ADVANCED IMAGE PROCESSING

ASSIGNMENT 2

NAME- JYOTISH RANJAN

M. Tech AI,2023

Classical methods: N-Cut, K-means **(10 Marks)**

- Implement the N-Cut algorithm to segment the images into two or more segments (More than two segments for at least one image). Test it on the images given here.
- Perform N-Cut using two similarity measures.
- Perform K-means based image segmentation for these images. Vary K between 3 to 6 to get coarse to fine grained segmentation. You can use already available k-means code.
- Qualitatively analyze all the results.

CODE IMPLEMENTATION:

CODE link

Step 1: Computation of Similarity And Degree Matrices Using RGB And Grayscale Intensity

1. **Calculating average intensity across RGB channels for each pixel and for grayscale image using intensity values.**
2. **It iterates through all pixels and calculates the squared Euclidian distance between pixels and difference of intensities that was calculated in previous step.**
3. **Now, calculate similarity score using a Gaussian Kernel function.**
4. **The resulting matrix W encodes the pairwise similarities between pixels based on the RGB values.**
5. **Matrix D is diagonal matrix whose diagonal elements are row sum of W.**

Step 2: N Cut Algorithm

1. **Now find eigenvector corresponding to second smallest eigenvalue of (D-W).**
2. **Divide the elements of this eigenvector into 2 classes based on median value of eigenvector.**
3. **Reshape this eigenvector to shape of image used.**
4. **Plot this eigenvector.**

Step 3: For More than 2 segments

1. **Extracting 3 eigenvectors of D-W (RGB similarity Matrix).**
2. **Calculating median of the 3 eigenvectors.**
3. **Calculating mean of values produced by the 3 eigenvectors for each pixel.**
4. **Classifying these pixels based on where this mean value of each pixel lies compared to medians calculated for eigenvectors.**
5. **Reshape this eigenvector to shape of image used.**
6. **Plot this result.**

Step 4: For K – Means Clustering:

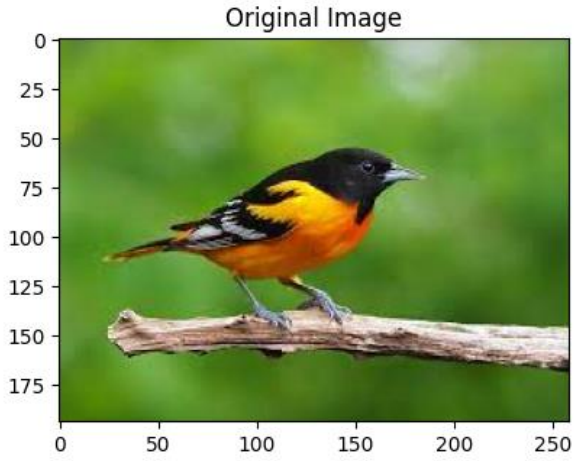
1. **Set termination criteria like number of iterations and accuracy.**
2. **Use cv2.kmeans function on the image.**
3. **Plot the result.**

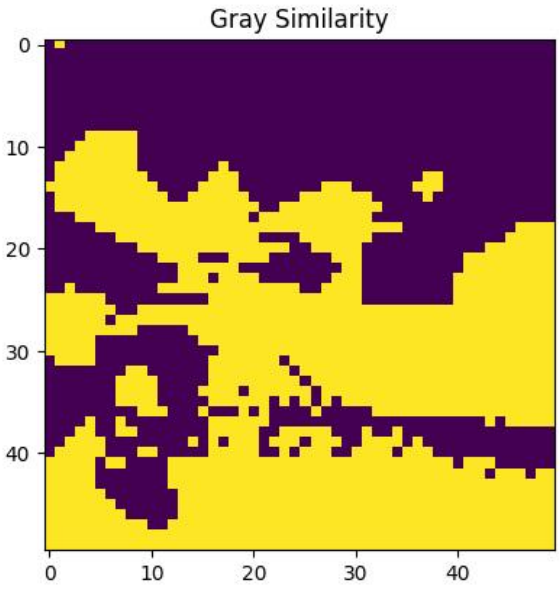
Qualitative Study:

