ALGORITHIM PROJECT

Mentor

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Graph construction code

```
public static List<Edge> BuildEdges(RGBPixel[,] img, Func<RGBPixel,
byte> channelSelector)
{


    int height = ImageOperations.GetHeight(img);
    int width = ImageOperations.GetWidth(img);
    var edges = new List<Edge>(height * width *4 );

    int[] dx = { -1, -1, -1, 0, 0, 1, 1, 1 };
    int[] dy = { -1, 0, 1, -1, 1, -1, 0, 1 };

      //

    for (int y = 0; y < height; y++)
    {
        for (int x = 0; x < width; x++)
        {
            int node = y * width + x;
            byte color = channelSelector(img[y, x]);

            for (int k = 0; k < dx.Length; k++)
            {
                int nx = x + dx[k];
                int ny = y + dy[k];
                if (nx < 0 || ny < 0 || nx >= width || ny >= height)
                    continue;



                int node2 = ny * width + nx;

                if (node2 < node) continue;
                byte color2 = channelSelector(img[ny, nx]);
                int weight = Math.Abs(color - color2);


                edges.Add(new Edge(node, node2, weight));
            }
        }
    }

    return edges;
}
```

Image segmentation code

```
public class Segmenter
{
private readonly RGBPixel[,] img;
private readonly int width;
private readonly int height;
private readonly long k;


public Segmenter(RGBPixel[,] image, long kValue)
{
img = image;
height = ImageOperations.GetHeight(image);
width = ImageOperations.GetWidth(image);
k = kValue;
}

private int[,] RunMonoChannel(Func<RGBPixel, byte> selector)
{

int total = width * height;
var edges = GraphBuilder.BuildEdges(img,selector);
edges.Sort((a, b) => a.Weight.CompareTo(b.Weight));
var dsu = new DisjointSet(total);

foreach (var e in edges)
{
int a = dsu.FindLeader(e.U);
int b = dsu.FindLeader(e.V);
if (a == b) continue;

double ta = k / dsu.GetSize(a);
double tb = k / dsu.GetSize(b);
double ma = dsu.InternalDiff(a) + ta;
double mb =dsu.InternalDiff(b) + tb;

if (e.Weight <=Math.Min(ma, mb))
{
dsu.Union(a, b, e.Weight);
}

}

var leaders = new int[height, width];


Parallel.For(0, height, y =>
{
```

```
for (int x = 0; x < width; x++)
{
int id = y * width + x;
leaders[y, x] = dsu.FindLeader(id);
}
});
return leaders;
}


int comp;
public int[,] RunColor()
{
// Segmentation on R, G, B
int[,] lr = null, lg = null, lb = null;


Parallel.Invoke(
() => { lr = RunMonoChannel(p => p.red); },
() => { lg = RunMonoChannel(p => p.green); },
() => { lb = RunMonoChannel(p => p.blue); }
);

int total = width * height;

var finalDsu = new DisjointSet(total);

int[] dx = { 1, 1, -1, -1, 0, 1, 0, -1 };
int[] dy = { 1, -1, 1, -1, 1, 0, -1, 0 };

for (int y = 0; y < height; y++)
{
for (int x = 0; x < width; x++)
{

int id = y * width + x;
for (int i = 0; i < dx.Length; i++)
{
int nx = x + dx[i], ny = y + dy[i];
if (nx < 0 || ny < 0 || nx >= width || ny >= height) continue;

int nid = ny * width + nx;
if (lr[y, x] == lr[ny, nx] &&
lg[y, x] == lg[ny, nx] &&
lb[y, x] == lb[ny, nx])
{
finalDsu.Union(id, nid, 0);
}}}
```

```
var finalLeaders = new int[height, width];


Parallel.For(0, height, y =>
{
for (int x = 0; x < width; x++)
{
int id = y * width + x;
finalLeaders[y, x] =finalDsu.FindLeader(id);
}
});
return finalLeaders;
}
public (int count, List<int> sizes) GetStats(int[,] leaders)
{
var freq = new Dictionary<int, int>();
int h = leaders.GetLength(0);
int w = leaders.GetLength(1);

for (int y = 0; y < h; y++)
for (int x = 0; x < w; x++)
{
int leader = leaders[y, x];
if (!freq.ContainsKey(leader)) freq[leader] = 0;
freq[leader]++;
}


var sizes = new List<int>(freq.Values);
sizes.Sort((a, b) => b.CompareTo(a));
return (sizes.Count, sizes);
}
```

