Watermelon Detection in Farmland with Image Processing and Hough Transform

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Final Project for ECE 588 Image and Video Processing

Motivation

- We want to improve the watermelon farming process by automating the monitoring process.
- Detecting watermelon in the field is challenging. Unlike apples and other fruits, watermelon is generally green, introducing additional challenges when segmenting it from its stems and leaves.

Watermelon Image Processing Workflow

- Our goal: Find the center and radius of the watermelon based on the longest dark stripe on it.

Contrast Enhancement

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Build a mask to segment ground, sky and plants.

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Noise Reduction with blurring filter and morphological opening procedure

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Detect dark strips by Hough Transformation and find the location basing on the longest strip

Methods – Contrast Enhancement

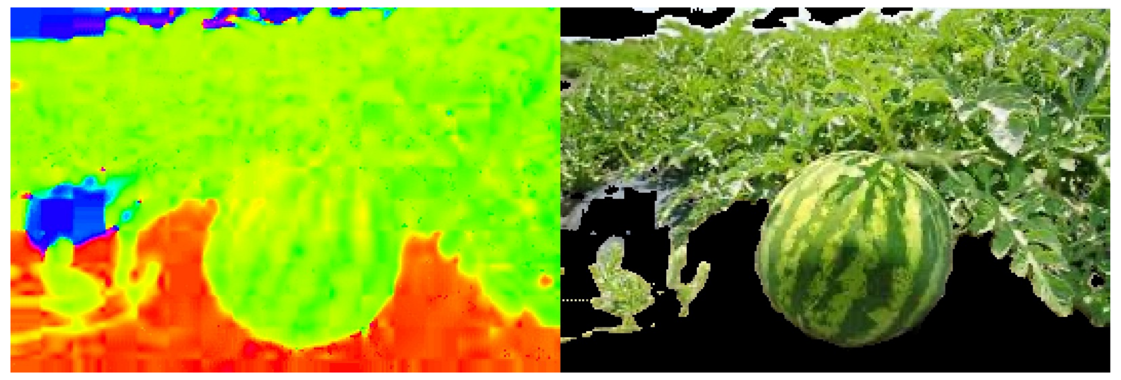
- Preprocessing raw images to segment ground, sky and plants.
- Fully utilize the gray scale space to maximize difference between watermelon strips and spaces between them.

Gray Image *Adjusted Image*

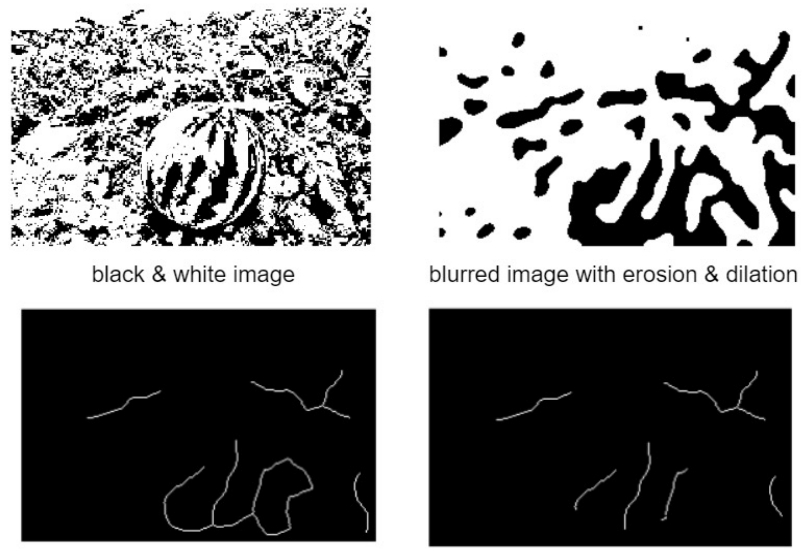
- Perform a **local binarization of the gray image**. We chose local binarization because, since most of the images were taken outdoors, the light source was restricted to only the sun, which caused different exposure in different areas of the watermelon surface due to its shape. Thus, a global binarization would result in incomplete strips.

Methods – Noise Reduction

- We build up a mask to **segment the sky, ground, and plants based on Hue.** This mask was applied in the following noise reduction procedure.



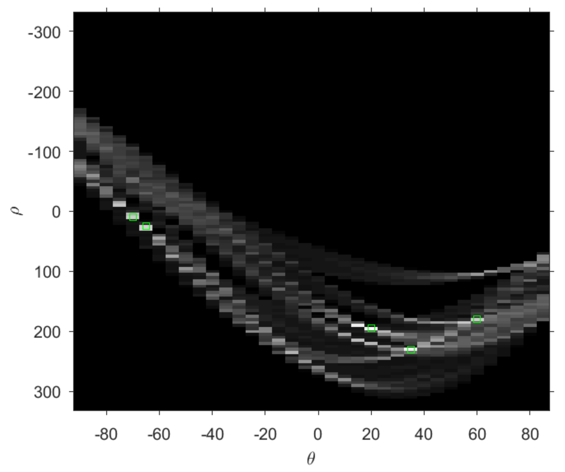
- We reduce the noise of watermelon leaves and vines by applying a blurring filter using function together with the morphological opening procedure using function.
- After applying morphological operations, we use our self-defined ***Black-White-Skeleton (bwskel)*** function to extract the skeleton of the texture edges. The process of skeletonization erodes all objects to centerlines without changing the essential structure of the objects, such as the existence of holes and branches.



black & white image | blurred image with erosion & dilation | skeletonized image | skeletonized image with hue mask

Methods – Texture Detection

- We utilize **Hough transform** to detect lines based on the skeletonized image. We apply MATLAB build-in function to identify the top 5 peaks in the Hough transform which gets the highest votes to form lines among all locations in the image.
- We set a **minimum length,** which is 20% of the shortest side of the image's length and width, to detect valid lines for the texture.



