NEON NIST DSE – Tree Crown Delineation

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ABSTRACT

- **GOAL**: Delineate tree crowns from AOP camera and hyperspectral data

- Identifying the position and size of individual tree from remote sensing is useful in understanding forest structure and is an important first step in species identification
- Tracking tree density from satellite images has become very important, especially with growing concerns regarding climate change

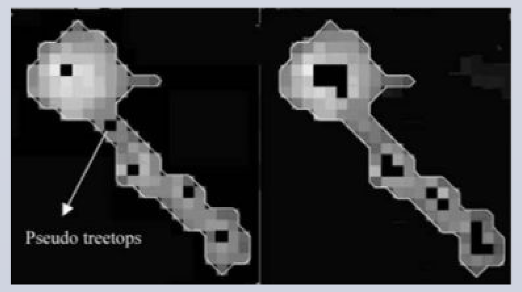
INTRODUCTION

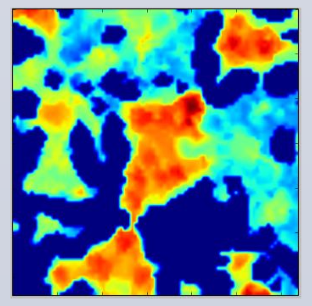
CHALLENGES

- Understanding the data and figuring out good visualization techniques to work on high dimensional hyperspectral & LiDAR data.
- Low resolution of images and presence of noise in the data made delineation very challenging
- Availability of data was also scarce which made deep learning and other machine learning algorithms unsuitable
- The variety in the tree composition is different for different plots

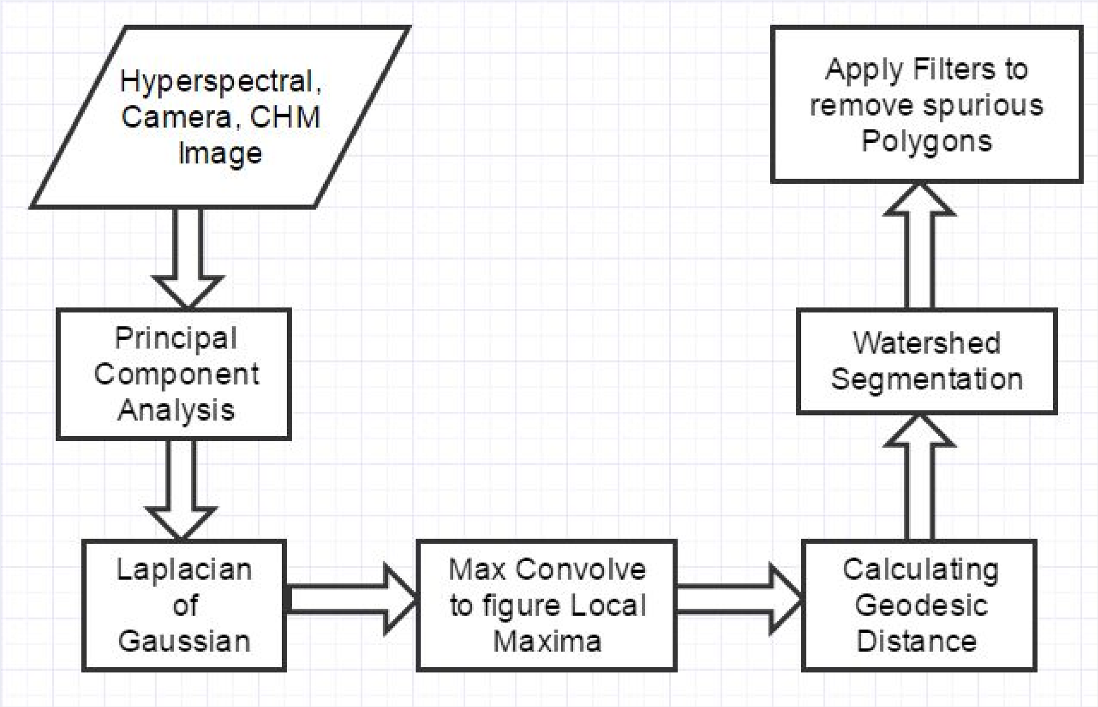
KEY CONTRIBUTIONS:

- Ensemble approach to handle multiple region types and tree compositions
- Use of canopy height model (CHM) to delineate crowns based on the variation in the tree heights from the ground
- Use of hyperspectral data to fill in the gaps in information due to the lower dimensional nature of camera and CHM rasters
- Laplacian of Gaussian as a edge detection as a first step before marker based watershed segmentation
- Use of 8 connectivity neighbourhood approach to Region Growing with the local maxima as the focal point
- Developed the evaluation pipeline for delineation, alignment and species classification. And also wrote the report generation module
- Use of Geodesic distance to identify portions of the image with clusters of maximal reflectance

