CSCE 5222 Feature Engineering

Project Plan

Group 11
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1. Problem statement

Our project is about image segmentation. We offer efficient segmentation methods in this project to separate green-field crops from background photos. We must overcome a number of obstacles in order to reach our goal. One of them is how water ponds and forests are frequently used as farming fields. If time allows, we'll start working to solve this problem. The effectiveness of our strategy may also be impacted by changes in the hue of various crop fields. Our method might be applied to precision agriculture applications and satellite image processing.

Here is an illustration of the project's results. Figure 1 illustrates the original and ideally processed versions of an image that has been segmented, respectively.

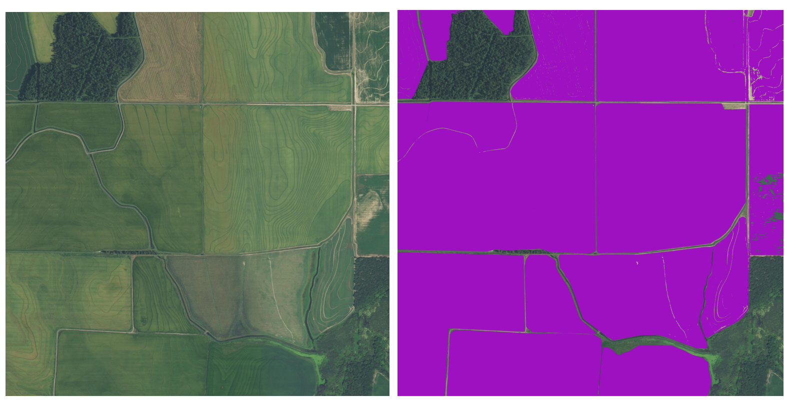


Figure 1: Original image (left) and segmented processed image (right).

2. Data

We use nine satellite JPG format images that have a 1-meter ground sample distance and dimensions of 2048x2048.

Subject	Feature	Thought
Woods	Higher green intensity than other subjects with adjacent shadow to the left (all images were taken at the same time range)	Different texture against crops -> Contrast enhancement may help
House / storage	Similar color intensity with road and unused crops	Minority, ignored?
Roads	Small, straight lines, something occluded by trees' shadow	Edge detection, such as Canny or Sobel?
Crop field	Various of green intensity, artifacts made	Color thresholding is not expected to work.Artifacts made from plows should be ignored
Unused crop field	Closest to white	Color might be treated as an exception

3. Method

3.1. Ground truth - In order to obtain the segmented ground truth images, we used an online painting tool and manually segmented the crop fields.

3.2. Preprocessing

- Convert images into gray to get the images ready for edge detection.
- Apply histogram stretching to enhance image contrast.
- Another variant is histogram equalization which is used for the same purpose depending on the real cases.

<u>Goal</u>: Since some algorithms can only function with binary images, this step is necessary to enable the ones that follow, such as grayscale images, where contrasted images could aid in identifying details, patterns, and classes.

3.3. Techniques for segmentation

- Thresholding: Our first approach will be implementing a threshold method to see how it separates the crop fields from the image. Based on the intensity, the pixels in an image get divided by comparing the pixel's intensity with a threshold value. In this context, we are planning to apply Otsu's threshold method as well as adaptive thresholding.

  - Ostu's thresholding: The threshold value is determined automatically for the image being passed for segmentation. In other words, it automatically calculates a threshold value from the image histogram for a bimodal image (Otsu, 1979).
    - Otsu's Binarization is widely used in document scans, removing unwanted colors from a document, pattern recognition etc.
    - The drawback is that some classes (peaks) in images that are not bimodal will exhibit undesirable binarization effects.
  - Adaptive thresholding can be useful since the threshold value gets calculated for smaller regions which account for various threshold values for different regions (Yanowitz & Bruckstein, 1989).

Goal: This step is optional since we want to test how much color thresholding can improve the dataset as classes in the dataset are predicted to have comparable variations of green. Additionally, some crops are immature and have a noticeably whiter tint than others.

- Edge-based detection: Various edge detection techniques including canny, sobel became quite popular in image segmentation (Al-Amri et al., n.d.).
  - Canny: In our task, canny detector helps by following below mentioned steps:
    - The presence of Gaussian filters allows removal of any noise in an image.
    - The signal can be enhanced with respect to the noise ratio by non-maximum suppression method which results in one pixel wide ridges as the output.
    - Detects the edges in a noisy state by applying the thresholding method.
    - The effectiveness can be adjusted by using parameters.
    - It gives a good localization, response and is immune to a noisy environment.

  - Sobel: The main advantages of the Sobel operator are that it is simple and more time-efficient. However, the edges are rough.

