Seaweed Growth Detection in Aquaculture Environment Using Simple Linear Iterative Clustering Method

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DOI: 10.46617/icbe8001

Abstract: Estimating the total biomass of cultivates in aquaculture plantations (fisheries, mussel plants, seaweed farms and compound sites) remains to be an issue for the industry and the researchers alike. There has been a diverse array of approaches towards this issue, like using markers, manually stapling the leaflets, weighting the actual mass of the organism and calculating the total mass by extrapolation. Seaweed growth detection is a subset of this problem. Our goal is to introduce a solution by automatically detecting the ratio of the target object in images of seaweed taken from an underwater environment. Researchers/operators then can evaluate the total mass of seaweed. This study aimed to function as a decision support system. The system is built based on an image segmentation algorithm named Simple Linear Iterative Clustering (SLIC) which is a kind of superpixel segmentation. This paper conveys the results obtained from our approach towards the seaweed growth detection, elaborates on the usage and feasibility of our solution in seaweed sites and showcase the economic impact in the industry. Other dimensions of the growth detection methods in current practice for seaweed growth is also discussed, such as lack of automation in the current best-practices while focusing on the difficulties accompanying this status-quo.

Keywords: Aquaculture, Seaweed, Growth Detection, SLIC

1. Introduction:

Detection of growth is a necessity in seaweed cultures, however, it is labor-intensive and conventional methods mostly consist of manual measurement techniques [1]. A study that contain a computer vision component focuses on aerial detection of natural growth of harmful algae on lake and bay area surfaces [2]. Another paper on automatic detection of seaweed also focuses on aerial imagery of seaweed [3]. Application of computer vision and machine learning techniques on underwater seaweed images hasn't been given much focus, to the best of our knowledge. Currently seaweed growth detection is in general being done manually in aquaculture farms and since the biomass is underwater, a diver must physically go under and take photos and samples from the seaweed to be analyzed and weighed later. For example, it is possible to scrape off some part of the seaweed and calculate the mass of the whole biomass, but it requires a lot of manual labor to achieve [8] [9] (based on the method proposed by Can Bizsel, Dokuz Eylül University).

An approach developed and used in IMPAQT project uses a method in which seaweed leafs are marked with a staple to be checked again later, inferring the rate of growth, however, this method can be applied for only certain species of seaweed and it still mostly requires human labor since it uses manual measurement techniques. Therefore, it can be said that there is a need for automatic detection on this kind of imagery and this paper aims to fill the gap. The goal of this study is developing a novel technique of detecting the weight and growth rate of the biomass in aquaculture environments (mussel, fish, seaweed etc.). this technique can be employed in industrial facilities enabling the industry to save manual effort and related costs. Seaweed is chosen as our model organism, as images obtained from other options does not provide enough stability to make a proper segmentation.

2. Material and Methods

The novel approach is based on the embodiment of computer vision techniques applied to the seaweed growth problem combined with newly implemented data streaming architecture developed for and used within our projects. The method aims to achieve detection of the ratio of biomass in an underwater seaweed image with reasonable accuracy.

2.1. Seaweed samples and images

Seaweed samples images were taken using GoPro by SCUBA divers (courtesy of Şeyma Tarkan, Çamlı Yem ve Besicilik San ve Tic. A.Ş.). There are some difficulties in detecting the ratio of seaweed in the images such as:. 1) the samples were underwater images, which presented its unique set of challenges. 2) The contrast was variable and there wasn't adequate amount of it in parts of the images. 3) The brightness was inconsistent and it varied based on factors as time of the day and depth. Initially a set of images was acquired from Camli aquaculture site, who is one of the partners in IMPAQT (Image 1). Our code was implemented following the results obtained from the samples from the image set using trial and correction. Samples were selected for clarity and usability. The presumption is, in realistic applications, images taken for detection should be similar in terms of angle and distance (proposed method is either manually or by using a preplaced camera, which will enable the user to take images from the same angle and distance).

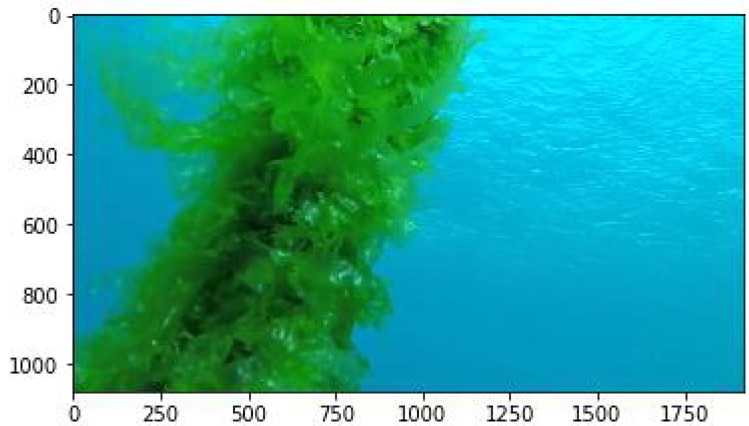

Image 1 - Sample image from the data set

The first step is to separate the seaweed and the background in the image to calculate the area of seaweed. This step is called 'image segmentation'. Python's scikit-image module was used for image segmentation operations. Scikit-image is an extensive library including a range of image processing methods using machine learning [4]. Simple Linear Iterative Clustering as also used, Simple Linear Iterative Clustering (SLIC) is one of the most excellent superpixel segmentation algorithms with the most comprehensive performance and is widely used in various scenes of production and living [5]. SLIC algorithm uses k-means under the hood, by which the image is segmented using the color value of the regions being truncated to the nearest mean. It takes in all the pixel values of the image and tries to separate them out into the given number of sub-regions [6] [7].

