

Comparative Analysis of Image Segmentation Techniques Using Graph Traversal

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Abstract: Computer vision relies entirely on image processing and the base of image processing is image segmentation, for an image to be processed productively it is very important that its segmentation has to be accurate. Moreover, it has to be so precise that not a single pixel is left or duplicated after segmentation. At the same time, resource consumption (like memory consumption, time complexity) has to be taken care of. The objective of this work is to check how graph traversal algorithms (Especially Single Source Shortest Path and Depth First Search Algorithms) are better than other in the field of image Segmentation.

I. INTRODUCTION

Image Segmentation is subset of Image Processing which further is a base for computer vision. As segmentation is just a step-in image processing but, it entirely defines the failure/success of processing an image, as well as, the quality of processing a image is dependent on the segmentation algorithm used. Segmentation is this much important that, using a trivial approach could lead to decrease in quality but on the other hand it could also lead to increase in performance (in terms of time taken to segment a image). Using a non-trivial approach has its own pro's and con's like a trivial approach, it could lead to improved quality of segmentation but it, on other hand, leads to decrease in performance. Graph traversal techniques are non-probabilistic, non-trivial approaches i.e., they don't follow any concept of "guess" or probability model to estimate any parameter (pixel intensity, position, etc). These techniques rather work on absolute basis although this absolute basis reduces the performance but on the other hand it improves the quality of segmentation. Segmentation is, partitioning an image into objects (disjoint sub-images) such that recombination of those sub-images leads to the original image, similarly, when an image is segmented using graph theoretical approaches it objects are sub-divided into

disjoint sub-graphs with the same condition that reunion of those sub-graphs must lead to the original image (graph).

$$A_1, A_2, \dots, A_k \text{ form partition of graph } G, \quad \text{if } A_i \cap A_j = \Phi \text{ (} i, j \in \{1, 2, \dots, k\}, i \neq j \text{) and} \\ A_1 \cup \dots \cup A_k = G$$

Once focus is shifted on graph, terminologies like slope (for a line), area of circle, angle between two line, etc becomes easy to find-out, which would be much of ease for edge linking using global processing [8]. When work is done without using graph theories, (x, y) coordinates (for 2-D) are considered after discretization, same is the requirement for graph theories. For converting a image to graph, mapping is done pixel by pixel from image to a graph. This also solves the problem of discretization and thus incur no discretization errors [9].

An important difficulty in segmentation is that, it has ill-posed nature i.e., since a image content has multiple interpretations hence it is difficult to find a single correct answer for a image. This is the main problem due to which segmentation is not generalized for all scenarios. This suggests that image segmentation should incorporate the mid-level and high-level knowledge in order to accurately extract objects of interest.

II. RELATED WORK

Graph Traversal Algorithm focuses on certain points and other techniques it is also an image segmentation technique. As an image is denoted with $f(x, y)$ and f is the intensity/gray level at position x, y . Now, in this technique, move from very first position 0, 0 till a meaningful pixel is found. The movement is done one basis of distance of 1 that means 1 pixel at a time. Once a meaningful pixel is found then follow one these two approaches

Single Source Shortest Path: - In this technique, find out the boundary of the object. Here, concept of weighted graph is used. The weight assigned to the edges is 1 and 0. Weight is assigned to objects on the basis of pixel being object pixel or background pixel. Object pixels have weight of 0 and background pixel have weight of 1. Once a meaningful pixel is found the terminology followed is of single source shortest path, find out the next pixel which have weight less and set a variable to 1 which represent that the pixel is being visited. the algorithm terminates when the next pixel is already visited. It eliminates few shortcomings of other algorithms like it do not required to be initiated using other

algorithms, it do not require the output to be known, It is very rugged algorithm i.e., it do not let any object or pixel behind.

Depth First Search: - This technique is developed to find out regions of the image. In this algorithm, once a meaningful point is found it will put that point in the stack and check for the same features in the neighbourhood. If neighbour's have the same features then it will put them to the stack and search for their neighbour's. In this fashion it moves on and when no pixel is left behind then the stack pop's out. This is the exact working of Depth First Search Algorithm. It also starts from the very first pixel 0, 0 hence it also does not need any separate algorithm to initiate. Its performance is also rugged.

