MEASURING LIGHT THROUGH TREES FOR DAYLIGHT SIMULATIONS:
A Photographic and Photometric Method

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Established in collaboration with MIT

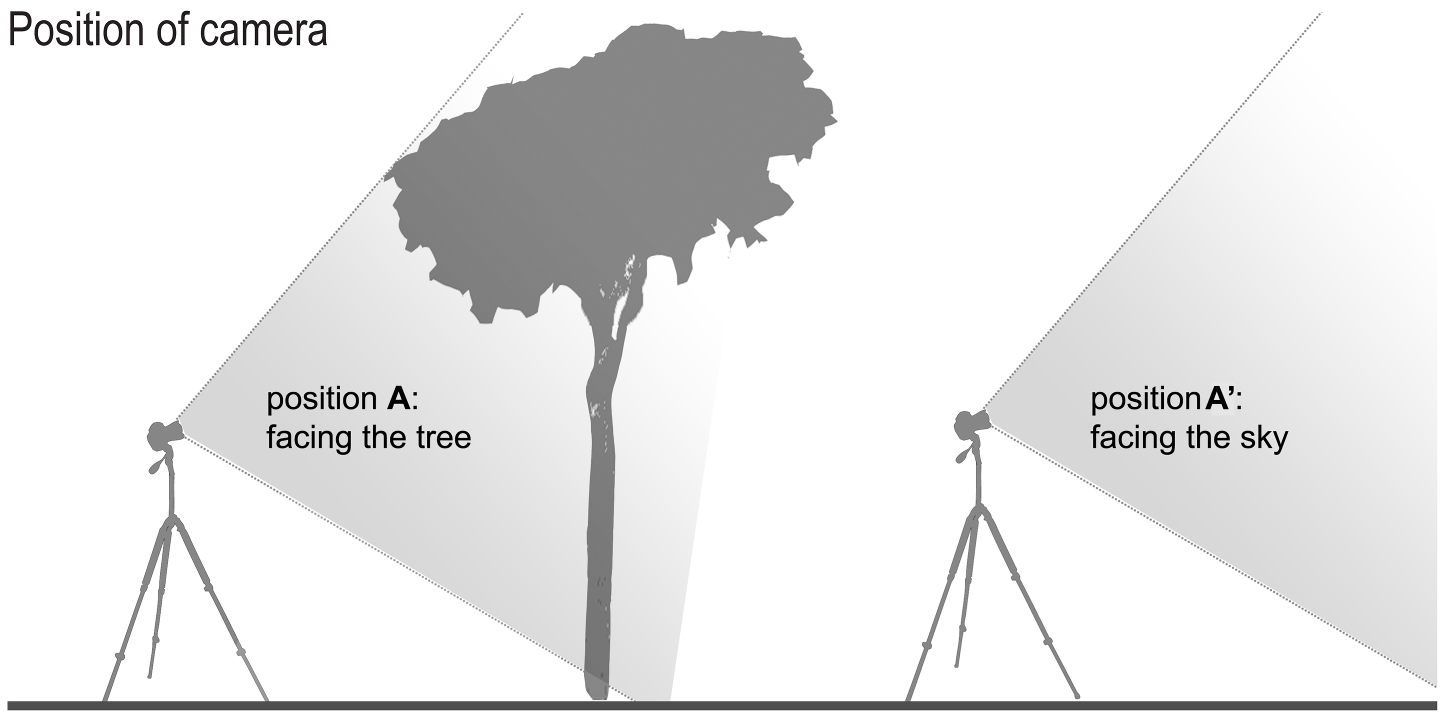
INTRODUCTION

Trees attenuate the quantity of daylight entering buildings, creates dappled patterns of daylight and the colour of trees effect the amount of reflected light. General modelling practice in daylight simulations simply trees as cones, cylinders or spheres with an assumed reflectance of 20%. We wanted to investigate a method that would allow one to photograph a tree on site and translate it into a geometrical model for daylighting simulation without drastically increasing the simulation time.