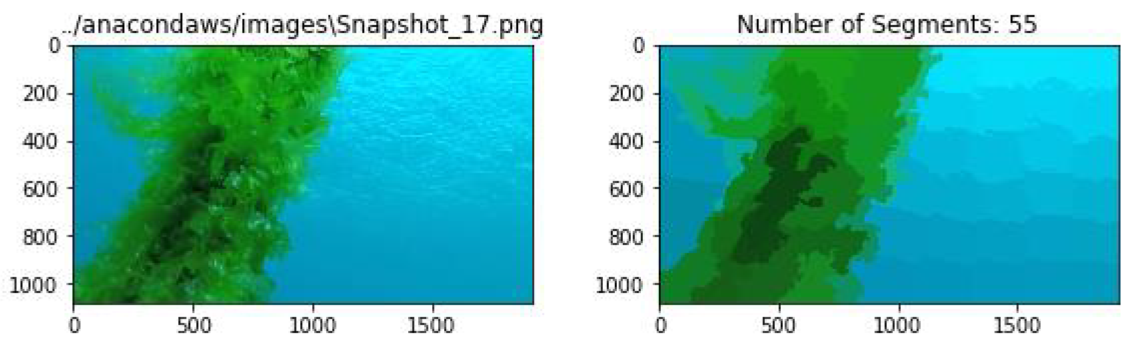

Image 2 - SLIC method applied with 55 segments

In the sample in Image 2, SLIC is applied and the image is segmented into 55 parts. Just after segmentation, each segment doesn't necessarily have a realistic color value, just random colors denoting the difference in segments. To correct this, the segmented image is color mapped onto the original image using the average color values of each segmented area. This way, photorealistic image is obtained after segmentation. It will be used in the following steps as thresholding to convert it to a black and white image based on the color values. SLIC method can be counted as unsupervised segmentation as it does not take any threshold value from the user. The only parameter is the number-K, which denotes the number of segments in the result. It is observed that the success of the segmentation shows a little variation between different numbers of segments and a value for number-K around '9' best suits this problem. Too high number of segments is not preferred as it starts to include parts of the background in the segmented object, nor too few, as some area from our target object is lost, which is seaweed in this case (Image 3).

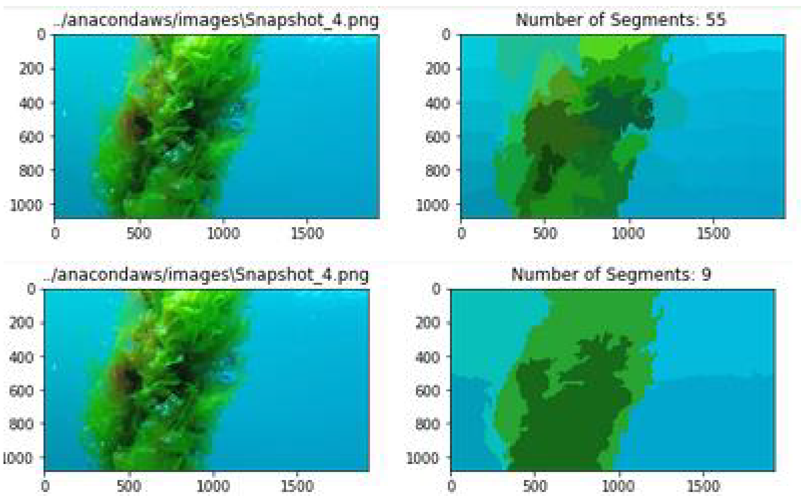

Image 3 - 55 segmentation compared to 9 segmentation

2.2. Simple color thresholding

Simple color thresholding is a technique used based on the comparison of the color values of each pixel in the image. It naturally requires some pixel operations on the image, in which each pixels green channel value is compared to the blue channel value in the RGB values of the pixel. This method is an heuristic solution developed for this study, step by step by evaluating the experimental results in each iteration to find out the solution which gave the best outcome.

2.3. The ratio of white pixels

As the final step, the ratio of white pixels in the final image will be calculated, as it will directly give us the desired result, which is the ratio that our target object (seaweed) takes space in the image (Image 4). The size of the image is known, therefore the total pixel value can be calculated: 1080 x 1920 = 2073600. The white pixels are counted by scanning the image by the code, running a 'for loop' through each pixel. From this point on, the ratio of white pixels can be obtained: 780004 / 2073600 = 0.3762 and 785239 / 2073600 = 0.3787 for the samples respectively.

```
Size of our image:
1080
1920

Number of white cells:
780004

Ratio:
0.3761593364197531
```

```
Size of our image:
1080
1920

Number of white cells:
785239

Ratio:
0.3786839313271605
```

Image4 - Final calculations for 7 and 9 segments. The code automatically detects the size of the image.