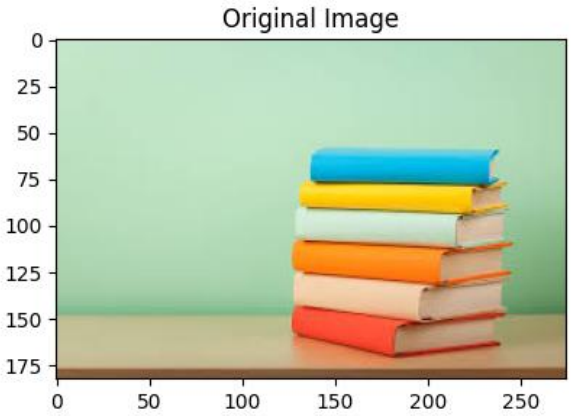
- **For bird, book and sunset RGB Similarity performs well maybe because of more spectrum of colour variations.**
- **For dog, grayscale intensity performs well maybe because of sudden change in intensity value of image.**
- **When more than 1 eigenvector is used for segmentation then some noise is introduced which impacts the result of segmentation.**
- **Value of K which segments image well based on naked eye:**
  Dog (K == 3), Bird(K==4,5), Sunset(K==4) and Books (K == 6).
  At lower value of K image segmentation is coarser and at higher values it is more finer.
- **Calculating pixel similarity by varying sigma values is tough to achieve so this makes NCUT little bit difficult to implement.**

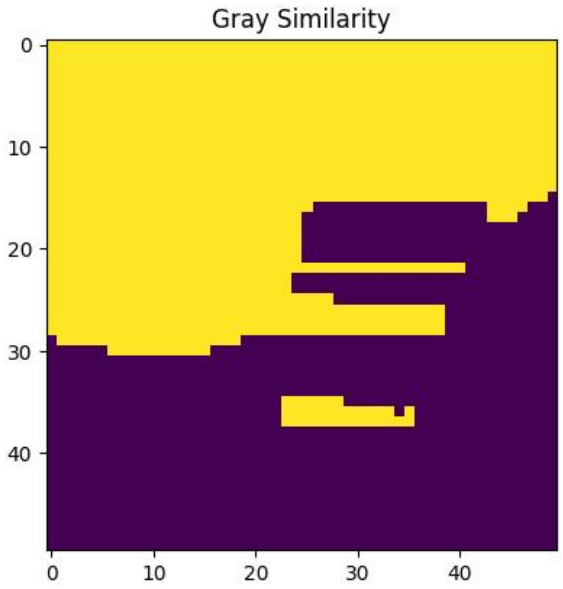
Results:

Grayscale Intensity Similarity:

