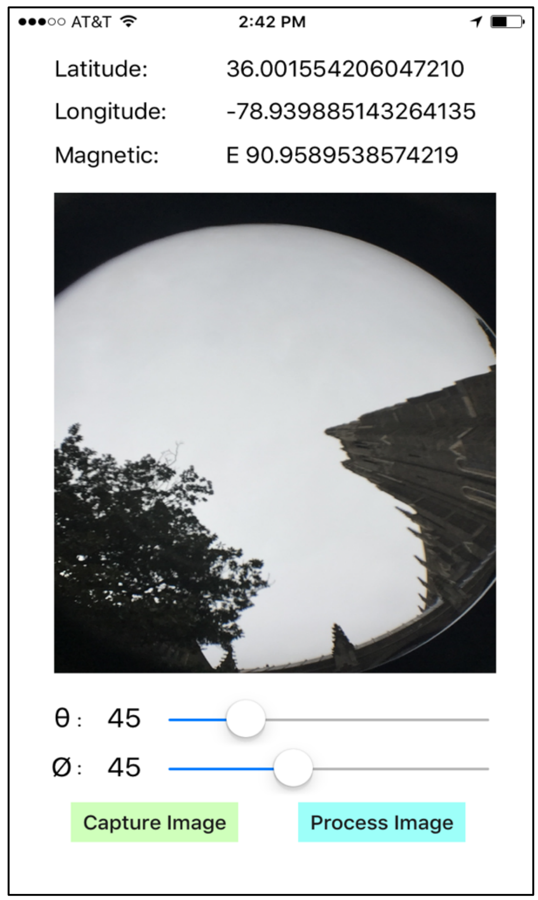

Figure 7 – User can process the image

Once the user taps the process image button, the image sent to a webserver, where the image is processed or thresholded using an image processing algorithm. The original and thresholded images are displayed below in figures 8 and 9.

Figure 8 – Original image

Figure 9 – Thresholded image

Image thresholding

Once the colorful image reaches the server, it is converted into a black and white one. Here black denotes the obstructions such as canopy and buildings, which we want to get rid of, and white portion denotes the clear area through which sun light can reach the floor passing through any obstructions. This process of converting a colorful image into black and white one is referred to as thresholding. In this project a naïve thresholding approach is used. We took a certain shade of grey color in the RGB spectrum and considered any shade/color below that white and above that black. Ideally, this approach can be optimized.

Parameters theta and phi

In this application, theta denotes the magnetic directions such as North, North East etc., and phi denotes the angle of the light as it falls on the fish eye lens. Together these two parameters help us divide the image into multiple sections. These sections and the corresponding SVF values can be seen in the results section.

Result

Once the image is processed, the results are sent to the user in two different approaches. The figures are displayed in the app and a copy of the results, original image, and thresholded image are sent together in an email to the user. To explain how the results can be easily interpreted, in figure 10 we have presented a sample image with overlaying graphics. Also in table 1 the corresponding sky view factors or the light intensities are provided. As section 5 has a dense canopy, the SVF value is very low at 3.39% and on the other end in section 1 there is hardly a canopy, so the SVF value is high at 83.9%

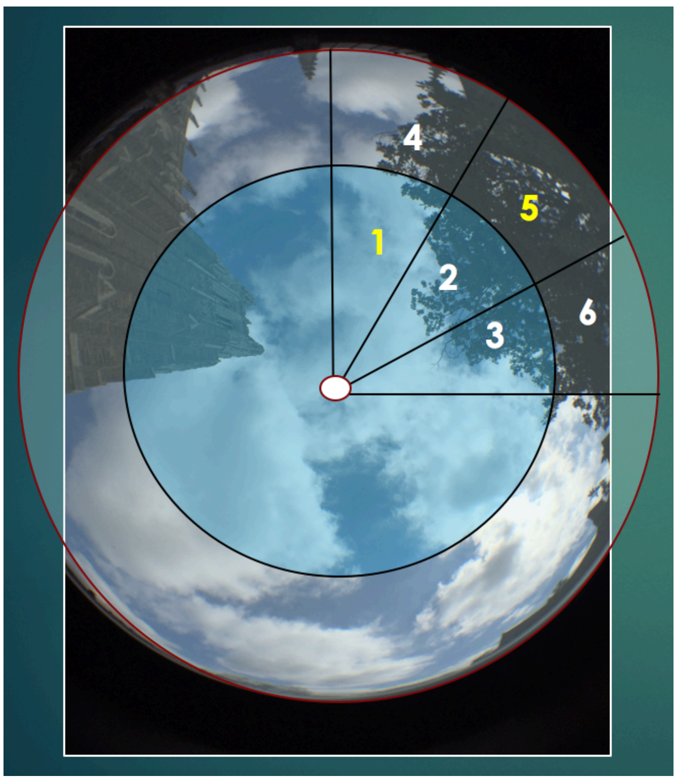

Figure 10 – Example image of how the results can be understood

Section #	Intensity %
1	83.9
2	73.12
3	60.57
4	33.76
5	3.39
6	2.1

Table 1 – Intensities are presented next to the section numbers

Limitations

Though fish eye lens offers a wide angle view, the smart phones especially iPhone doesn't capture the full image. It results in cropping on two sides of the image as shown below in figure 10. This limitation hampers our solution in estimating the sky view factor.

Figure 11 – Aspect ratio results in cropped sides

Improvements

To improve the app further, effort needs to be invested in developing a better image thresholding algorithm. Besides that, a leveler component can be added to the first screen of the app.