3. Results and discussion:

After trying various values for segmentation, the conclusion is; applying several values for number-K and taking the average is the best practice. Direct binary segmentation is not possible due to it losing too much area of the object because of truncating (Image 5).

Image 54 - Binary segmentation (2 segments)

Simple color thresholding method also worked well compared to other thresholding techniques based on histograms, as it does not need any input from the user, meaning it is unsupervised [6]. This technique alone is useful for truncating single pixels to black and white values but without segmentation, it introduces some error since there is a color variation in both the target object (seaweed) and the background (Image 6.1, Image 6.2).

Image 6.1 - Simple color thresholding without segmentation. The problem can be observed that some areas are falsely counted as background.

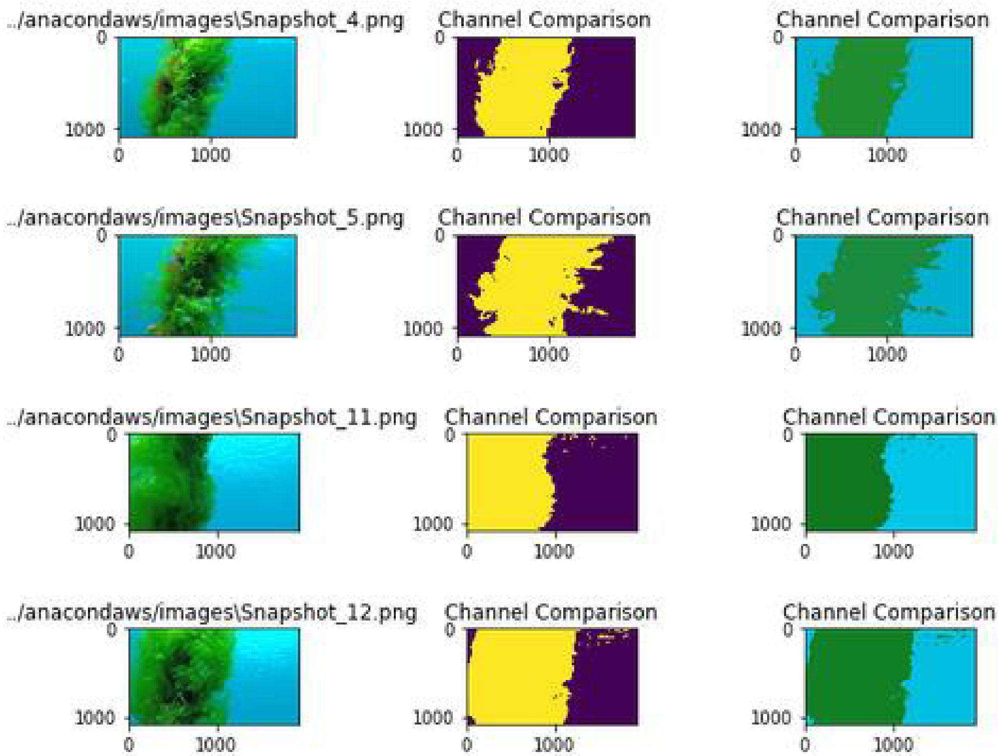

Image 6.2 - Various samples on simple color thresholding. Color mapping is applied.

After combining all three techniques, target results were achieved. A couple of successful examples of the application of thresholding onto an image with 7 and 9 segment SLIC method applied can be seen in Image 7. Color mapping is taken advantage of to create enough color variation for thresholding. This demonstrates that there is an optimum range for number of segments. Increasing the K value doesn't always result in new segments since some segments are truncated.

Image 7 – Resultant black and White image after applying all three techniques (SLIC, color mapping and thresholding). Number of segments is 7 for the first and 9 for the second image.

From image 7 it can be noticed the similarities in numbers for different K values of 7 and 9. It shows that for this image, segmentation is stable and successful. Taking the average value normalizes any variation in segmentation. The final output of the program is a single ratio for each image, as described for image 7. The K value is specifically set for this kind of binary segmentation as in our image set, which includes a color map (green & blue heavy) similar to what is widely seen in aquaculture environments. If needed, parameters can be tuned to work best in other kinds of images with little additional effort.

4. Conclusion

The system can be utilized in research or operational efforts where there is a need to decrease the manual work for segmentation where there is a large volume of an image set. Periodic control is very labor-intensive in aquaculture environments, so setting up a small camera will be useful to take stable images from the same distance and angle. It will help users obtain enough images to make an average calculation. When results obtained from image sets from different dates are compared, a growth rate and lifecycle estimation can be made, combined with interpretations of experts in the aquaculture field. After mapping the real weight of the biomass with the ratio values, it is possible to estimate the total mass of the seaweed using extrapolation. When used alongside conventional techniques, the developed technique can aid users with tools to make smart calculations based on a large set of images that cannot be manually inspected.

5. Acknowledgment:

This work has been realized in context of the IMPAQT project. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 774109.

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