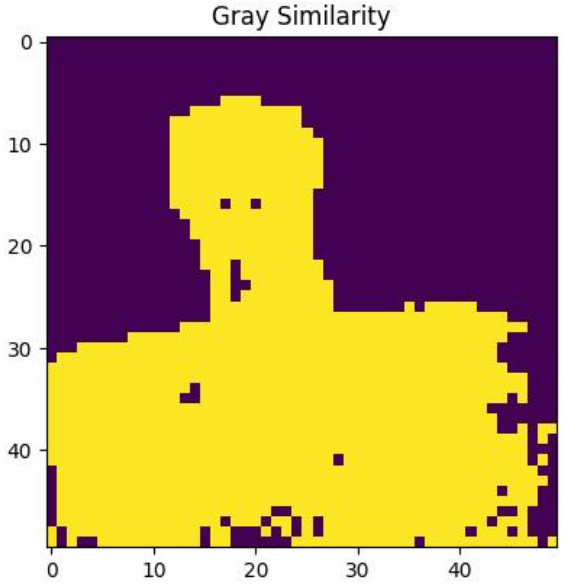


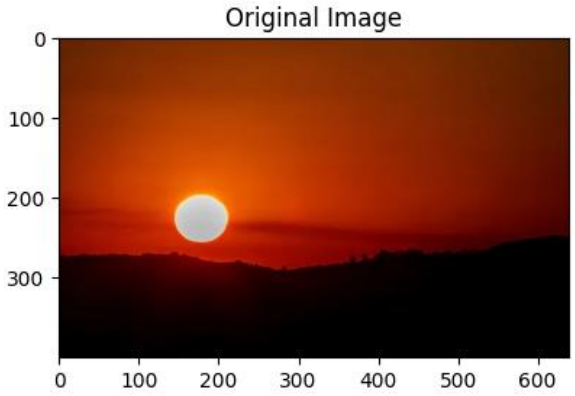


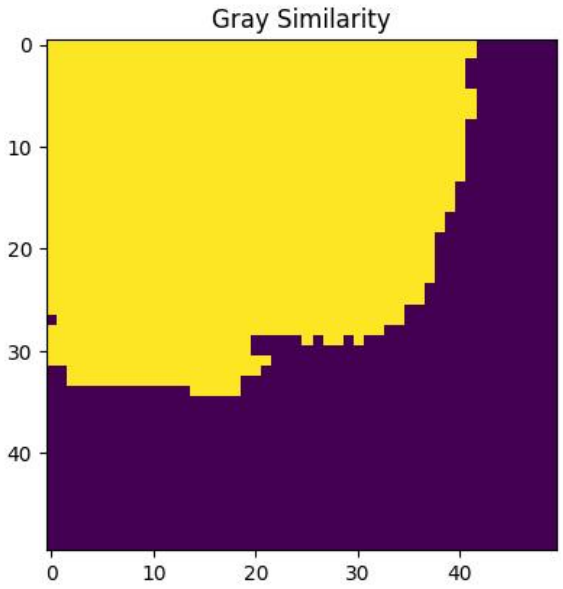

Original Image
0
25
50
75
100
125
150
175
0
50
100
150
200
250


Gray Similarity
0
10
20
30
40
0
10
20
30
40

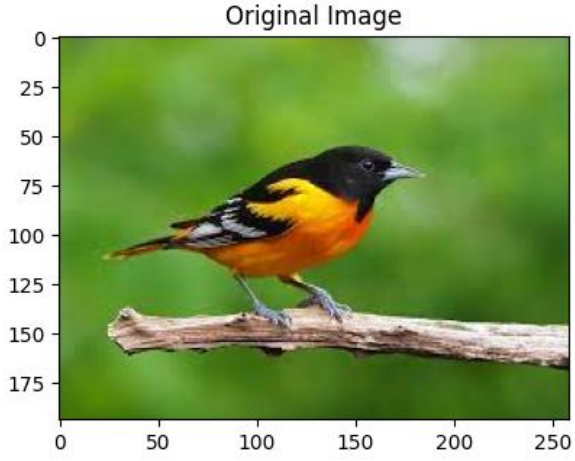

Original Image
0
100
200
300
400
500
0
200
400
600
800

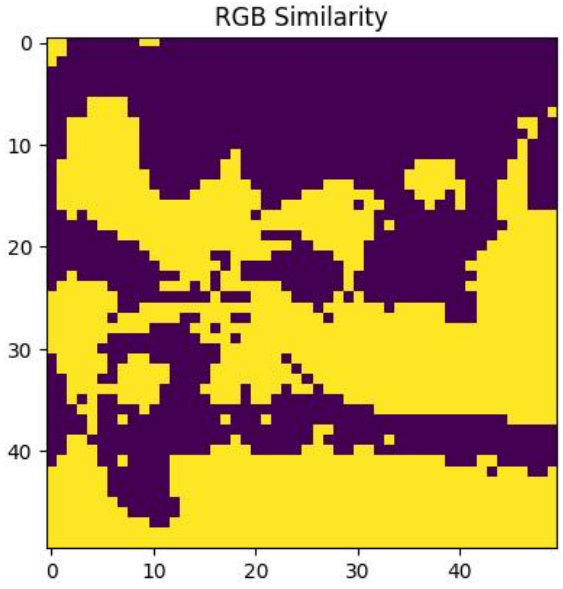

Gray Similarity
0
10
20
30
40
0
10
20
30
40

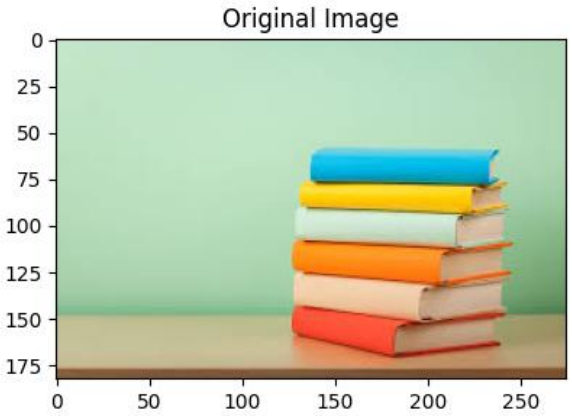


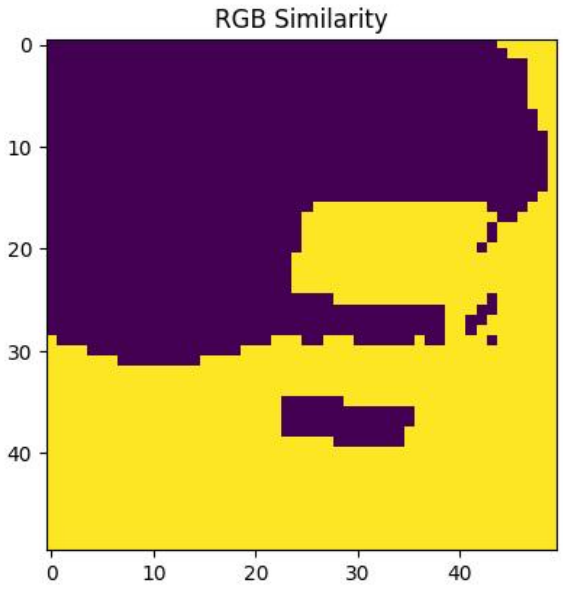