Helper Function for Image segmentation (DisjointSet)

```
public DisjointSet(int n)
{
componants = n;
parent = new int[n];
groupSize = new int[n];
internalDiff = new double[n];

for (int i = 0; i < n; i++)
{
parent[i] = i;
groupSize[i] = 1;
internalDiff[i] = 0.0;
}
}

public int GetComponants()
{
return componants;
}
public int FindLeader(int x)
{
if (parent[x] == x) return x;

return parent[x] = FindLeader(parent[x]);
}

public void Union(int x, int y, double weight)
{
int leader1 = FindLeader(x);
int leader2 = FindLeader(y);

if (leader1 == leader2) return;

if (GetSize(leader1)<GetSize(leader2))
{
//swap
(leader2, leader1) = (leader1, leader2);
}

parent[leader2] = leader1;
groupSize[leader1] += groupSize[leader2];

internalDiff[leader1] = Math.Max(Math.Max(internalDiff[leader1],
internalDiff[leader2]), weight);
componants--;
}
public int GetSize(int x);

return groupSize[FindLeader(x)];
}
public double InternalDiff(int x)
{
return internalDiff[FindLeader(x)];
}
```

Helper Function for Image segmentation (Edge)

```
struct Edge
{
    public int U, V;
    public int Weight;
    public Edge(int u, int v, int w) { U = u; V = v; Weight = w; }
}
```

Image segmentation visualization code

```csharp
public RGBPixel[,] Colorize(int[,] leaders)
{
var rnd = new Random();
var colors = new Dictionary<int, Color>();

int h = leaders.GetLength(0);
int w = leaders.GetLength(1);



RGBPixel[,] mat = new RGBPixel[h, w];

for (int y = 0; y < h; y++)
for (int x = 0; x < w; x++)
{
int leader = leaders[y, x];
if (!colors.ContainsKey(leader))
colors[leader] = Color.FromArgb(rnd.Next(256), rnd.Next(256),
rnd.Next(256));



mat[y, x].red = colors[leader].R;
mat[y,x].green = colors[leader].G;
mat[y,x].blue = colors[leader].B;
}
return mat;
}
```

ANALYSIS

Graph construction code

```
public static List<Edge> BuildEdges(RGBPixel[,] img, Func<RGBPixel,
byte> channelSelector)
{
      // O(1) FOR ALL

    int height = ImageOperations.GetHeight(img);
    int width = ImageOperations.GetWidth(img);
    var edges = new List<Edge>(height * width *4 );

    int[] dx = { -1, -1, -1, 0, 0, 1, 1, 1 };
    int[] dy = { -1, 0, 1, -1, 1, -1, 0, 1 };

      //

    for (int y = 0; y < height; y++)
    {
        for (int x = 0; x < width; x++)
        {
    // TOTAL COMPLIXITY FOR LOOPS O(N) ; N = pixels
            int node = y * width + x;
            byte color = channelSelector(img[y, x]); // o(1)

            for (int k = 0; k < dx.Length; k++) // o(1)
            {
                int nx = x + dx[k]; // o(1)
                int ny = y + dy[k]; // o(1)
                if (nx < 0 || ny < 0 || nx >= width || ny >= height)
                    continue; // o(1)



                int node2 = ny * width + nx; // o(1)

                if (node2 < node) continue; // o(1)
                byte color2 = channelSelector(img[ny, nx]); // o(1)
                int weight = Math.Abs(color - color2); // o(1)


                edges.Add(new Edge(node, node2, weight)); // o(1)
            }
        }
    }

    return edges;
}
// TOTAL COMPIXTY O(N)
```

