

## **Project 2 – Content-based Image Retrieval**

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### **Introduction:**

In this project, we studied various Content-based image retrieval (CBIR) techniques. We extracted multiple features from images such as Color Histogram, Texture, Spatial Variance, and HSV Histogram and performed feature matching to retrieve the desired content. These techniques can be used alone or in combination to retrieve images from a large database based on their content. The choice of technique will depend on the type of images being retrieved. Colour histogram matching may be a good choice for images with strong colour patterns. Histogram of Gradient Magnitude and Orientation can be used for object detection. Spatial variance can be used to retrieve images having similar colour patterns.

### **Task1: Output**



pic.1016.jpg

pic.0986.jpg

pic.0641.jpg

pic.0233.jpg

### **Task2: RGB 3D Histogram**

output for pic.0164.jpg



pic.0164.jpg

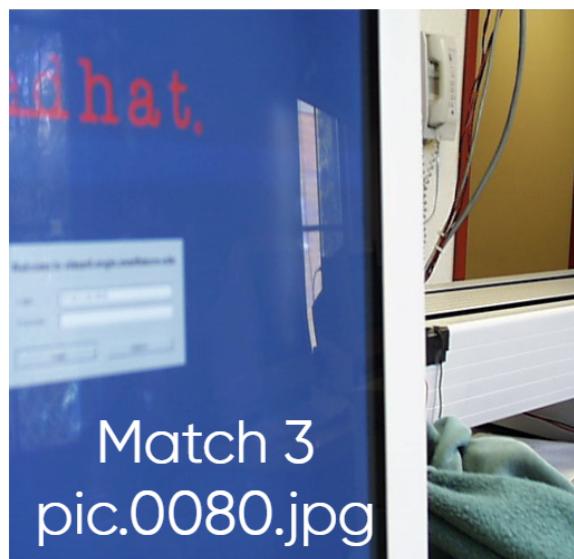
pic.0110.jpg

pic.1032.jpg

pic.0092.jpg

We also tried 2D Histogram using RG channel.

Top 3 matches for Target Image pic.0164.jpg



### Task 3: Multi-Histogram Matching

We used RGB Multi Histogram.

The 1st histogram is an RGB Histogram for the entire image.

2nd histogram is an RGB Histogram for the centre portion of the image (50% image).

Weights for matching are 0.4 for the full image histogram and 0.6 for the centre image histogram.

Below are the outputs for pic.0274.jpg:

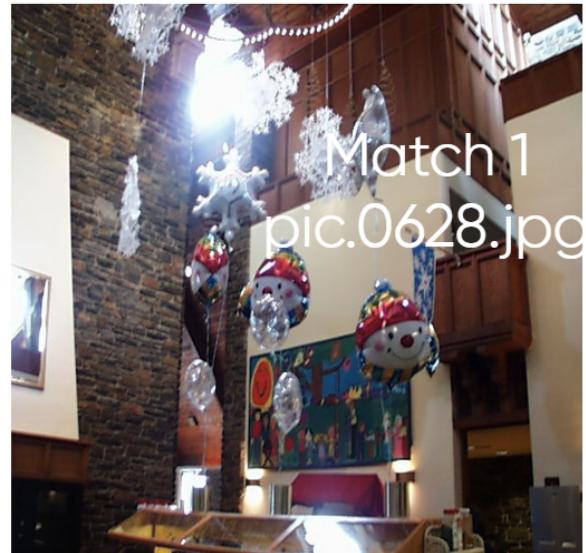
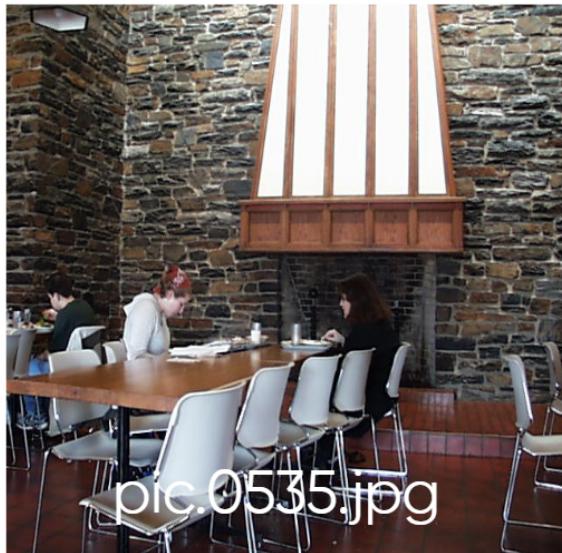


## Task 4: Texture and Color

Texture and colour histogram combination. Here we have used a 2D histogram of the Magnitude and Orientation of the Gradient grayscale image for the texture feature and 3 channel RGB histogram for the colour feature.