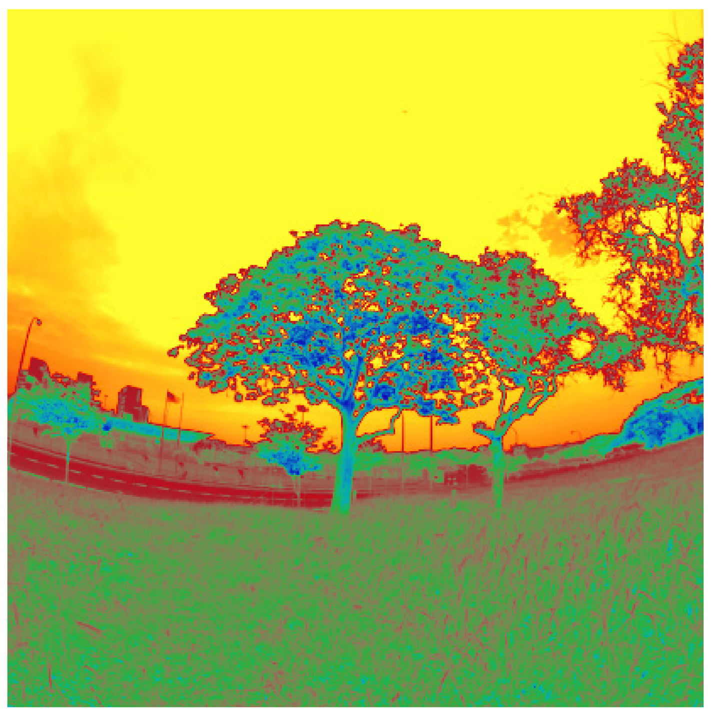
1. IMAGE CAPTURING

We capture the image of the tree using two canon EOS 5D camera with fish eye lens of equisolid projection. We take an HDR (High Dynamic Imaging) hence the sensitivity is kept at ISO 100, with a fixed aperture of f/5.6 and varying shutter speed from 4 to 1/8000 seconds. One camera faces the tree and captures the light that passes through the tree crown and the other camera faces the sky and captures the sky luminance. Both the cameras face the same portion of the sky. For the test study we take a total of 6 photographs, 4 vertical profiles and two undercrown.

Position of camera



HDR image capture



2. IMAGE PROCESSING

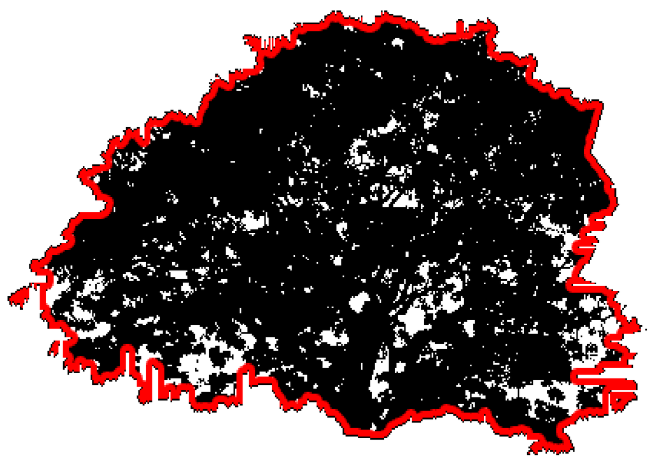
Once the image is captured, it is processed in two steps. The first step is to threshold the image -- converting a colour image into a binary image of black and white pixels. The aim of thresholding is to separate the tree crown from its background which in most cases is the sky. After thresholding, the area of interest is determined by manually cropping the crown from the rest of the image. We created a simple algorithm that draws a tight boundary of the cropped tree crown. It is within this boundary that the percentage of gaps is in the crown is calculated.