Image segmentation code

```
public class Segmenter
{   // O(1)
private readonly RGBPixel[,] img;
private readonly int width;
private readonly int height;
private readonly long k;


public Segmenter(RGBPixel[,] image, long kValue)
{
// O(1)
img = image;
height = ImageOperations.GetHeight(image);
width = ImageOperations.GetWidth(image);
k = kValue;
}

private int[,] RunMonoChannel(Func<RGBPixel, byte> selector) // n log n
{

int total = width * height; // O(1)
var edges = GraphBuilder.BuildEdges(img,selector); //n
edges.Sort((a, b) => a.Weight.CompareTo(b.Weight)); // n log n
var dsu = new DisjointSet(total); //n

foreach (var e in edges) //n
{
int a = dsu.FindLeader(e.U); //log n
int b = dsu.FindLeader(e.V); //log n
if (a == b) continue; // 1

// O(1)
double ta = k / dsu.GetSize(a);
double tb = k / dsu.GetSize(b);
double ma = dsu.InternalDiff(a) + ta;
double mb =dsu.InternalDiff(b) + tb;

if (e.Weight <=Math.Min(ma, mb))
{
dsu.Union(a, b, e.Weight);
}

}

var leaders = new int[height, width]; // O(N)

//nlogn for loop
```

```
Parallel.For(0, height, y =>
{
for (int x = 0; x < width; x++)
{
int id = y * width + x;
leaders[y, x] = dsu.FindLeader(id); // log N
}
});
return leaders;
}


int comp;
public int[,] RunColor()
{
// Segmentation on R, G, B
int[,] lr = null, lg = null, lb = null;


Parallel.Invoke( // n log n per each which is total NlogN
() => { lr = RunMonoChannel(p => p.red); },
() => { lg = RunMonoChannel(p => p.green); },
() => { lb = RunMonoChannel(p => p.blue); }
);


//var l = RunCombinedRGB();
int total = width * height;

var finalDsu = new DisjointSet(total); // n

int[] dx = { 1, 1, -1, -1, 0, 1, 0, -1 };
int[] dy = { 1, -1, 1, -1, 1, 0, -1, 0 };

for (int y = 0; y < height; y++)
{
for (int x = 0; x < width; x++)
{
/// BOTH LOOPS O(N)
int id = y * width + x;
for (int i = 0; i < dx.Length; i++) // O(1)
{
int nx = x + dx[i], ny = y + dy[i];
if (nx < 0 || ny < 0 || nx >= width || ny >= height) continue;

int nid = ny * width + nx;
if (lr[y, x] == lr[ny, nx] &&
lg[y, x] == lg[ny, nx] &&
lb[y, x] == lb[ny, nx])
{
finalDsu.Union(id, nid, 0); // log n
}


}
}
/// TOTAL N LOG (N)
}



var finalLeaders = new int[height, width]; // N

//nlogn for loop

Parallel.For(0, height, y =>
{
for (int x = 0; x < width; x++)
{
int id = y * width + x;
finalLeaders[y, x] =finalDsu.FindLeader(id); // log n
}
});
return finalLeaders;
}
public (int count, List<int> sizes) GetStats(int[,] leaders)
{
var freq = new Dictionary<int, int>(); // O(1)
int h = leaders.GetLength(0);
int w = leaders.GetLength(1);

for (int y = 0; y < h; y++)
for (int x = 0; x < w; x++)
{
int leader = leaders[y, x];
if (!freq.ContainsKey(leader)) freq[leader] = 0;
freq[leader]++;
}
// Total loop complexity: O(n), where n = h * w


var sizes = new List<int>(freq.Values); // O(s), s = number of unique
leaders (segments)
sizes.Sort((a, b) => b.CompareTo(a)); // s log s
return (sizes.Count, sizes); // O(1)
}
// TOTAL COMPLIXITY O(n + s log s)
```