Weights for matching are 0.5 each for colour and texture features.

Top 3 matches for Target Image pic.0535.jpg -->



Histogram Intersection method is used for calculating texture metric in this task. To get proper texture we have added orientation of gradient image as well in the texture feature vector.

In task 4 output we can clearly see that the output images have similar textures for instance all the images have a similar wall in the background.

Distance calculation for feature matching of Histogram.

$$d(H1, H2) = \sum I_{min}(H1(I), H2(I))$$

### Task 5: Face Images

We added human faces and landscape images to the Olympus dataset and created a new dataset called olympus3. This dataset will be used for further tasks.

In this task, we have used a histogram of gradient orientation and magnitude to detect faces from the dataset.

Weights for matching are 0.3 for colour hist and 0.7 for HOG.

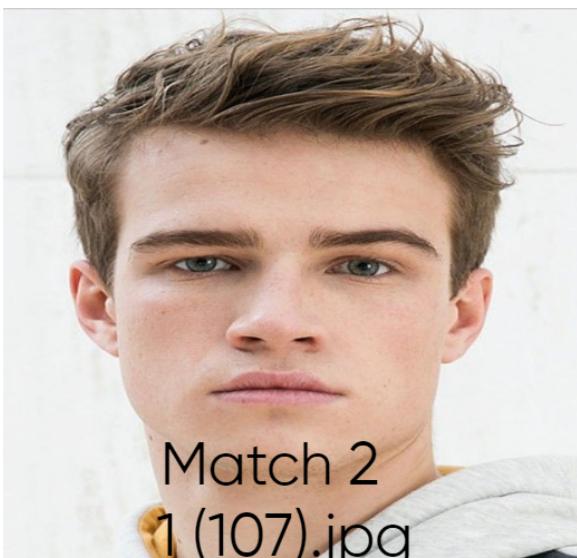
Top 3 matches for Target Image 1 (9).jpg -->



1 (9).jpg



Match 1  
1(24).jpg



Match 2  
1(107).jpg



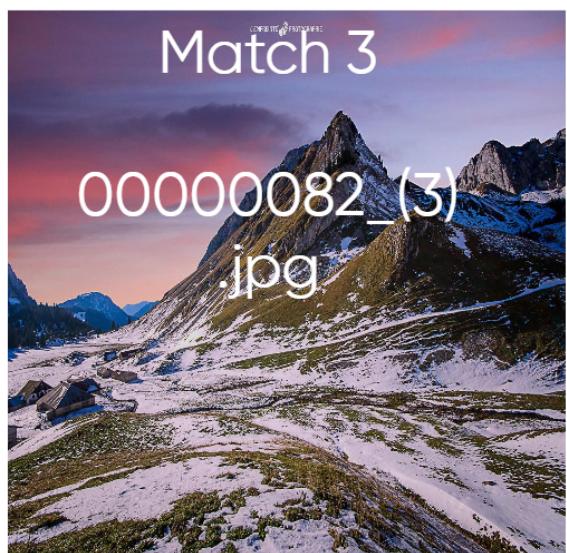
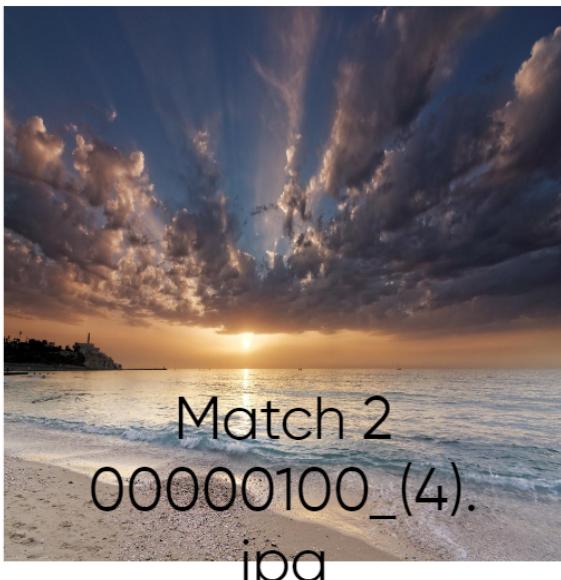
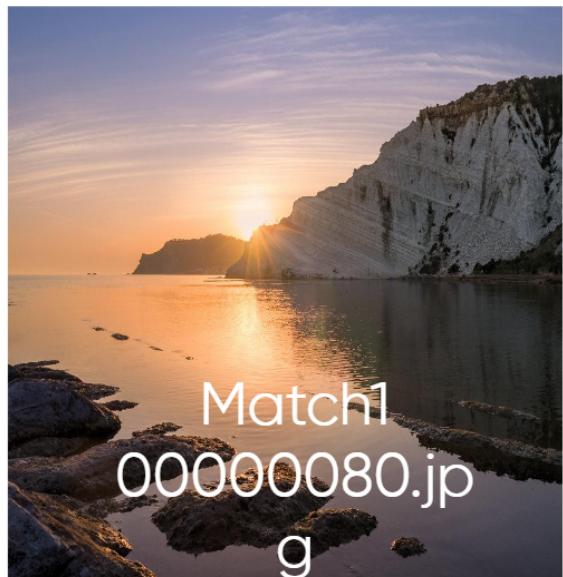
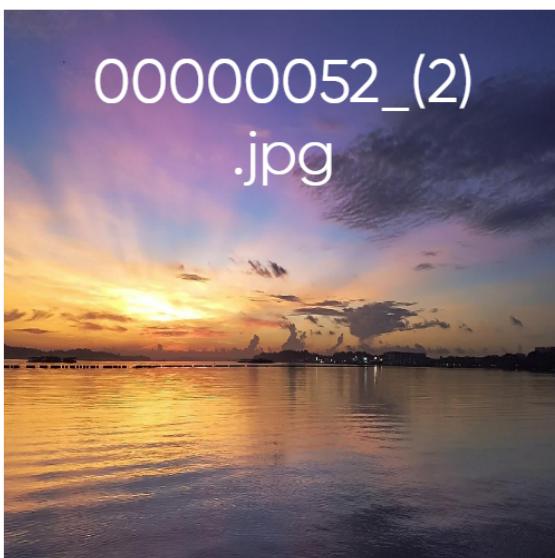
Match 3  
1(40).jpg

