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Assignment 2 Report

Content-based Image Retrieval (CBIR) is a computer vision technique used to retrieve images based on their visual content. The main idea behind CBIR is to extract relevant features from an image, such as color, texture, shape, etc., and use these features to search for similar images in a database.

The process starts with image indexing, where the features of each image in the database are extracted and stored in a csv file. Then, when a query image is submitted, its features are extracted and compared to the features of the indexed images to determine the closest matches.

CBIR can be used in various applications, such as image database management, multimedia retrieval, and visual search engines. It has become an important research area in the field of computer vision due to its wide range of potential applications in different domains.

**Using Histograms of Oriented Gradients for Content Detection**

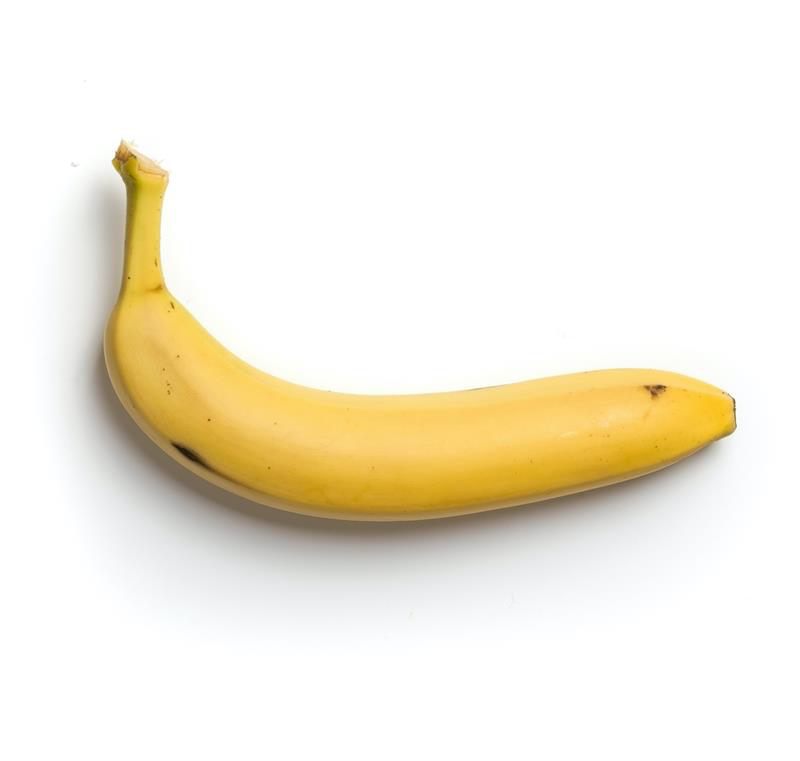
A study was carried out the highlight the issues of using feature sets for human detection, showing that locally normalized Histogram of Oriented Gradient (HOG) descriptors provided excellent performance relative to other existing feature sets including wavelets.

Pixels are computed on a dense grid of uniformly spaced cells, and they use overlapping local contrast normalizations for improved performance. The process typically involves using linear SVM as a baseline classifier.

The HOG process can be done in the steps below.







A banana on a table

Description automatically generated with medium confidence



When I posted the first picture above, Microsoft word was already able to detect that this was a “banana on the table” and displayed that as an Alt text alternative. This is an example of image detection and content-based image retrieval being used in a real-world scenario.

The Histograms of Oriented Gradients technique counts occurrences of gradient orientation in localized portions of an image. The method is like that of edge orientation histograms, scale-invariant feature transform descriptors, and shape contexts, but differs in that it is computed on a dense grid of uniformly spaced cells and uses overlapping local contrast normalization for improved accuracy.

The parameters for the HOG Descriptors include winSize, blocksize, blockStride, cellSize, nbins, derivAper, winSigma, histogramNormType, L2HysThresh, gammal correction, nlevels=64, Use signed gradients.

We also incorporated the use of a colour picker to store specific pixels as a feature vector and use that while performing the match function on corresponding queries which uses specified distance metrics to produce desired results.

Some results obtained from query calls are shown below.

**Results**

**Required results 1:**

**Baseline Matching**

TARGET:

D:/media/photos/db/olympus/pic.1016.jpg

A picture containing outdoor, tree, red, flower

Description automatically generated

RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0029 | 2       pic.0646 | 3       pic.0021 | 4       pic.0331 | 5       pic.0658 |
| A picture containing ground, floor, indoor  Description automatically generated | A picture containing text, wall, indoor, rack  Description automatically generated | A picture containing wall, indoor, wood  Description automatically generated | A red flower on a bush  Description automatically generated with medium confidence |  |

**Required results 2:**

**Histogram Matching**

**Whole Image RGB histogram using 8 bins for each of RGB and histogram intersection as the distance metric**

TARGET: D:/media/photos/db/olympus/pic.0164.jpg

A building with a flag on top

Description automatically generated with medium confidence  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0110 | 2       pic.1032 | 3       pic.0092 | 4       pic.0976 | 5       pic.0426 |
|  |  |  |  |  |

**1.0 Full Image with HIST\_INTERSECT**

TARGET: D:/media/photos/db/olympus/pic.0535.jpg

  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0285 | 2       pic.0628 | 3       pic.0952 | 4       pic.0337 | 5       pic.0731 |
|  |  | A picture containing text, tree, outdoor, park  Description automatically generated | A picture containing indoor, floor, lamp  Description automatically generated | A picture containing ground, outdoor, transport, construction  Description automatically generated |

**Required results 3:**

**Using 8 bins RGB histogram and histogram intersection in Multi-Histogram Matching with different combinations of histograms**