Thresholded image

Determining area of interest

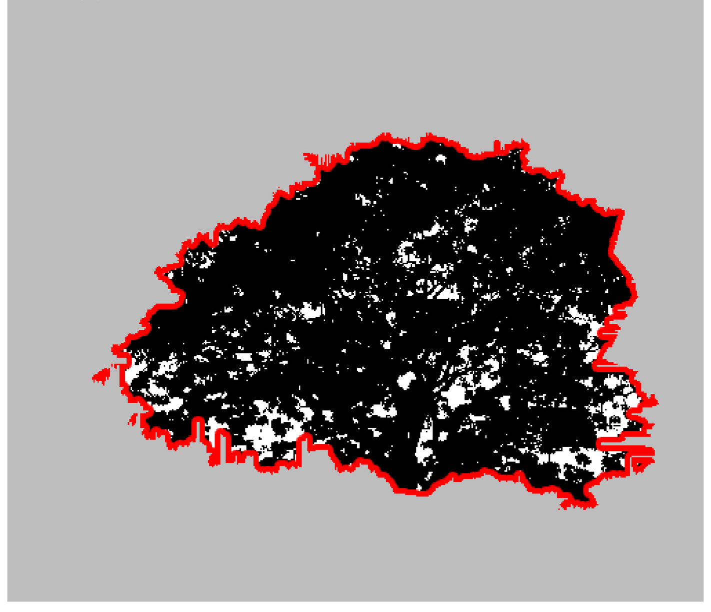
Manual cropped tree crown

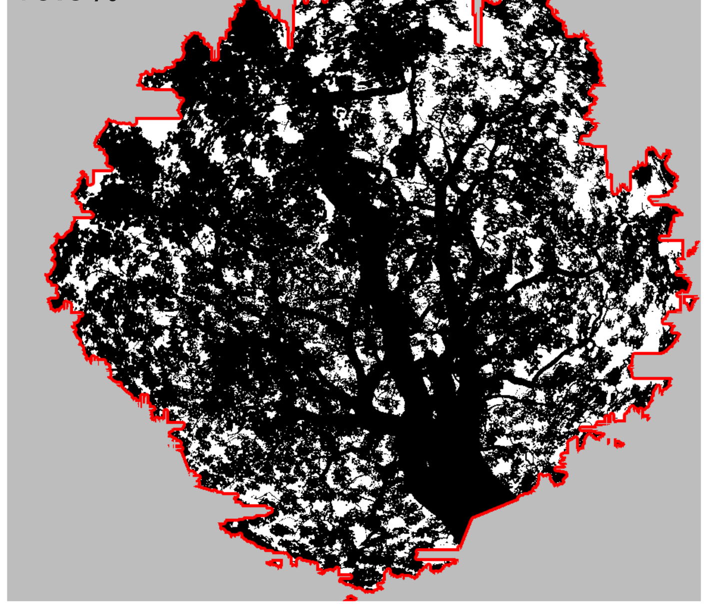
Tight boundary with the algorithm



3. IMAGE ANALYSIS & RESULTS

Gap percentage of the crown is the percentage of the gap sizes within the crown. The higher this percentage, the higher the transmittance of light through the crown will be. The gap percentage of the crown is calculated by dividing the total number of gaps (white pixels) in the crown by all the pixels of the crown. From the 6 images of the pilot tree, the average vertical crown gap percentage is 6.7% and average undercrown gap percentage is 13.5%, that is almost double the difference. This shows the significance of calculating vertical profile gap percentages unlike previous research methods that only looked at the undercrown.