## Extension 1: Matching Sunrise and Desert Pictures

We have used a histogram of HSV colour space and also added the variance of each colour bin into the feature vector. The total feature vector size is  $8*8*8 + 3 = 515$  with 8 bins for each channel of HSV and 3 values of variance in each channel.

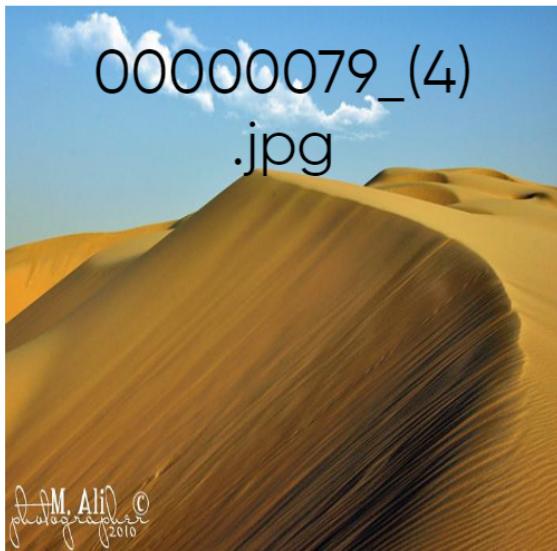
Weights for matching are 0.5 for HSV histogram and 0.5 for variance.

Top 3 matches for Target Image 00000052\_(2).jpg :

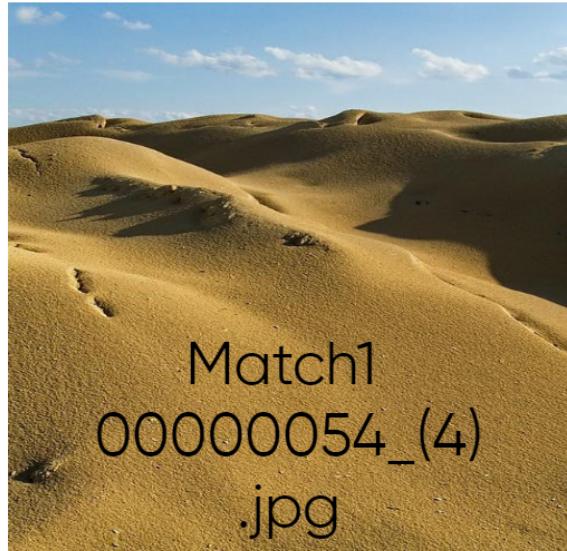


## Dessert Photos

Top 3 matches for Target Image 00000079\_(4).jpg :