Table 1-Comparison and Contrast between Different types of segmentation.

Name/Parameters	Self-Initiated	Rugged	Knowledge Required	Linear/Parallel	Clustering	Space Complexity	Time Complexity
Region Growing	No	No	Threshold	Parallel	Develop Externally	$i*i$	$i*s$
Region Splitting and Growing	Yes	Yes	Threshold	Parallel	Develop Externally	$M*N$	$i*j$
Segmentation using Ants	Yes	Yes	Threshold	Parallel	Develop Externally	i	$M*N$
Genetic	Yes	Approx.	Knowledge of Output	Parallel	Develop Externally	i	$g*c$
Threshold-based	Yes	Approx.	Threshold	Parallel	Develop Externally	i	$M*N$

Graph Traversal	Yes	Yes	Threshold	Parallel	Already Available	i	$(M*N) + i$
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- Table Comparison of different types of Segmentation Approaches.
- Where c is length of chromosome, i is size of object, j is number of split regions, M*N is size of image, s is number of seeds and g is number of generations it takes to converge to solution.

III. PROPOSED METHODOLOGY

The actual algorithm that implemented in this study is given in the section below:

a. Boundary Based Segmentation (Discontinuities)

Boundary based segmentation has been inferred from the single source shortest path graph traversal algorithm. As, single-source shortest path algorithm considers weight between the edges to find path but while segmenting an image, it is considered that if 2 pixels are neighbors and have same gray level then the edge between them carries weight otherwise the weight is zero. Hence segmentation has been carried-out using this concept. Moreover, gestalt principle (M. Wertheimer, 1938) of dissimilarity is used to find out boundary of the object. It is mainly implemented in OCR'S.

Terms used ahead are:

xMax: used to get maximum range of x coordinate in the image.

yMax: used to get maximum range of y coordinate in the image.

s[x,y]: used to indicate that a pixel at (x,y) coordinated is already traversed or not.

Connected[x,y]: It will store the value of next adjoining pixel with similar properties.

conn(x,y,a,b): It is the function used to link pixel at (x,y) with next similar pixel at (a,b).

objStart[x,y]: It is an array that will hold the starting index to every object.

Algorithm Segmentation (p(x,y))

```
{
    xMax:=Maxof(x);
    yMax:=Maxof(y);
    Obj:=0;
```

```

for y:=0 to yMax do
for x:=0 to xMax do
{
    a[x,y]:=GetIntensityat(P(x,y));
    S[x,y]:=FALSE;
    Connected[x,y]:=0;
}
b:=x; c:=y
for y:=0 to yMax do
for x:=0 to xMax do
{
    Counter:=0;
    Find a edge[f,g] adjacent to edge[b,c] && where abrupt change of
intensity is there and S[f,g]=FALSE
    {
        S[f,g]:=TRUE;
        Connected[b,c]:=Conn(b,c,f,g);
        Counter:=1;
        if(f=x && g=y) then break;
        Find a edge[d,e] adjacent to edge[f,g] && where abrupt
change of intensity is there and S[d,e]=False
        {
            S[d,e]:= TRUE;
            Connected[f,g]:=Conn(f,g,d,e);
            b:=d;
            c:=e;
        }
    }
    if(Counter=1) then
    {
        Obj:=Obj+1;
        ObjStart[Obj,0]:=x;
        ObjStart[Obj,1]:=y;
    }
}
}