Helper Function for Image segmentation (DisjointSet)

```
public DisjointSet(int n)
{
componants = n; // O(1)
parent = new int[n];// O(N)
groupSize = new int[n];// O(N)
internalDiff = new double[n];// O(N)

for (int i = 0; i < n; i++) // O(N)
{
parent[i] = i;
groupSize[i] = 1;
internalDiff[i] = 0.0;
}
}

public int GetComponants() //O(1)
{
return componants;
}
public int FindLeader(int x) //O(Log N)
{
if (parent[x] == x) return x;

return parent[x] = FindLeader(parent[x]);//O(Log N)
}

public void Union(int x, int y, double weight)
{
int leader1 = FindLeader(x); //O(Log N)
int leader2 = FindLeader(y); //O(Log N)

if (leader1 == leader2) return; // O(1)

if (GetSize(leader1)<GetSize(leader2))
{
//swap
(leader2, leader1) = (leader1, leader2); // O(1)
}

parent[leader2] = leader1;// O(1)
groupSize[leader1] += groupSize[leader2];// O(1)

internalDiff[leader1] = Math.Max(Math.Max(internalDiff[leader1],
internalDiff[leader2]), weight);// O(1)
componants--;// O(1)
}
public int GetSize(int x)//O(Log N)
{
return groupSize[FindLeader(x)];//O(Log N)
}
public double InternalDiff(int x)//O(Log N)
{
return internalDiff[FindLeader(x)];//O(Log N)
}
```

Helper Function for Image segmentation (Edge)

```
struct Edge // O(1)
{
    public int U, V;
    public int Weight;
    public Edge(int u, int v, int w) { U = u; V = v; Weight = w; }
}
```

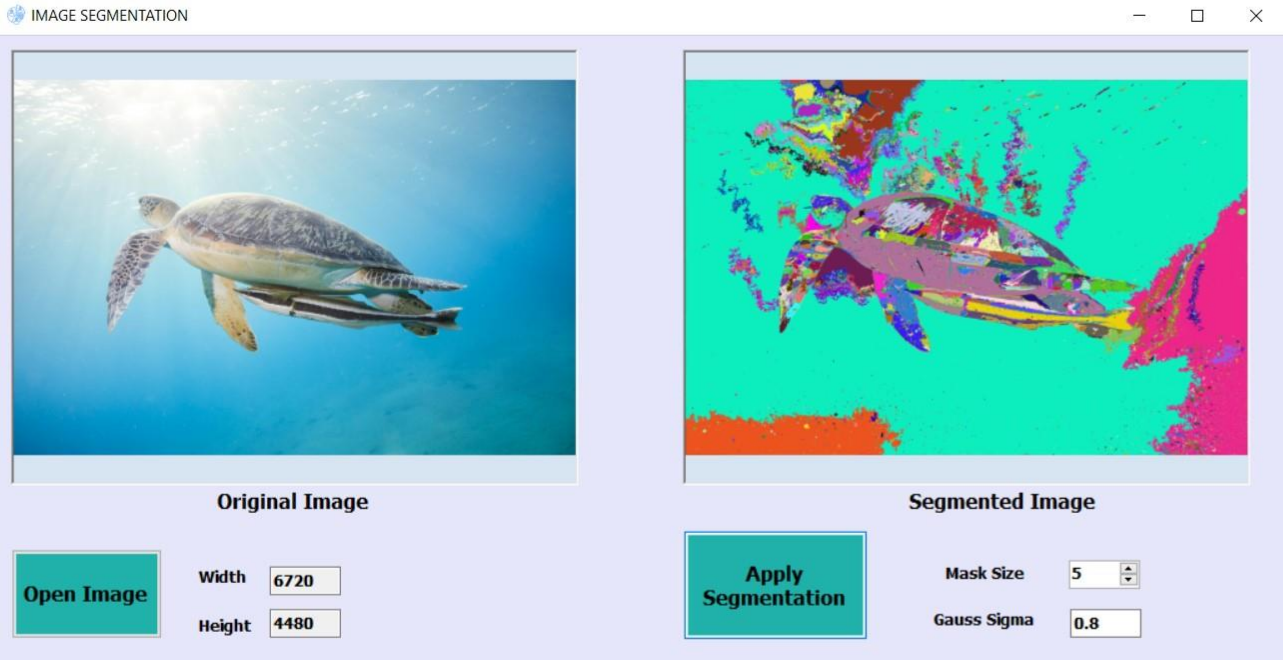
Image segmentation visualization code

```
public RGBPixel[,] Colorize(int[,] leaders)
{
var rnd = new Random(); // O(1)
var colors = new Dictionary<int, Color>(); // O(1)

int h = leaders.GetLength(0); // O(1)
int w = leaders.GetLength(1); // O(1)



RGBPixel[,] mat = new RGBPixel[h, w]; // n

for (int y = 0; y < h; y++)
for (int x = 0; x < w; x++)
{
int leader = leaders[y, x]; // O(1)
if (!colors.ContainsKey(leader))
colors[leader] = Color.FromArgb(rnd.Next(256), rnd.Next(256),
rnd.Next(256));
// O(s), s = number of unique leaders (segments)



mat[y, x].red = colors[leader].R;  // O(1)
mat[y,x].green = colors[leader].G; // O(1)
mat[y,x].blue = colors[leader].B; // O(1)
}
return mat;

// TOTAL COMPLIXITY O(N)
}
```