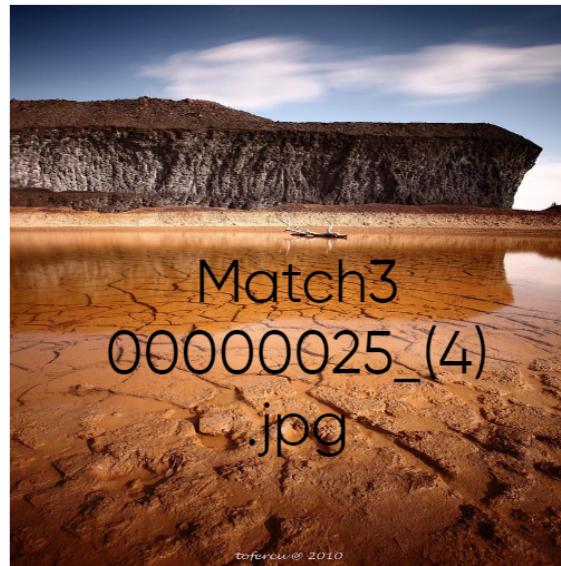
00000079\_(4)  
.jpg



Match1  
00000054\_(4)  
.jpg



Match2  
00000023\_(4)  
.jpg



Match3  
00000025\_(4)  
.jpg

## Extension 2: LAW filter

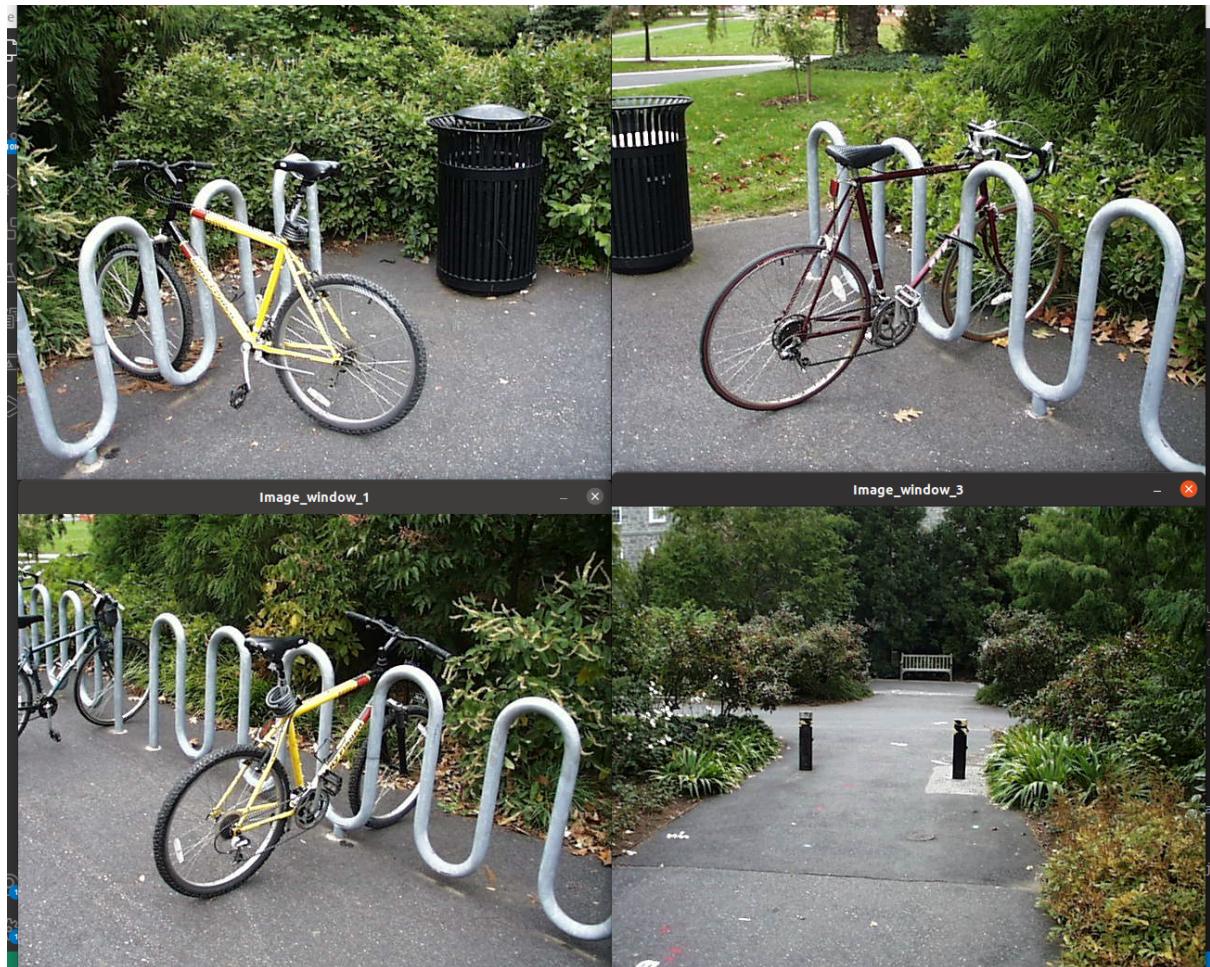
We ran RGB histogram for colour and added texture feature using histogram of filtered images obtained from 14 **LAW** filters. We are giving equal weights to the texture and colour histogram for feature matching.

