EE608 Project Report

Digital Image Processing

Region Growing Based Image Segmentation

Introduction

Image segmentation is a process of partitioning image into multiple segments to represent image into something more meaningful and easier to analyse. Segmentation subdivides an image into its constituents regions or objects. The level of detail to which the subdivision is carried depends on the problem being solved. That is segmentation should stop when the objects or regions of interest in an application have to be detected.[1] There are two groups of segmentations namely, Semantic and Instance. Semantic segmentation is an approach detecting, for every pixel belonging to a class of the object and Instance segmentation is an approach that identifies for every pixel, a belonging of the object.

There are lots of Image segmentation algorithms are available now which include and not limited to Thresholding Segmentation, Edge-Based Segmentation, Region-Based Segmentation, Watershed Segmentation, Clustering-Based Segmentation and Neural Networks.

Image segmentation finds many more applications in the real word as in face recognition, number plate identification, Image based searching, medical imaging etc. So, It is a good area to work with image segmentation.

Basic Idea & Principle

We have to view the image segmentation as a process that partitions ***R*** (entire spatial region occupied by image) into ***n*** subregions, $R_1, R_2, R_3, \ldots\ldots, R_n$ such that

[1] Digital Image Processing by *Rafael* C. *Gonzalez* *&* Richard E. Wood

1. $\bigcup_{i=1}^{n} R_i = R$
2. R_i is a connected set, $i = 1,2,3,...n$
3. $R_i \cap R_j = \phi$ for all i and j, $i \neq j$
4. $Q(R_i) =$ TRUE for $i = 1,2,3,...n$
5. $Q(R_i \cup R_j) =$ FALSE for any adjacent regions R_i and R_j

$Q(R_k)$ is the logical predicate defined over the points in set R_k and ϕ is the null set. Two regions R_i and R_j are said to be adjacent if their union forms a connected set. The above condition says that the segmentation must be complete which is every pixel must be in a region. The points in the region be connected in some predefined sense (4 or 8 connected). The region must be disjoint which means no overlap of region is allowed. If $Q(R_k)$ = True if all the pixels in R_k must have the same intensity level. Finally, the two adjacent regions R_i and R_j must be different in the sense of predicate Q. Thus the fundamental problem in segmentation is to partition an image into regions that satisfy the above conditions.

Region-Based Segmentation

The objective of this segmentation is to partition an image into regions. This problem can be approached by finding boundaries between region based on discontinuities in intensity levels. Segmentation was achieved by thresholds based on the distribution of pixels properties, such as intensity values or colours.

Region Growing

Region growing is a procedure that groups pixels or subregions into larger regions based on predefined criteria for growth. The basic approach is to start with a set of seed points and from these grow regions by appending to each

seed those neighbouring pixels that have predefined properties similar to the seed: like specific ranges of intensity of colour. Descriptors alone can yield misleading results if connectivity properties are not used in the region-growing process.

The another problem in region growing is the formulation of a stopping rule. Region growth should stop when no more pixels satisfy the criteria of inclusion in that region. Criteria such as intensity values, texture, and colour are local in nature and do not take into account of the history of region growth. Additional criteria that increase the power of a region growing algorithm utilise the concept of size, likeness between a candidate pixel and the pixels grown so far and the shape of the region being grown.[2]

Pixel Connectivity

There are few types of pixel connectivity classified into 2D and 3D. The 2D pixel connectivity has types such as 4-connected, 6-connected, and 8-connected and in 3D, 6, 18 and 26 connectivity are available. Here we are going to make use of only 2D pixel connectivity that too limited with 8-connectivity.

4-Connected

4-connected pixels are neighbours to every pixel that touches one of their edges. These pixels are connected horizontally and vertically. In terms of pixel coordinates, every pixel that has the coordinates $(x \pm 1, y)$ or $(x, y \pm 1)$ is connected to the pixel at (x, y).

8-Connected

8-connected pixels are neighbours to every pixel that touches one of their edges or corners. These pixels are connected horizontally, vertically, and diagonally. In addition to 4-connected pixels, each pixel with coordinates $(x \pm 1, y \pm 1)$ is connected to the pixel at (x, y).

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[2] Digital Image Processing by *Rafael* C. *Gonzalez* & Richard E. Wood

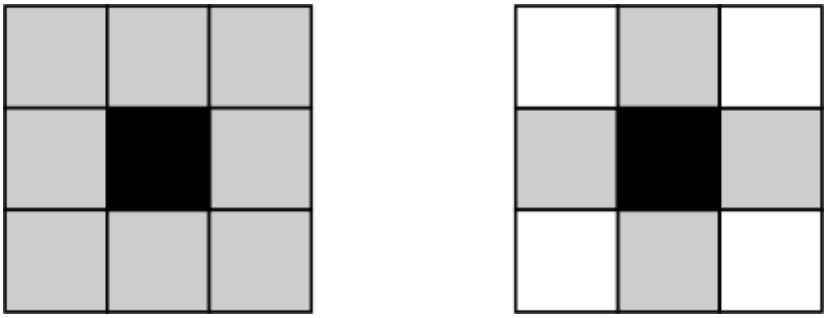


Fig 1: 8 point connectivity and 4 point connectivity

Implementation of Region Growing

Algorithm[3]

Let $f(x, y)$ denote an input image array; $S(x, y)$ denote a seed array containing 1s at the locations of seed points and 0s elsewhere and Q denote a predicate to be applied at each location (x, y). Arrays f and S are assumed to be of the same size. A basic region-growing algorithm based on 8-connectivity.