Running code

```
private void btnGaussSmooth_Click(object sender, EventArgs e)
{
double sigma = double.Parse(txtGaussSigma.Text);
int maskSize = (int)nudMaskSize.Value ;
ImageMatrix = ImageOperations.GaussianFilter1D(ImageMatrix, maskSize,
sigma);


Stopwatch timer = Stopwatch.StartNew();


var segmenter = new Segmenter(ImageMatrix, 30000); //O(1)
int[,] leaders = segmenter.RunColor(); // N Log N

var ImageMatrix2 = segmenter.Colorize(leaders); // O(N)

var (count, sizes) = segmenter.GetStats(leaders); // O(n + s log s)
timer.Stop();

long time = timer.ElapsedMilliseconds;

Debug.WriteLine("TIME:" + time);


ImageOperations.DisplayImage(ImageMatrix2, pictureBox2);




string outputPath = @"D:\Algorithims project\Image-
Segmentation\ImageSegmentation\ImageSegmentation\MyOutput.txt";

using (var sw = new StreamWriter(outputPath, false)) // O(leaders) ;
{
sw.WriteLine(count);

foreach (var s in sizes)
sw.WriteLine(s);
}


SaveFileDialog saveFileDialog1 = new SaveFileDialog();
saveFileDialog1.Filter = "bmp files (*.bmp)|*.bmp|All files (*.*)|*.*";
saveFileDialog1.RestoreDirectory = true;
if (saveFileDialog1.ShowDialog() == DialogResult.OK)
{
pictureBox2.Image.Save(saveFileDialog1.FileName, ImageFormat.Bmp);}}
```