  - Laplacian is another popular method for edge detection.
    - It is very sensitive to noise. Therefore, if an image contains noise, the Laplacian gives very large values and also ruins the image in the process.
    - The magnitude of Laplacian produces double edges, which is an undesirable property.
    - Thus, Laplacian alone is never used for edge detection. However, if some kind of noise filtering is done prior to the Laplacian operation, better results can be obtained.

Goal: We plan to apply an edge detector for the segmentation. Because we think sometimes woods might be detected as crop fields and in this context, edge detection may help us separate crop fields from the woods.

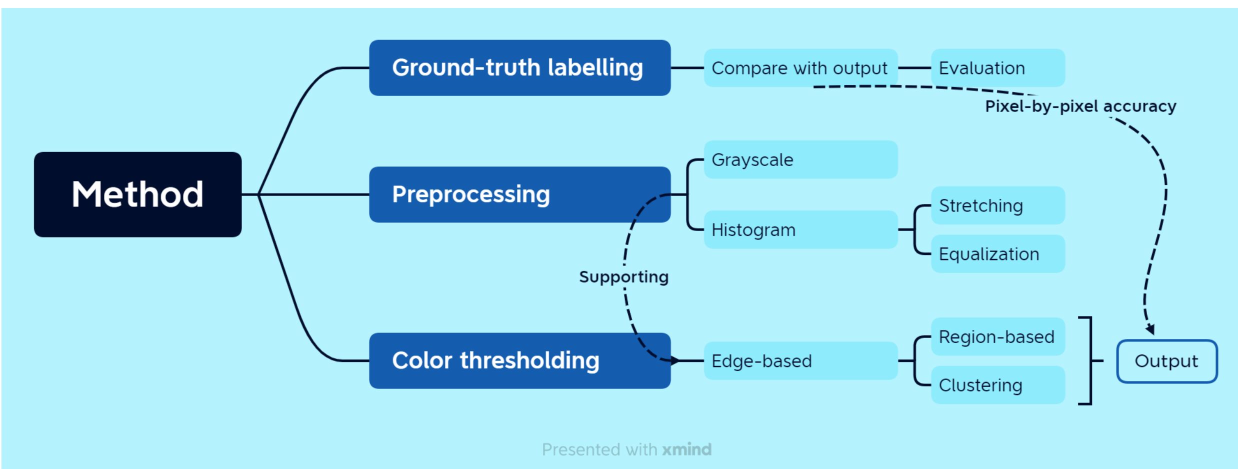
- Region-based detection: The region-based segmentation methods involve the algorithm creating segments by dividing the image into various components having similar characteristics (Wang et al., 2010). These components, simply put, are nothing but a set of pixels. Region-based image segmentation techniques initially search for some seed points – either smaller parts or considerably bigger chunks in the input image.

- ○ Region growing: It is preferable for noisy images, where it is highly difficult to detect the edges.
- ○ Region splitting and merging: After performing the split process, we will have many similarly marked regions scattered all across the image pixels, meaning, the final segmentation will contain scattered clusters of neighboring regions that have identical or similar properties. To complete the process, we need to perform merging, which after each split compares adjacent regions, and if required, based on similarity degrees, merges them.

Goal: This can be run in parallel with clustering in a compare-and-contrast manner to segment crop fields.

- Clustering: A group of pixels that can belong to more than one cluster or group but they can have varying levels of associativity per group. As the dataset's images have variants of green intensity, choosing a good k, the number of clusters can help in segmentation. Some choices include k-means, spatial k-means, mean shift, and spatial mean shift

Goal: To distinguish crops from the rest, multiple algorithms can be run simultaneously with various parameter combinations.



4. Evaluation

- Processed and ground-truth images will be compared pixel-by-pixel (Soomro et al., 2022).
- Segmented areas should be of a different color from those in the original image (in our case, pink) to avoid confusion.
- We use the metric as accuracy, computed by $\frac{TP + TN}{TP + FP + TP+FN}$
  - ○ TP: True Positive: Correctly segmented as crop fields
  - ○ FP: True Positive: Incorrectly segmented as crop fields, actually non-crop-fields
  - ○ TN: True Positive: Correctly segmented as non-crop-fields
  - ○ TP: True Positive: Incorrectly segmented as non-crop-fields, actually crop fields

5. Timeline

Tasks	Timeline	Role		
Ground truth generation	Sep 27	Truc		
Preprocessing	Oct 4	Riyad - hist stretching	Nghia - hist equalization	NA
Applying thresholding and edge detection with different combinations of parameters	Oct 10	Truc - thresholding and clustering	Nghia - edge-based	Riyad - region-based
Combining steps and debugging	Oct 28	Nghia		
Evaluation	Nov 15	Riyad		
Report writing and preparing slides	Nov 29	Truc		

References

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Wang, Z., Jensen, J. R., & Im, J. (2010). An automatic region-based image segmentation algorithm for remote sensing applications. *Environmental Modelling & Software*, *25*(10), 1149–1165.

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