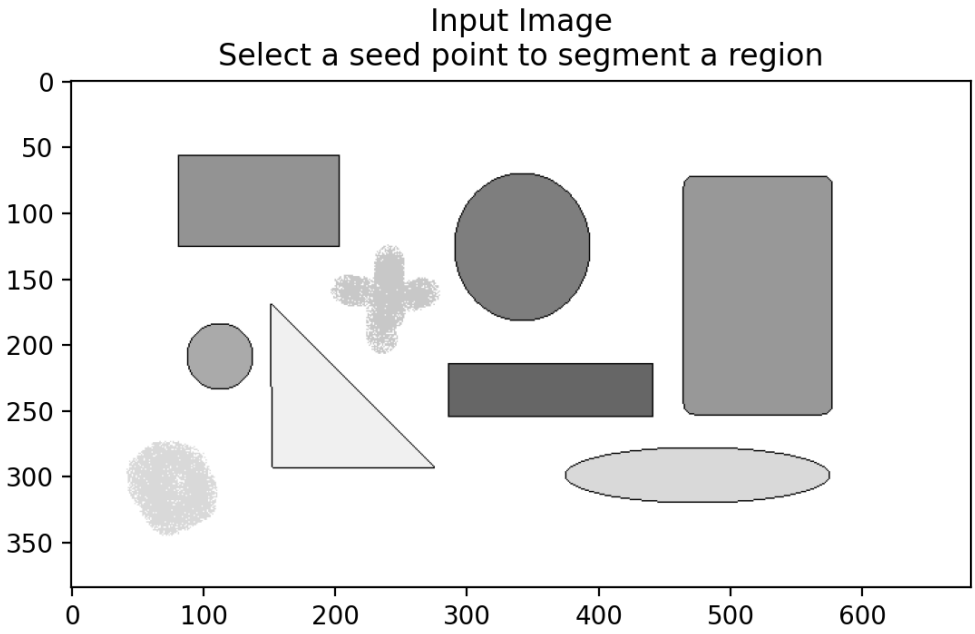
1. Find all the connected components in $S(x, y)$ and erode each connected component to one pixel; label all such pixels found as 1. All other pixels in S are labeled as 0.
2. Form an Image f_Q such that at a pair of coordinates (x, y), let $f_Q(x, y) = 1$ if the input image satisfies the given predicate, Q, at the those coordinates; otherwise, let $f_Q(x, y) = 0$
3. Let g be an image formed by appending to each seed point in S all the 1-valued points in f_Q that are 8-connected component to that seed point.
4. Label each connected component in g with a different region label (e.g., 1,2,3,…). This is the segmented image obtained by region growing.

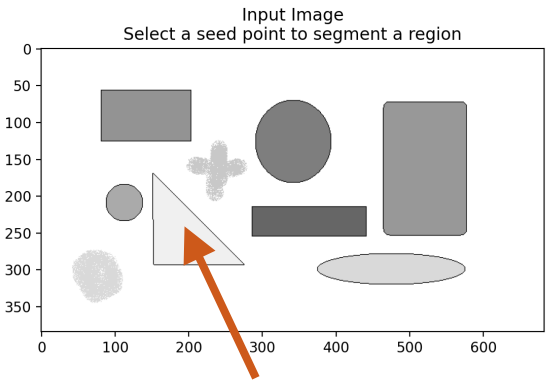
[3] Digital Image Processing by *Rafael* C. *Gonzalez* & Richard E. Wood

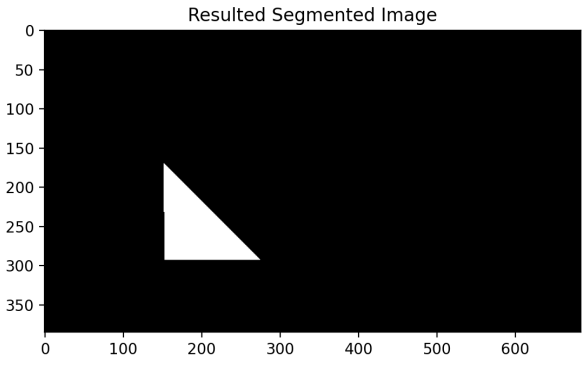
Results & Analysis

The algorithm is tested using various inputs and the results are shown in this section.

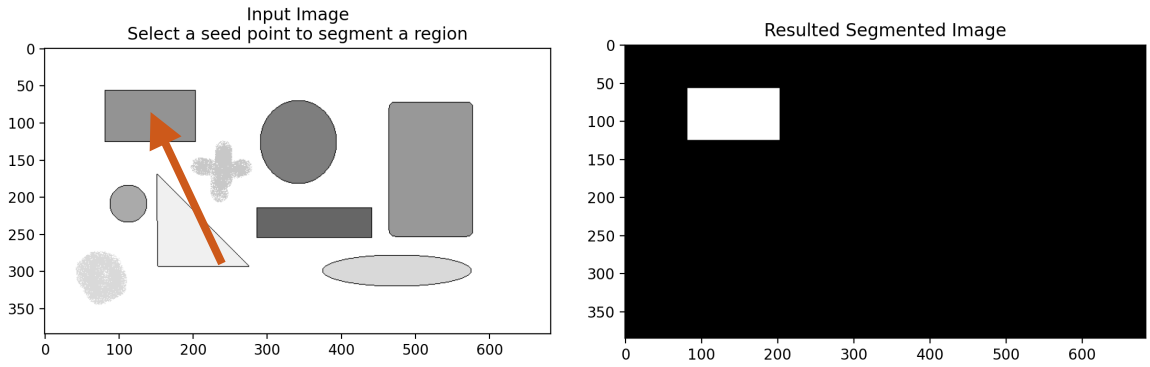
(1) Shapes1.jpg gray scale image:



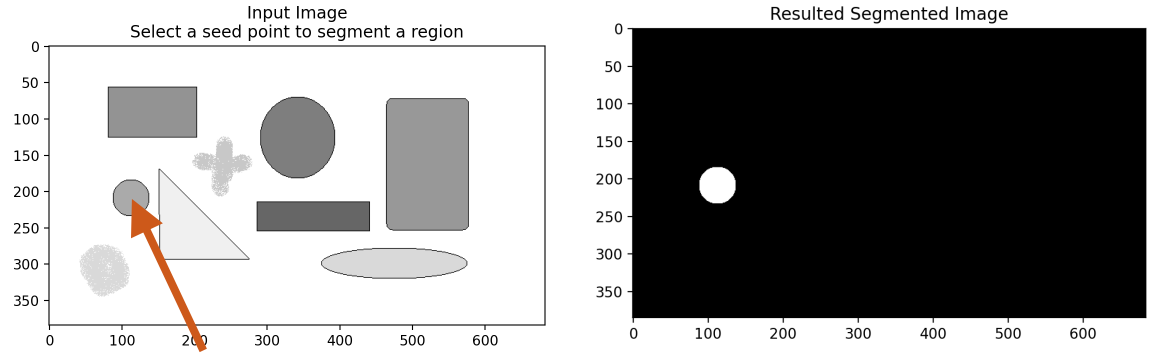




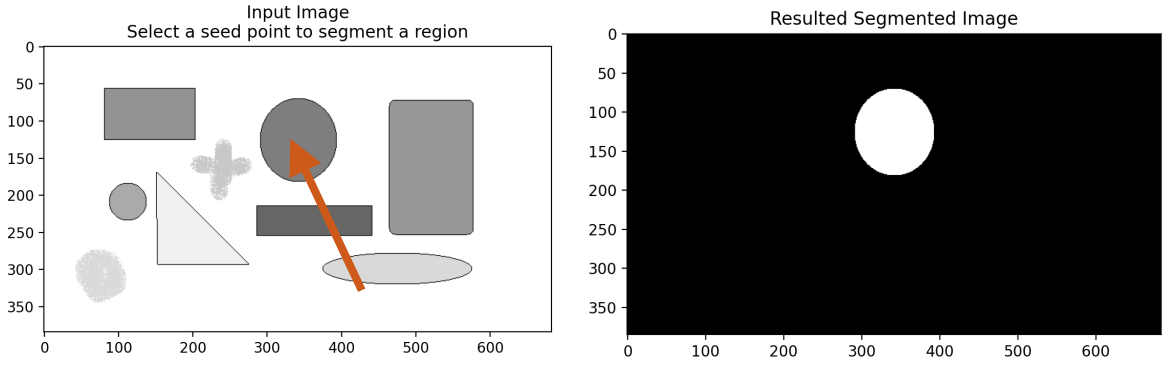
The triangle part is chosen as seed point and the result is obtained.



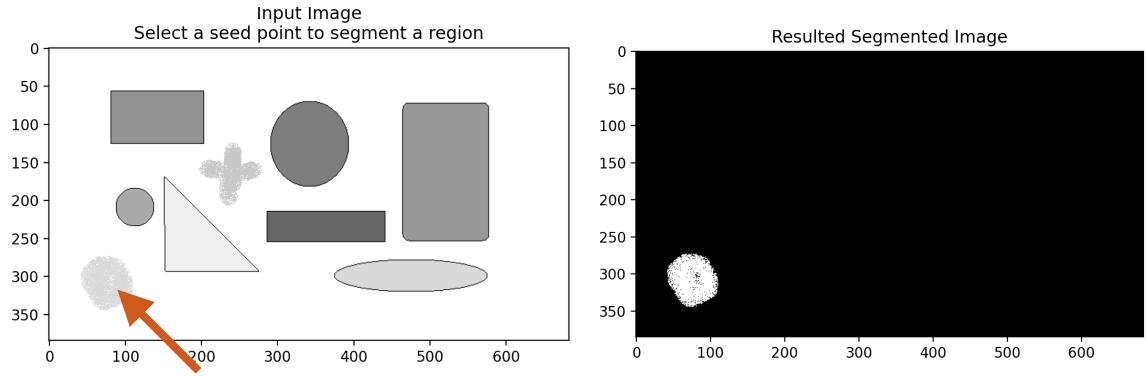
The upper rectangle part is chosen as seed point and the result is obtained.