OUTPUT SAMPLES

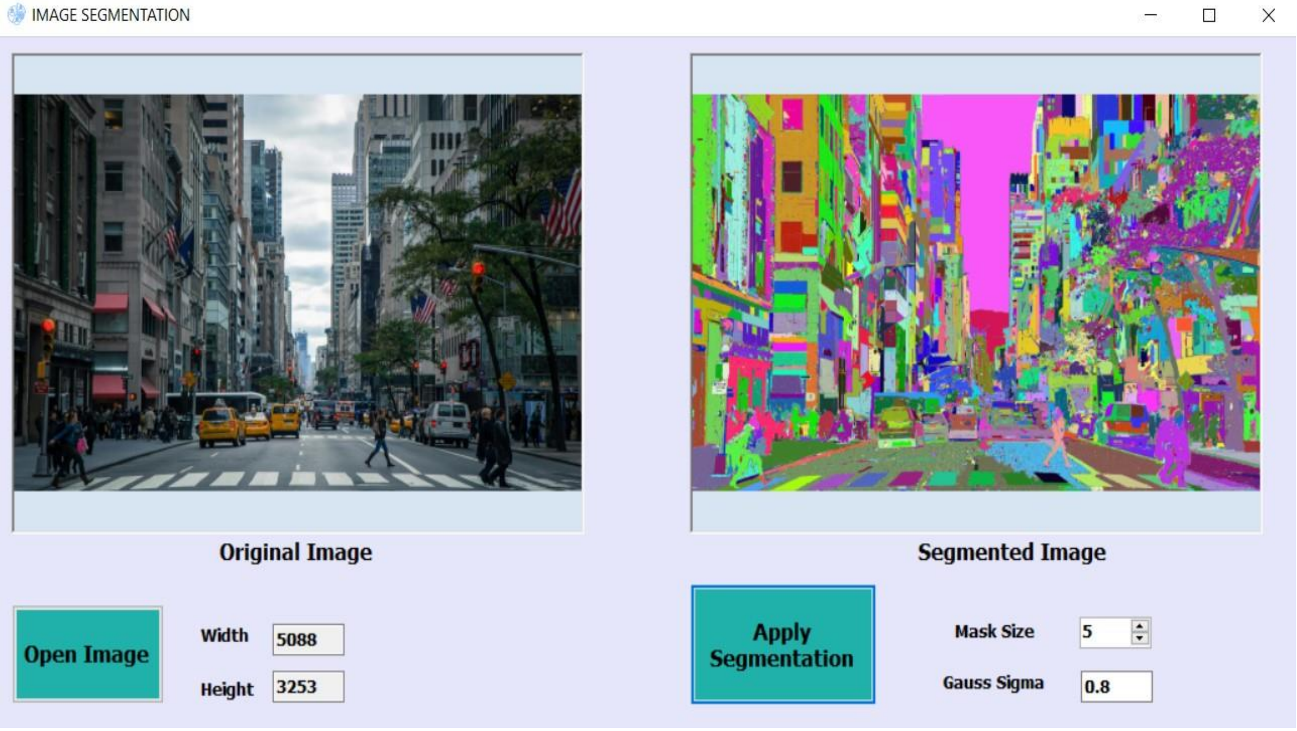


Width 6720

Height 4480

Mask Size 5

Gauss Sigma 0.8

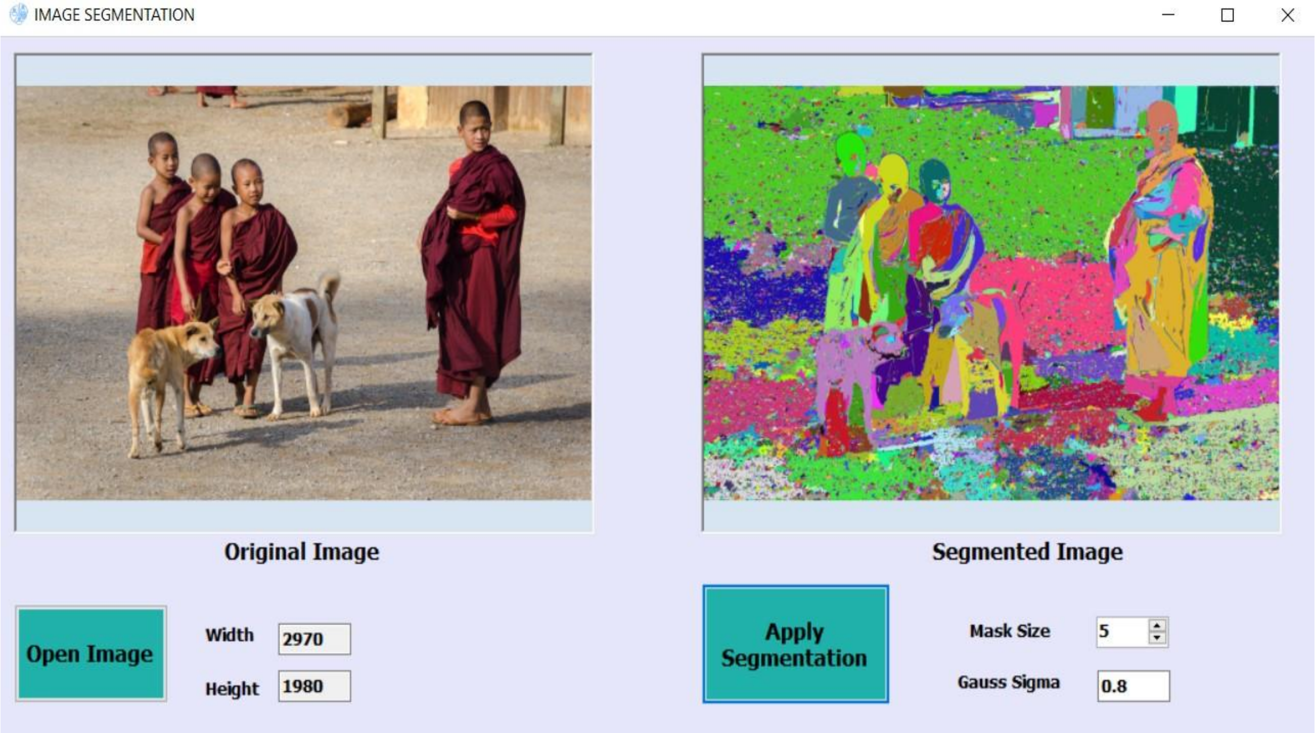


Width 5088

Height 3253