RGB Similarity

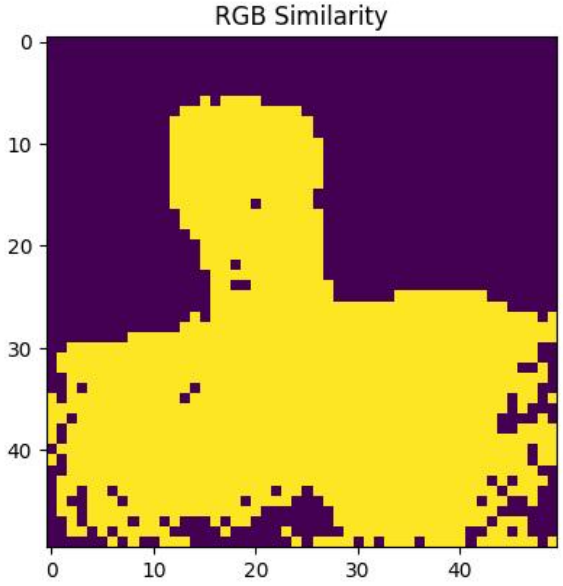


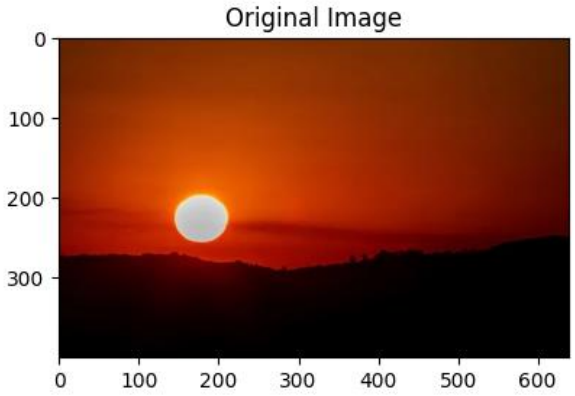


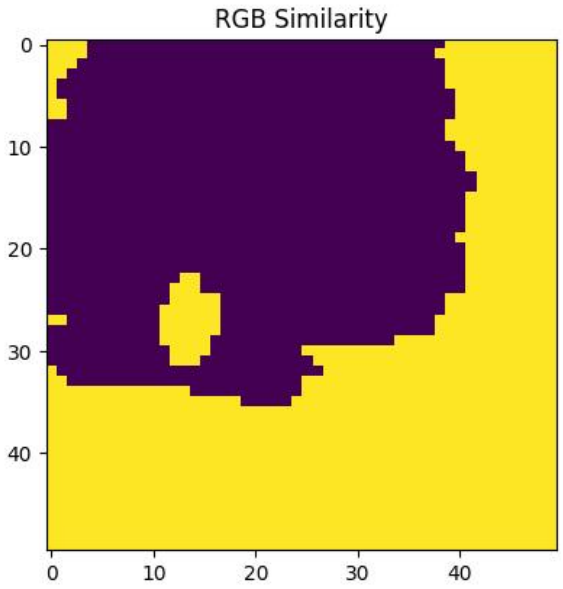

Original Image
0
25
50
75
100
125
150
175
0
50
100
150
200
250


RGB Similarity
0
10
20
30
40
0
10
20
30
40

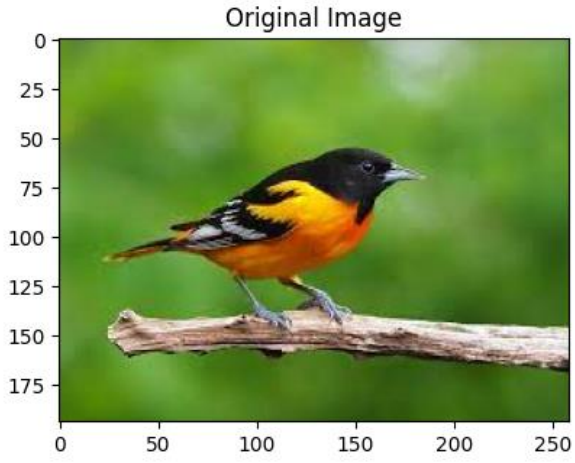

Original Image
0
100
200
300
400
500
0
200
400
600
800

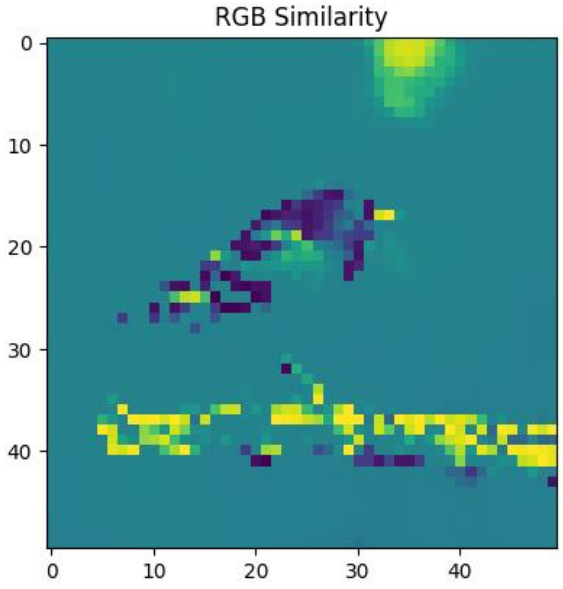

RGB Similarity
0
10
20
30
40
0
10
20
30
40

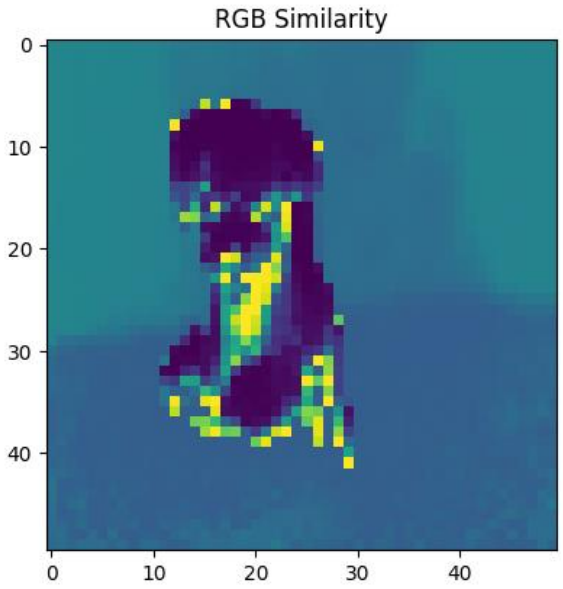