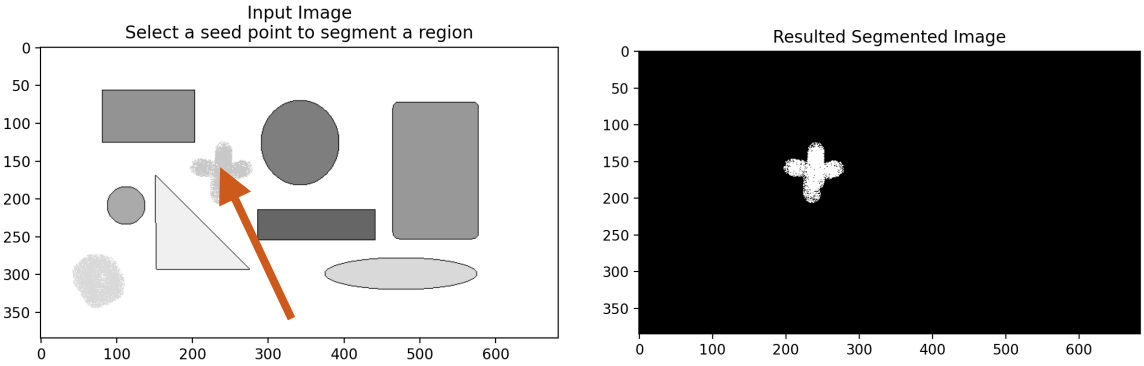
The lower circle part is chosen as seed point and the result is obtained.



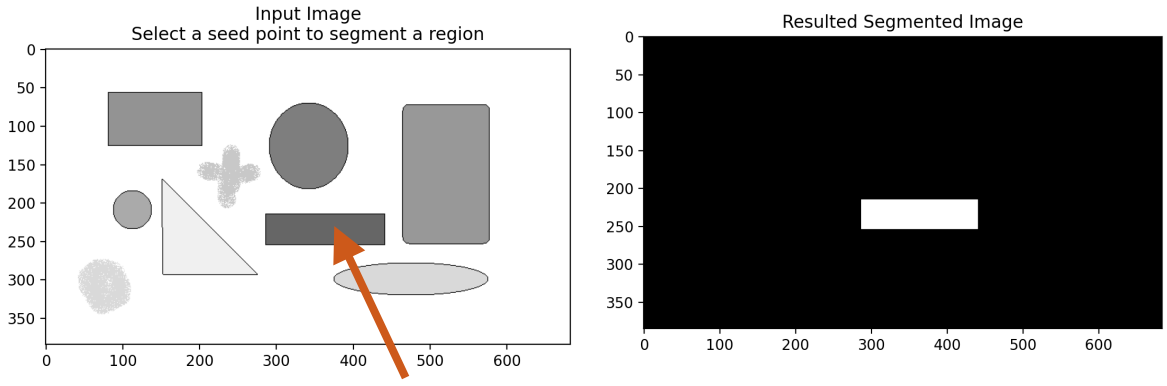
The centre circle part is chosen as seed point and the result is obtained.



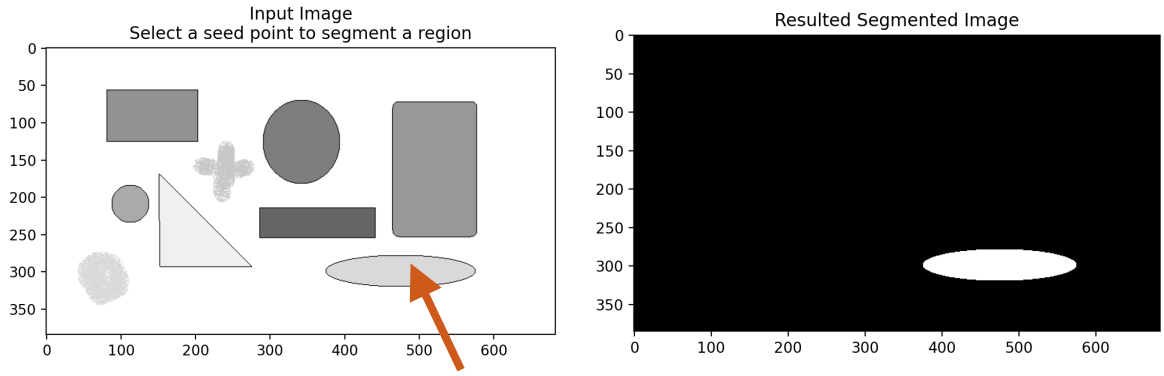
The spray lower part is chosen as seed point and the result is obtained.



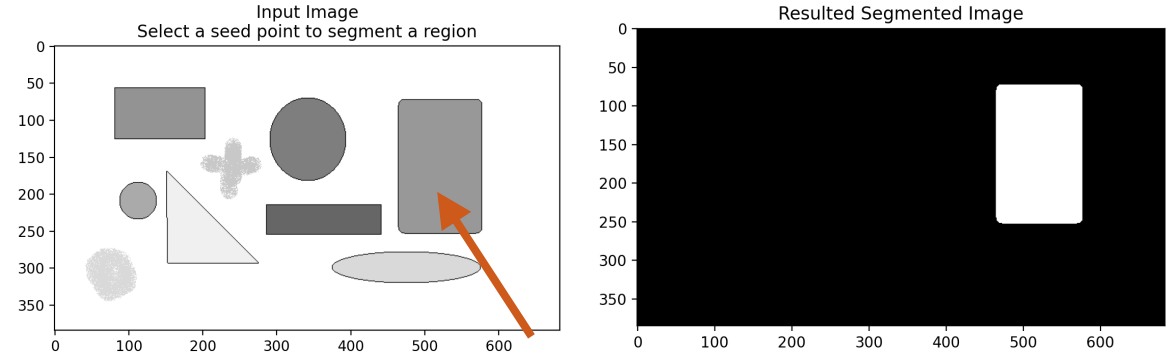
The plus sign part is chosen as seed point and the result is obtained.