Top 3 matches for Target Image pic.0711.jpg -->

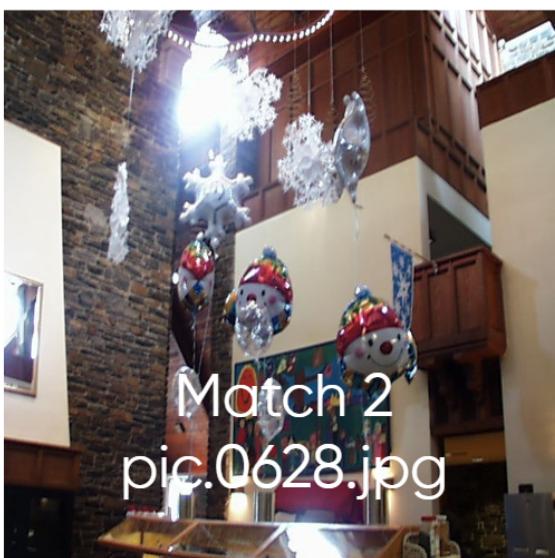
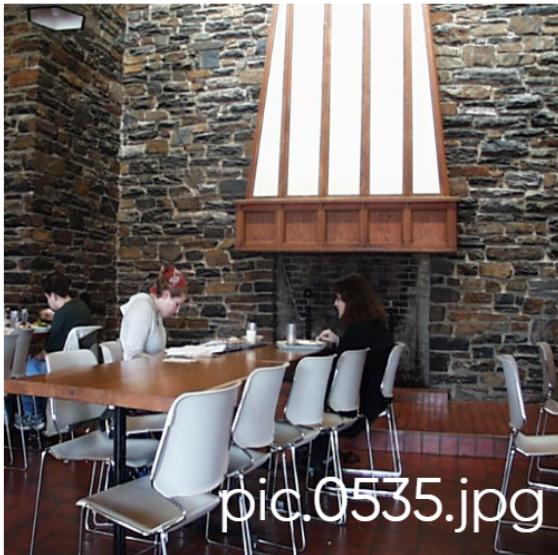
0.67529: pic.1084.jpg

0.685315: pic.1086.jpg

0.698209: pic.1094.jpg



Top 3 matches for Target Image pic.0535.jpg -->



## **Learning Outcomes:**

After studying content-based image retrieval techniques using Baseline Matching, Histogram Matching, Texture using 2D histogram of gradient orientation and magnitude, and Spatial Variance, we learnt the following things:

1. Understanding of the basics of CBIR and its applications.
2. Understanding of Histogram Matching and its implementation for image retrieval.
3. Knowledge of Texture analysis using 2D histograms of gradient orientation and magnitude, and its application in CBIR.
4. Understanding of Spatial Variance and its implementation for image retrieval.
5. Different distance calculations methods.
6. Ability to compare and evaluate the various CBIR techniques based on their strengths and limitations.
7. Ability to choose the appropriate CBIR technique for a given problem based on the nature of the images being retrieved.

## **Acknowledgements:**

<https://www.kaggle.com/datasets/ashwingupta3012/human-faces> - Face Dataset

<https://www.kaggle.com/datasets/arnaud58/landscape-pictures> - Sunrise and Desert Images

<https://learnopencv.com/histogram-of-oriented-gradients/> - for HOG Understanding