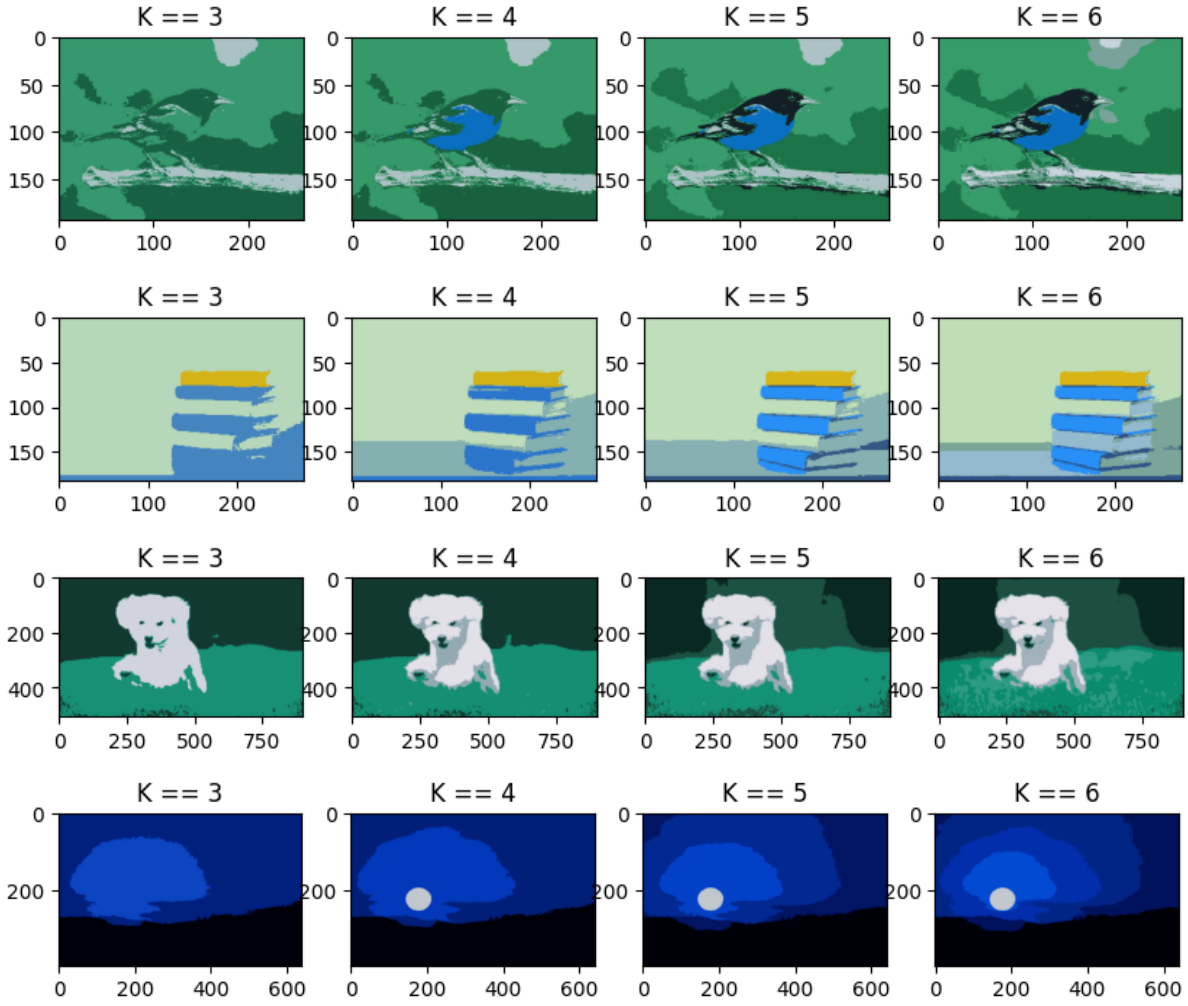
NCUT 4 segments:







K Means Clustering:



2.

Fully Convolutional Networks **(15 Marks)**

- Take a ResNet-18 backbone pretrained for ImageNet classification. Modify the last FC layers to convert it to a Fully Convolutional Network inorder to perform Image Segmentation. Implement two variants: (1) without skip connections. (2) with skip connections.
- Train these ResNet-18 based FCNs on the dataset given here. Then, evaluate the pixelwise accuracy and meanIOU on the test set.
- Compare the results from the two variants of FCN.

CODE IMPLEMENTATION:

Code link

1. Data Loading and Preprocessing which includes converting to tensor, data loaders for testing and training etc..
2. Building Model for both with and without skip connections using Resnet18 pretrained model.
3. Training both models setting epoch = 50, using ADAM optimizer and using Cross Entropy Loss.
4. Testing And Calculating Accuracies based on IOU and pixelwise Accuracy.