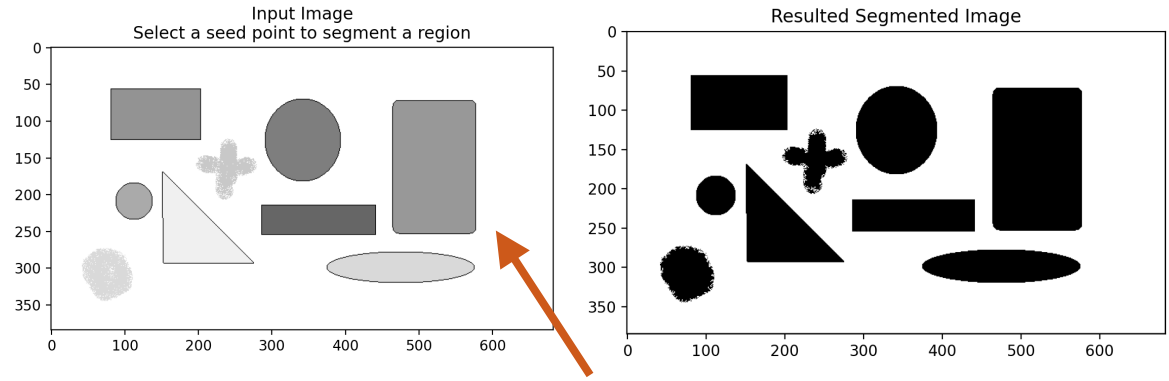
The centre rectangle part is chosen as seed point and the result is obtained.



The ellipse part is chosen as seed point and the result is obtained.



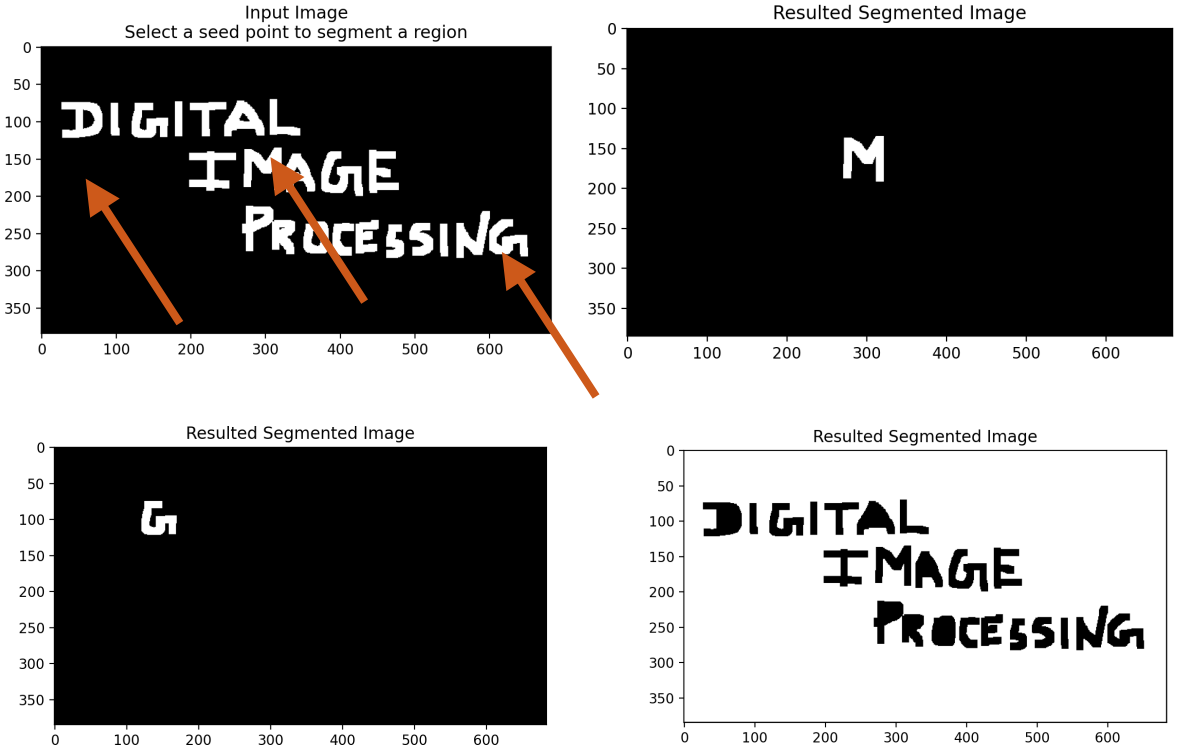
The big rectangle is chosen as seed point and the result is obtained.



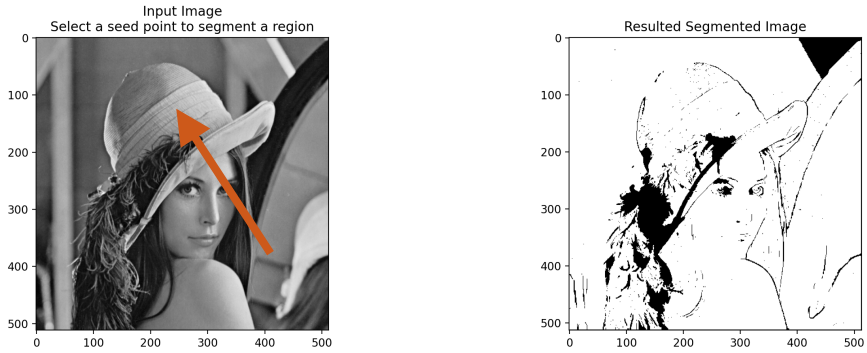
The background is chosen as seed point and the result is obtained.