Vertical profile avg gap percentage: 6.7%

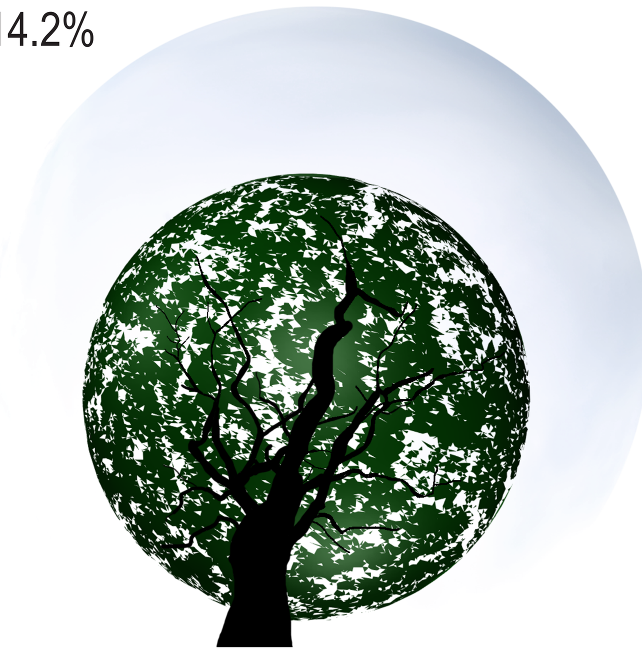

Undercrown avg gap percentage: 13.5%

4. GEOMETRIC MODELLING

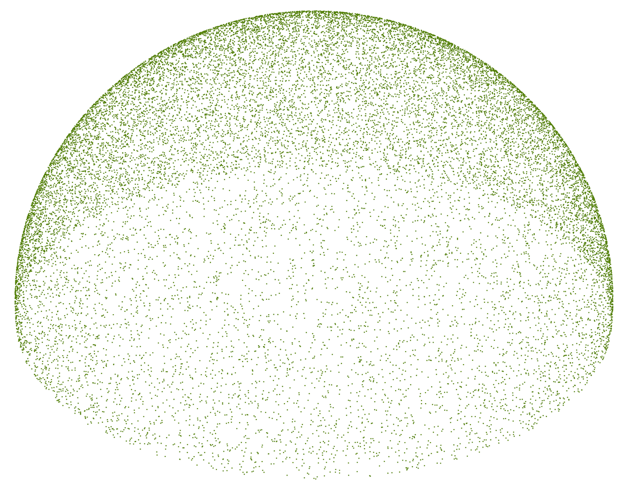
To model the tree crown geometrically to include in lighting simulations, we start by generating random distribution of points on a hemisphere. These points are combined to form vertices of mesh triangles. The mesh triangles are added randomly either as single triangles or clusters of triangles until the percentage of filled area is equal to 1 - sqrt(gap percentages). The gap percentage we use here is the average from all the vertical crown profile measurements. Results of undercrown gap percentage calculated from the image is 15.3% and from a geometric model created as described above is 14.2%.

Image of undercrown
15.3%

Modelled geometry undecrown
14.2%



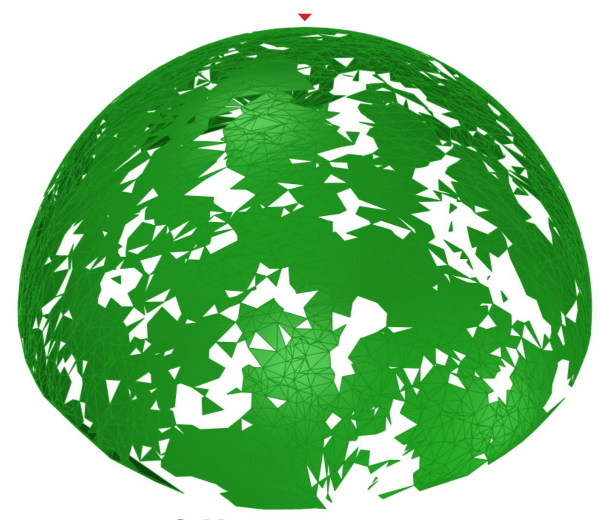
Random distribution of points



Filling mesh triangles

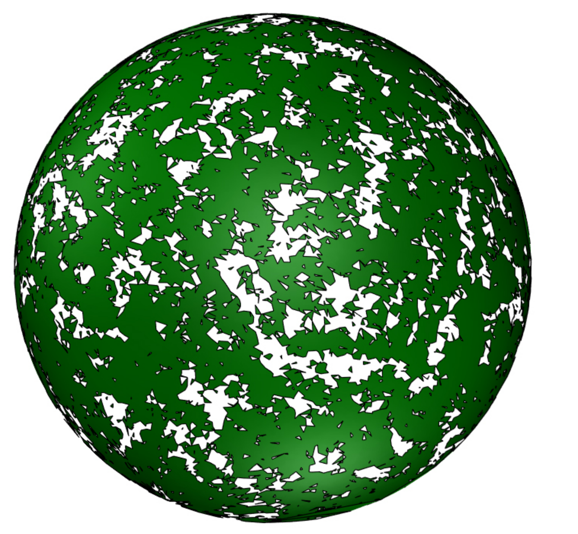
~20% filled

~50% filled

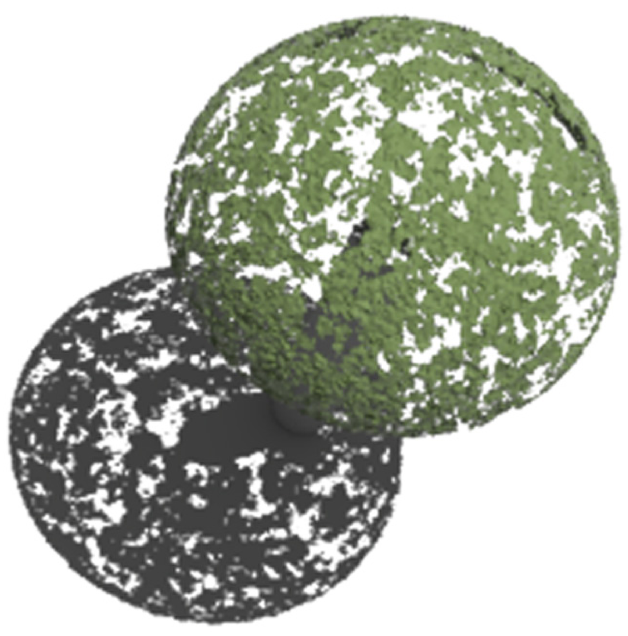


~70% filled

Undercrown view of tree geometry



Dappled effect of geometrical tree



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