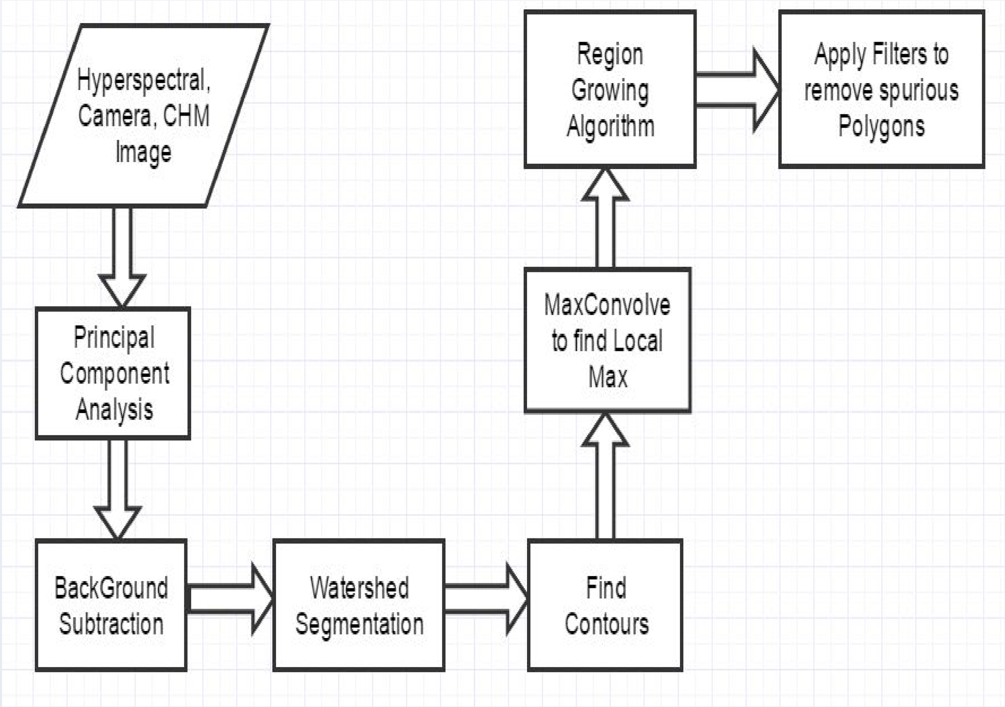




MODEL DESIGN



- Using Laplacian of Gaussian yields the edges i.e. regions of changing reflectance patterns
- On these edges we run geodesic distance computation to get the final tree crown regions
- The non local max convolution yields another set of tree tops which is concatenated with the geodesic tops to get the final polygons
- Spurious polygons are removed by filtering and over segmented polygons are handled using morphological transforms



- Background subtraction algorithm is applied to remove regions of extreme dark and bright pixels.
- Watershed algorithm is applied on the corrected image.
- Contours are extracted from the segmented image.
- For each contour, points of local maxima is found by max convolution method.
- Regions having similar height from the ground surface are found by following the growing algorithm, taking local maxima points as focal point.

EVALUATION METRICS

- Delineation is measured as a function of the predicted area which can be considered to fall into one of the following classes i.e. False Positive (FP), True Positive (TP) and False Negative (FN).
  - Due to unavailability of perfect ground truth we use a modified F1 score which is calculated on a subset of the predicted polygons for which ground truth is available

$$F_1 = \frac{2\,P \times R}{P + R}$$

- Alignment is measured as a probability distribution between the ground truth (g) polygons and the predicted polygons (p) and is evaluated based on the value assigned to the correct predictions