From the above result it is visible that the algorithm works better (100% true) results.

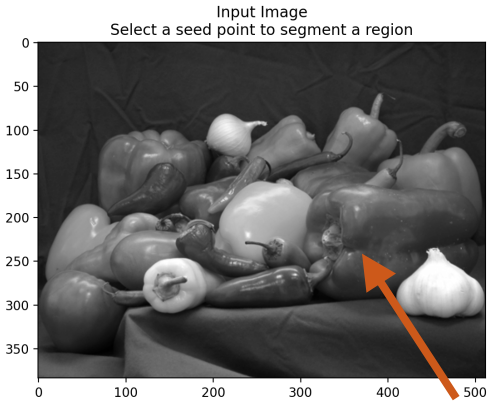
(2) DIPImage.jpg gray scale image:

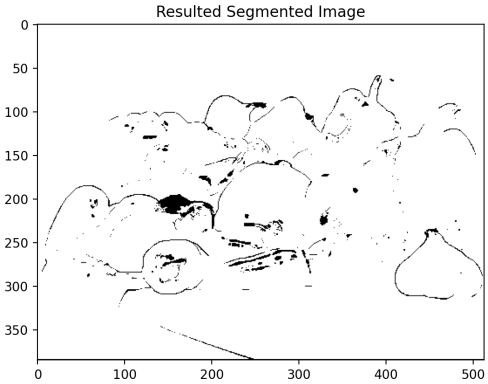


(3) Other random gray scale image:

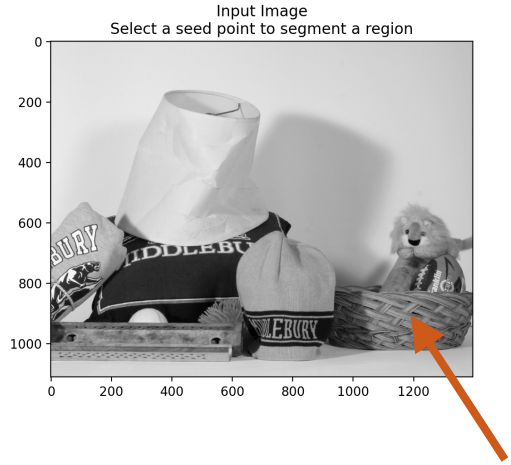


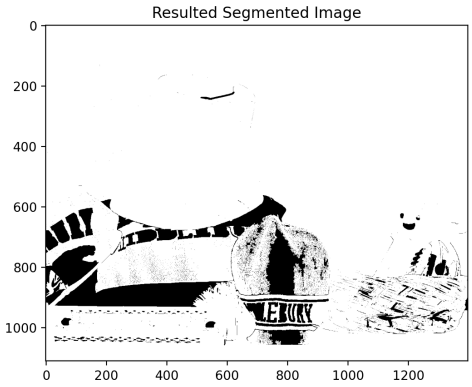
The region growing not worked as expected in the image. This is due to the various intensity light (less than +/- 8) variations in the image. So it is regarded as same region.

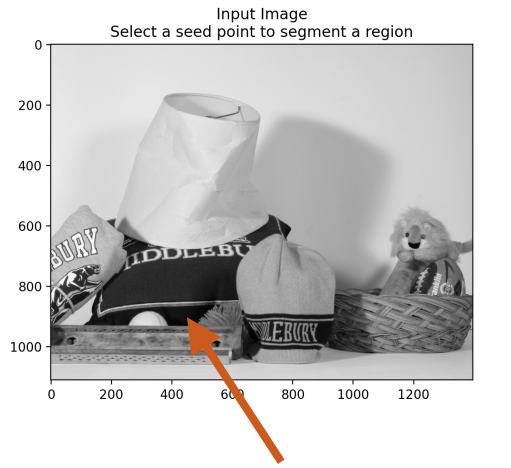


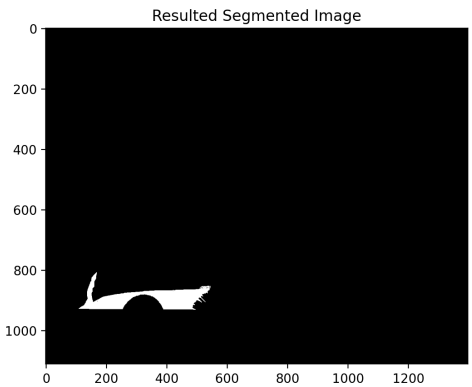


Similar to the above image, the region growing not worked as expected. This is due to the same reason intensity light (less than +/- 8) variations in the image. So it is grouping into same region.