Mask Size 5

Gauss Sigma 0.8

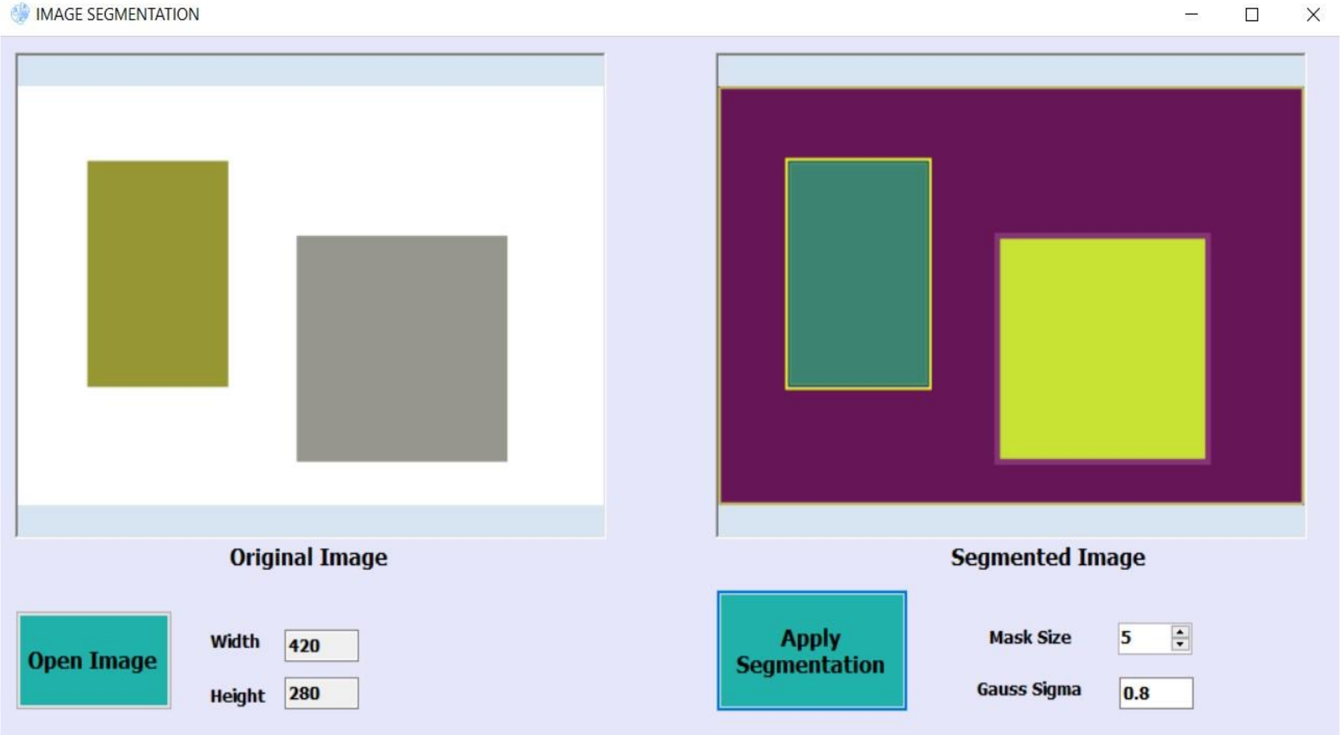


Width 2970

Height 1980

Mask Size 5

Gauss Sigma 0.8



Width 420

Height 280

Mask Size 5

Gauss Sigma 0.8