$$F_1 = \frac{trace(M)}{\sum_{i,j} m_{i,j}}$$

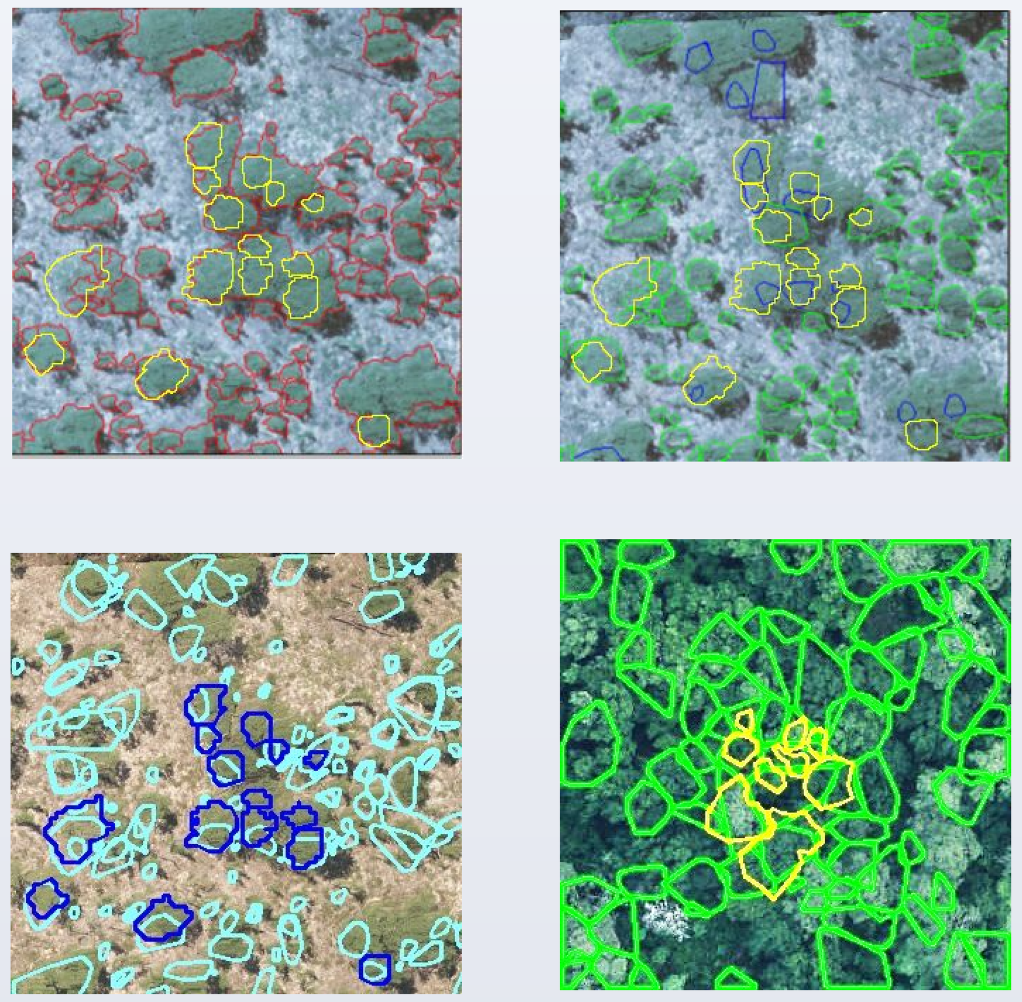
- The output is expected to be a probability matrix of M x N where M is the number of ITCs and N is the number of species. So we can use the Average Cross-Entropy loss (log loss) which is used in t[illegible]ction

$$\text{cost} = \frac{-\sum_{n,k} ln(p_{nk}) * \delta(g_n, k)}{N}$$

PROJECTION

- The vector files (shapefiles) have their coordinates mentioned on the WGS84 UTM Zone 17 North projection
- In order to evaluate or visualize the ground truth appropriate reprojection must be done
- Moving to and from world coordinates to pixel coordinates using the extent of the image on a per plot basis requires the formulation of an affine transformation
  - Given the extent of the plot and the dimensions of the raster we are able to get a mapping between the pixels and the world coordinates
  - This formulation can be used to project raster to vector points and vice versa

RESULTS



Plot Description / ID	F1 Score - For Models 1,2,3		
Mostly Sparse (006)	**62.21**	53.35	37.23
Dense (001)	**62.01**	57.37	41.255
Moderate (011)	32.28	**43.86**	40.25

CONCLUSION

- Any real world data is bound to be noisy, so we must first account for that before embarking on application of any model
- Improvements to the model might lead us towards a local maxima so we must be careful about premature optimization
- An ensemble of models, each tuned to work in a particular setting, would prove to be really beneficial to this task
- Watershed is really good at doing the delineation but it just needs few cues to send it on the right track

REFERENCES

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- Detection of individual tree crown in airborne lidar data. B.Koch et.al. 2002
- Individual tree crown delineation using local maxima approach and seeded region growing technique Jan NOVOTNÝ et. al 2011
- Individual Tree-Crown Delineation and Treetop Detection in High-Spatial-Resolution Aerial Imagery Le Wang, Peng Gong, and Gregory S. Biging