Results:

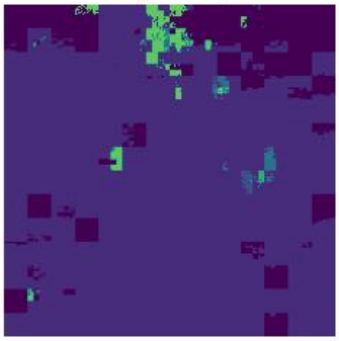
- **Without Skip Connections:**

  IOU : Approx .20
  Pixelwise Accuracy : Approx .92

Original Image

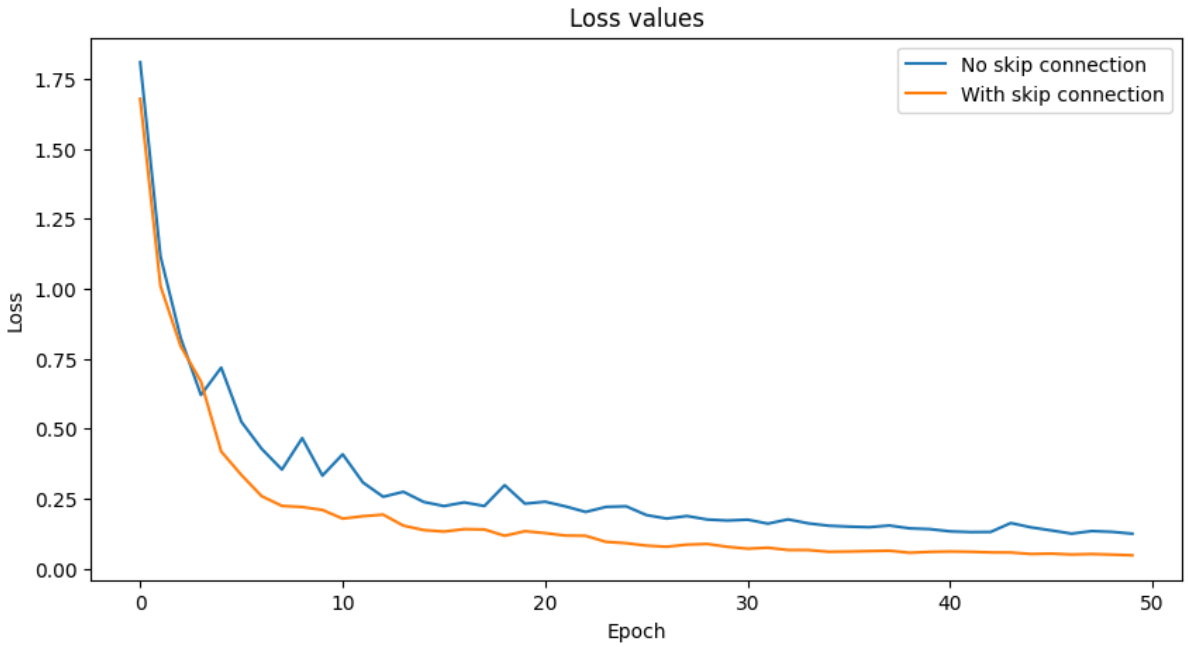
GT Mask

Predicted Mask(no skip connection)



- **With Skip Connections:**

  IOU : Approx ~ .32
  Pixelwise Accuracy : Approx ~ .96



Analysis:

In both mean pixelwise and IOU wise With skip connections performs better than Without Skip connections.

Reasons could be:

1. **Skip connections addresses the problem of vanishing gradients.**
2. **Skip Connections facilitates Identity Learning : This helps in learning the residual between the input and target output, making it easier for the network to converge.**
   In without skip connections the network has to learn approximate identity mapping.

3. **Skip Connections can act as a form of regularization by encouraging the network to learn sparse representations.**
4. **Skip connections enable information from earlier layers to be directly passed to later layers. This allows features learned at lower levels of abstraction to reused by higher layers.**

Why low IOU scores?

Resnet 18 may have fewer parameters and maybe less capacity to capture details in the image, especially in complex scenes. As a result, it struggles to produce accurate segmentation, leading to lower IOU scores. It depends on dataset too. For this dataset it is performing poorly.