Voting result of Hough Transform

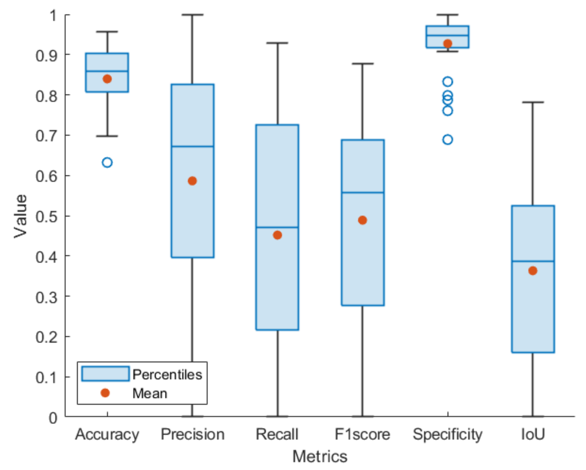
The longest line detected by Hough Transform

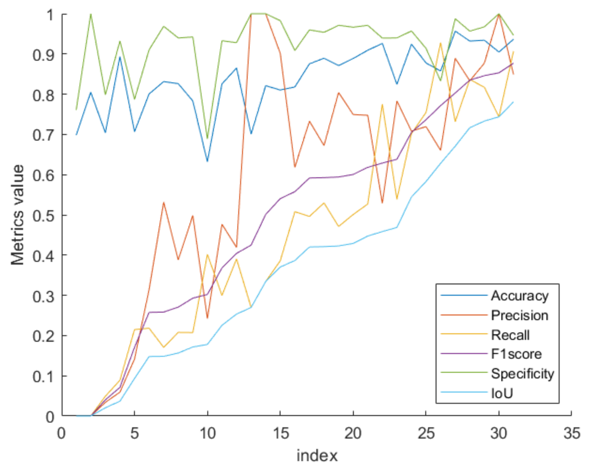
Methods – Location Determination

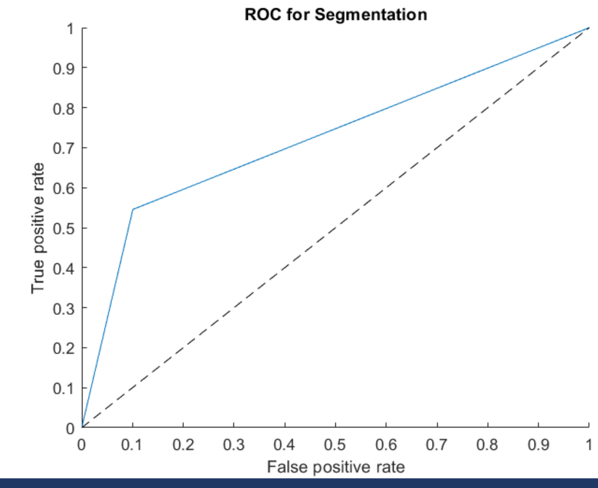
- We keep the **longest line** during each iteration and calculate a weighted sum of their centers and lengths.
- We view the shape of the watermelon as a circle, the center and half length of the longest line are likely to be the center and radius of that circle.
- We drew the circle and finally locate the watermelon. The following images show some sample results of the finalized detected location of the watermelon.

Watermelons were detected and circled in red

Result







- We compared the output of our method with the manual label of 31 images.
- The first picture shows the metrics of the test result over 31 watermelon images. The accuracy of 25-75 percentile is ranging from 80% to 90%.
- The second picture shows segmentation performance metrics for each image, sorted by intersect over union (IoU).
- In the third picture, the blue line shows the ROC curve for our model, and the black line shows the ROC curve for random guessing. The area under the ROC curve for our model is 0.7224.

Discussion

- Our watermelon detection method has some advantages, such as high accuracy and low computational complexity. However, there are still some shortcomings that need to be improved.
- In some cases, the images are affected by noise such as a large area of shades, which reduces the accuracy of the method. Because the result of this method largely depends on wide stripes in the image, the result will be greatly affected if there are wide, long, and straight stripes not on the watermelons. To improve this, the outlier in the Hough transformation can be removed to avoid detecting a too regular shape from artificial objects.

The result was largely distracted by trees and fences *Only the biggest watermelon was labeled in the image*

- Also, this method can only detect one watermelon in each image because it always regards the longest line segment as the watermelon's stripe. If there is more than one watermelon in the image, it is likely to take the average position of all the watermelons, or only recognize one of the watermelons. To solve this problem, some clustering algorithms can be applied such as Gaussian Mixture Models (GMM) to decide how different watermelons' stripes are clustered.

Reference

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[4] Rizam, M.S.B. & Yasmin, A.R. & Ihsan, M.Y. & Shazana, K.. (2009). Non-destructive watermelon ripeness determination using image processing and artificial neural network (ANN). 38. 542-546.

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