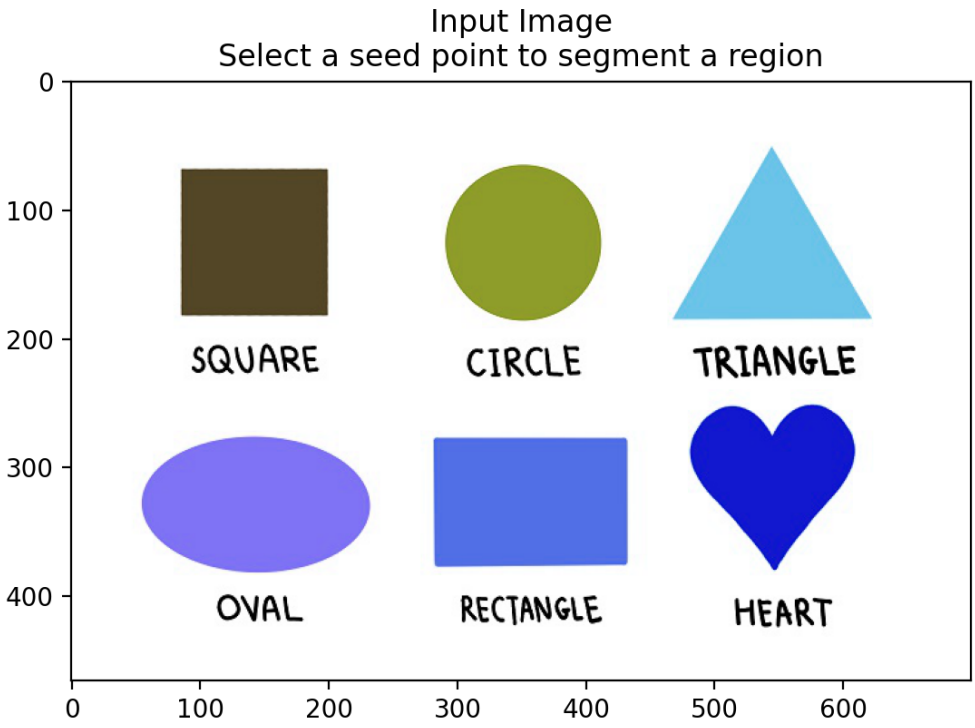


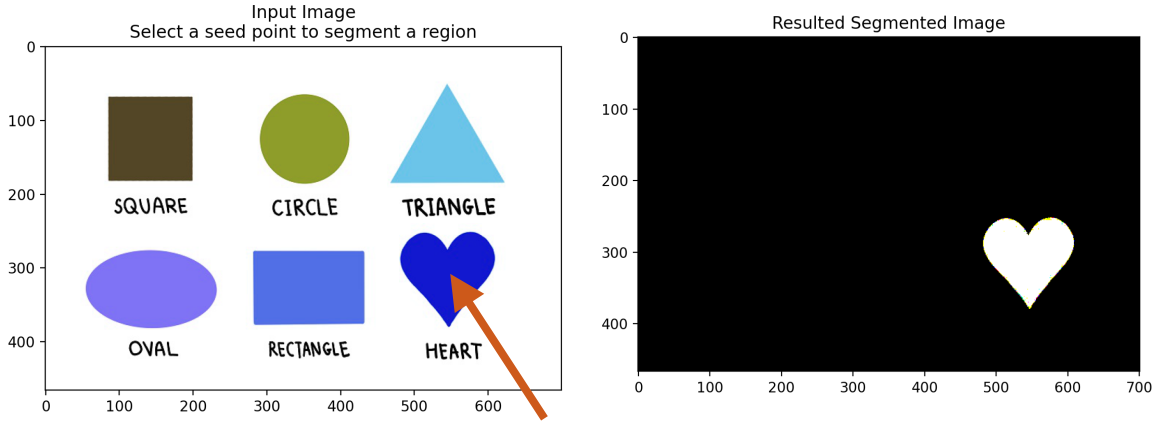
This examples holds the statement.

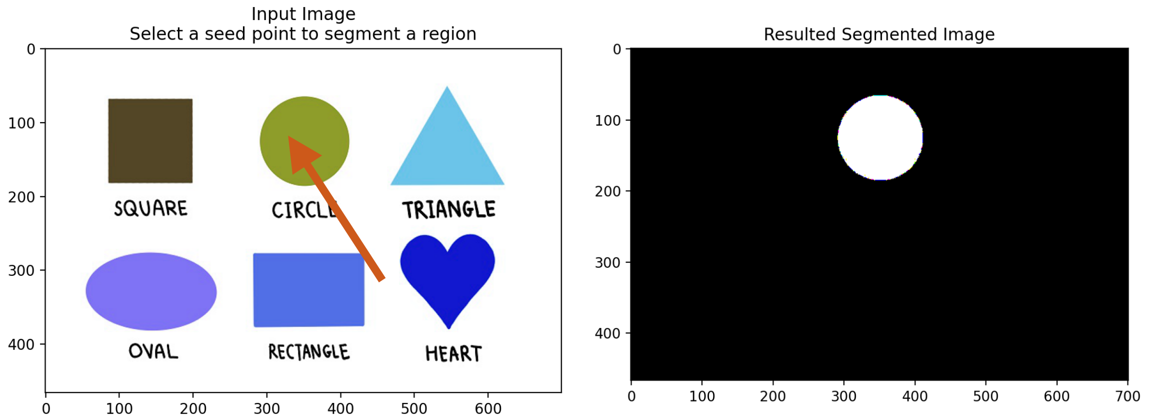
Color Image Test:

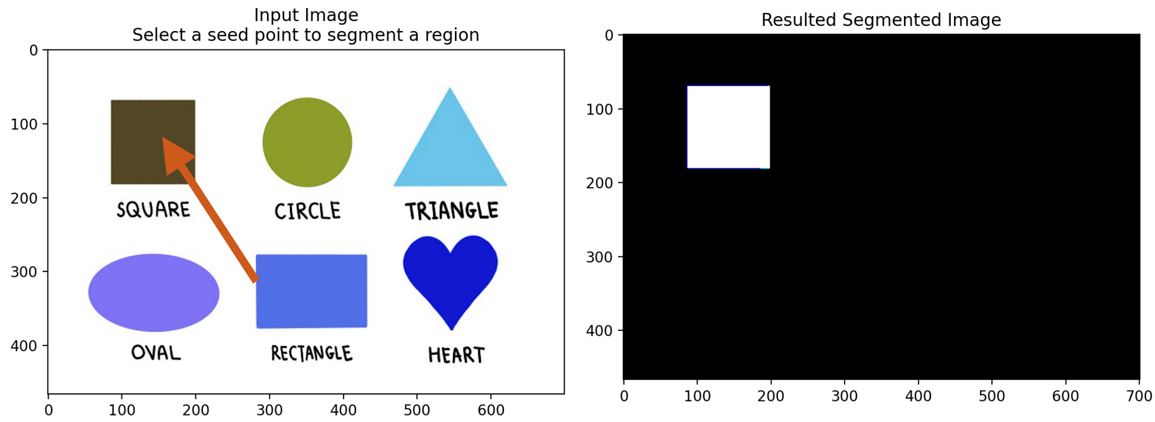
The code is tried using colour Images. We have initially tried to convert RGB into YCbCr colour model and apply region growing, but the image size reduces abruptly and choosing a seed point becomes difficult. Even the seed point is chosen the result obtained is not good as expected. Similarly the algorithm responded with HSV colour model.

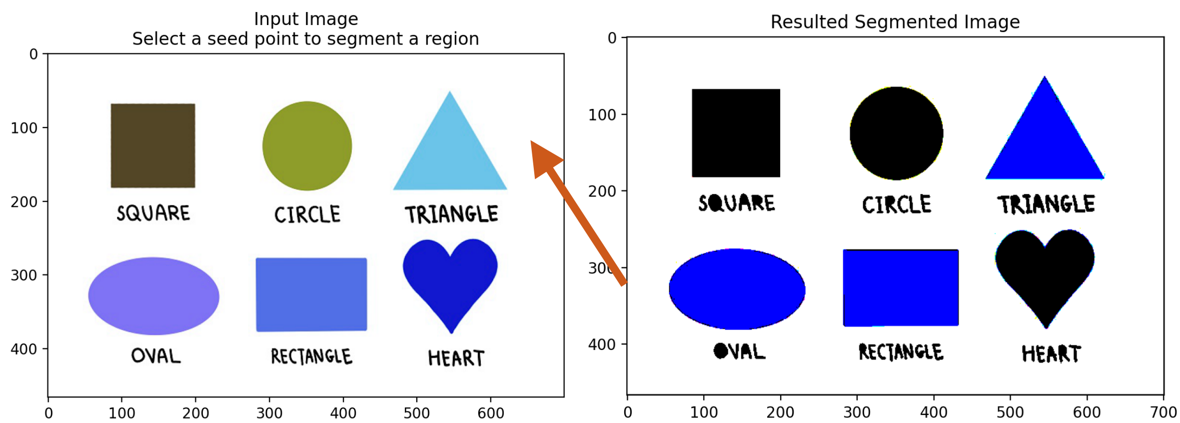
So, we have used the RGB model itself and applied Region growing for each planes and merged together. The result is good, but the background results in different colour. This happens is because when we passing R plane (0, 255, 0) and if the region is within the interest we assume pixel = 1 and rest as 0. Since same is repeated with all other planes, the region out of interest which is background gets different colour issues.




Input Image
Select a seed point to segment a region
SQUARE
CIRCLE
TRIANGLE
OVAL
RECTANGLE
HEART
Resulted Segmented Image


Input Image
Select a seed point to segment a region
SQUARE
CIRCLE
TRIANGLE
OVAL
RECTANGLE
HEART
Resulted Segmented Image


Input Image
Select a seed point to segment a region
SQUARE
CIRCLE
TRIANGLE
OVAL
RECTANGLE
HEART
Resulted Segmented Image


Input Image
Select a seed point to segment a region
SQUARE
CIRCLE
TRIANGLE
OVAL
RECTANGLE
HEART
Resulted Segmented Image
SQUARE
CIRCLE
TRIANGLE
OVAL
RECTANGLE
HEART

Conclusion

This is a basic implementation of region growing based image segmentation. It can be improved with new algorithms which works best available today. Here we implemented and obtained the desired result.

As stated, proper implementation of region based segmentation has wide applications in real world. In this project we learnt the what the region growing based image segmentation is, implementation and where it fails and where it works.

GitHub Link

Have a look at the **source code**, **user manual**, results obtained and various resources that presented in this project

https://github.com/Rajesh-Smartino/Region-Based-Segmentation

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Reference

1. R. C. Gonzalez and R. E. Woods, " Digital Image Processing" Third edition, Pearson Education, 2009.
2. Wikipedia resource: https://en.wikipedia.org/wiki/Image_segmentation
3. Wikipedia resource: https://en.wikipedia.org/wiki/Pixel_connectivity

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