```

IV. EXPERIMENTAL RESULTS

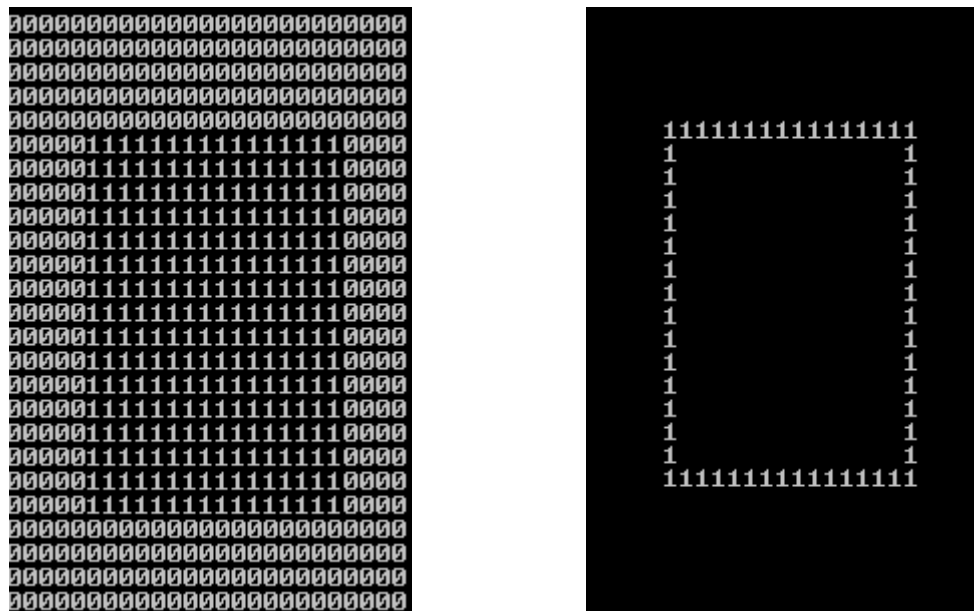


Figure 1- Getting regions from the image

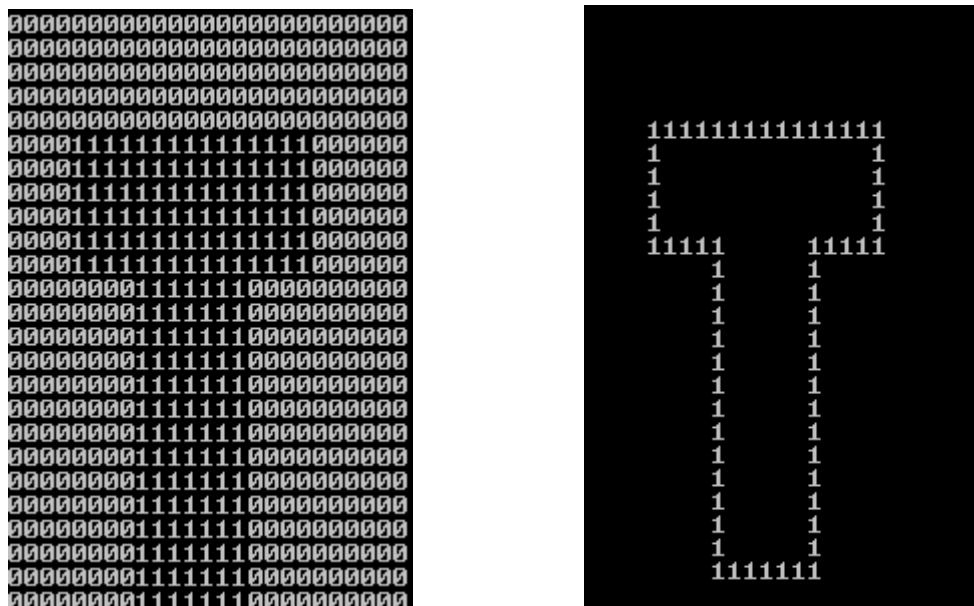


Figure 2- Finding Suitable regions for Segmentation

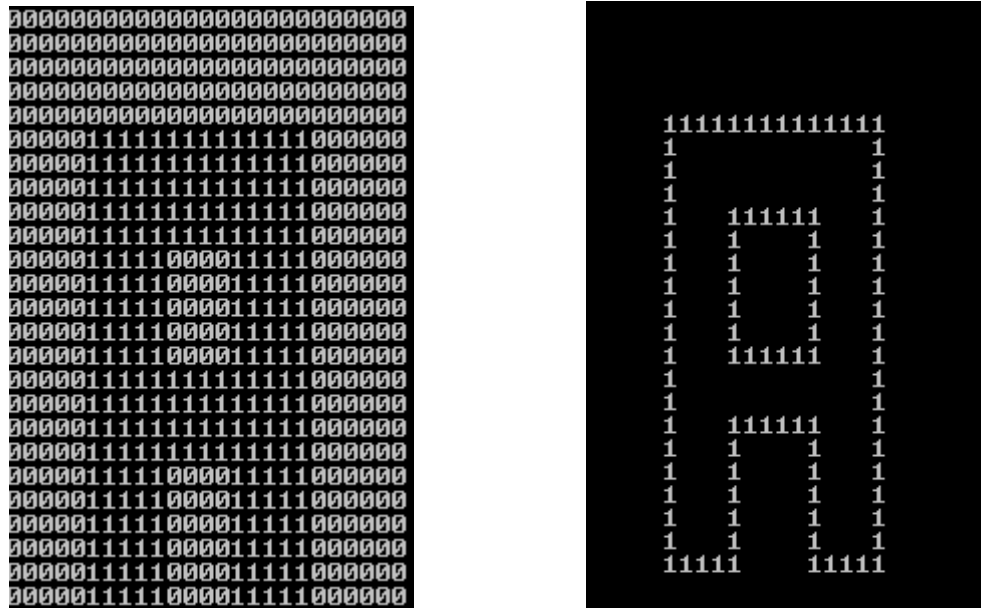


Figure 3- Getting Appropriate Regions from the image

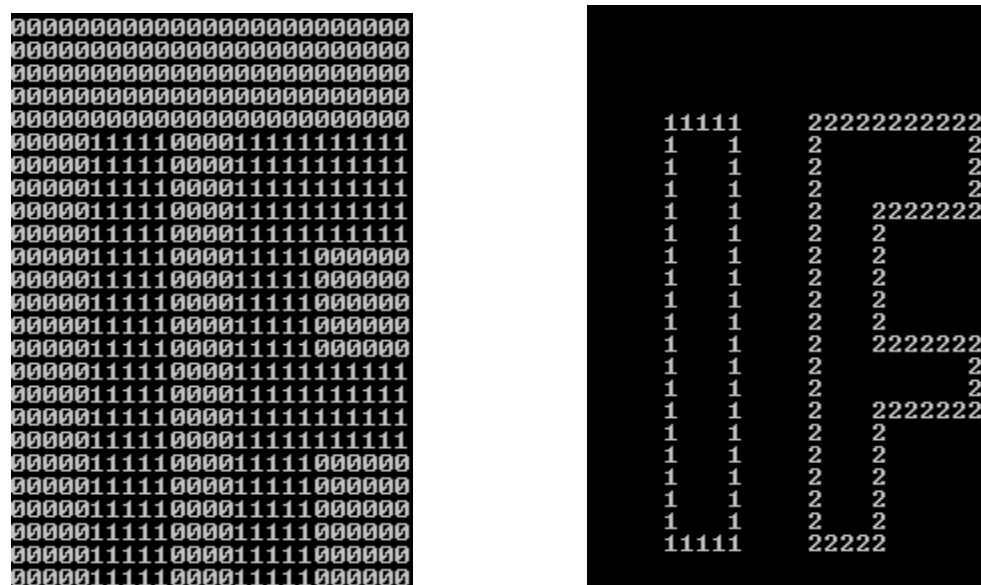


Figure 4- Getting Appropriate Regions from the image

V. Conclusion and Future Work

Image Processing is a very important concept but this concept is entirely dependent on the accuracy of segmentation. Segmentation act's as performance enhancer and sometimes it acts as Bottle-Neck. Image can only be processed accurately if the image is segmented properly. Segmentation has some dependencies like edge linking, clustering. If these stages are linked with segmentation then the segmentation becomes more fruitful, this

study had incorporated segmentation with these capabilities (or at-least given a direction). Storage of the segmented portion is also important issue; this study had also given a direction to store the segmented object optimally. The proposed algorithm is designed and implemented in C++. The comparison had shown significant improvement over the techniques available.

In the near future, these algorithms could work in applications like ocr's, industrial application, etc. These applications bring different stages of image processing to shrink into one algorithm which will increase the productivity and reduce the error rate of whole system.

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