**0.25 Full Image + 0.75 Center**

TARGET: D:/media/photos/db/olympus/pic.0274.jpg

  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0881 | 2       pic.0273 | 3       pic.0209 | 4       pic.0275 | 5       pic.0335 |
| A blue sign in front of green plants  Description automatically generated with low confidence |  |  | A picture containing tree, outdoor, sky, building  Description automatically generated |  |

**0.5 Full Image + 0.5 Center**

TARGET: D:/media/photos/db/olympus/pic.0274.jpg

A building with a light post in front of it

Description automatically generated with low confidence  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0273 | 2       pic.0881 | 3       pic.0209 | 4       pic.0213 | 5       pic.0409 |
|  | A blue sign in front of green plants  Description automatically generated with low confidence | A picture containing tree, sky, outdoor  Description automatically generated | A large building with trees in front of it  Description automatically generated with medium confidence |  |

**0.75 Full Image + 0.25 Center**

TARGET: D:/media/photos/db/olympus/pic.0274.jpg  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0273 | 2       pic.0881 | 3       pic.0209 | 4       pic.0213 | 5       pic.0409 |
|  | A blue sign in front of green plants  Description automatically generated with low confidence |  |  | A large building with trees in front of it  Description automatically generated with medium confidence |

**0.5 Full Image + 0.5 Center with HIST\_INTERSECT**

TARGET: D:/media/photos/db/olympus/pic.0535.jpg  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. pic.0285 | 2       pic.0628 | 3       pic.0089 | 4       pic.0355 | 5       pic.0952 |
| A picture containing indoor, building, floor, subway  Description automatically generated | A picture containing indoor, living  Description automatically generated | A person drinking from a glass  Description automatically generated with medium confidence | People sitting on couches in a living room  Description automatically generated with medium confidence | A picture containing text, tree, outdoor, park  Description automatically generated |

**Required results 4:**

**Texture and Colour Histogram Matching with various distance metrics**

**2D Texture with HIST\_INTERSECT**

TARGET: D:/media/photos/db/olympus/pic.0535.jpg

  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0568 | 2       pic.0454 | 3       pic.0576 | 4       pic.0262 | 5       pic.0581 |
|  |  |  |  |  |

**2D Texture with SSE**

TARGET: D:/media/photos/db/olympus/pic.0535.jpg  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0454 | 2       pic.0568 | 3       pic.0212 | 4       pic.0448 | 5       pic.0239 |
|  |  | A picture containing building, outdoor, stone, cement  Description automatically generated | A picture containing grass, outdoor, tree, plant  Description automatically generated |  |

**0.5 HOG + 0.5 Full Image RGB with HIST\_INTERSECT**

TARGET: D:/media/photos/db/olympus/pic.0535.jpg

People sitting at a table

Description automatically generated with medium confidence

RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0558 | 2       pic.0618 | 3       pic.0612 | 4       pic.0480 | 5       pic.0620 |
|  | Text  Description automatically generated | A picture containing sky, outdoor, building, city  Description automatically generated | The back of a car  Description automatically generated with medium confidence | A picture containing text, indoor, stack, stacked  Description automatically generated |

**Results for custom subject augmentation:**

TARGET:

D:/media/photos/db/olympus/pic.0937.jpg

A stuffed animal in a garden

Description automatically generated with medium confidence  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0785 | 2       pic.0691 | 3       pic.0494 | 4       pic.0872 | 5       pic.1007 |
| A pink rose on a bush  Description automatically generated with medium confidence | A picture containing ground  Description automatically generated | A group of flowers  Description automatically generated with low confidence | The back of a red truck  Description automatically generated with medium confidence | A white bunny in a garden  Description automatically generated with low confidence |

**Custom Design:**

**Custom Subject Extractor using various weights of lobster**

**1.0 Lobster**

TARGET: D:/media/photos/db/olympus/pic.1009.jpg



RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0669 | 2       pic.0778 | 3       pic.0226 | 4       pic.0307 | 5       pic.0395 |
|  |  |  |  | A picture containing person, indoor, cabinet, wall  Description automatically generated |

**0.75 Lobster + 0.25 2D Texture**

TARGET: D:/media/photos/db/olympus/pic.1009.jpg  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0872 | 2       pic.1012 | 3       pic.0887 | 4       pic.1014 | 5       pic.1072 |
| A picture containing outdoor, fence  Description automatically generated | A red flower in a bush  Description automatically generated with medium confidence | A traffic cone on a road  Description automatically generated with low confidence | A picture containing grass, outdoor, outdoor object, manhole cover  Description automatically generated | A group of flowers  Description automatically generated with low confidence |

**0.5 Lobster + 0.5 2D Texture**

TARGET: D:/media/photos/db/olympus/pic.1009.jpg

A red heart on a blue surface

Description automatically generated with low confidence  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0872 | 2       pic.0887 | 3       pic.1012 | 4       pic.1014 | 5       pic.0785 |
| A picture containing outdoor, fence  Description automatically generated | A traffic cone on a road  Description automatically generated with low confidence | A red flower in a bush  Description automatically generated with medium confidence | A picture containing grass, outdoor, outdoor object, manhole cover  Description automatically generated | A picture containing ground, outdoor, lighter  Description automatically generated |

**0.25 Lobster + 0.75 2D Texture**

TARGET: D:/media/photos/db/olympus/pic.1009.jpg  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0872 | 2       pic.0785 | 3       pic.0691 | 4       pic.0494 | 5       pic.1007 |
| A picture containing outdoor, fence  Description automatically generated | A picture containing ground, outdoor, lighter  Description automatically generated | A picture containing tree, outdoor, plant, sign  Description automatically generated | Text  Description automatically generated | A picture containing outdoor, grass, outdoor object  Description automatically generated |

**1.0 2D Texture**

TARGET: D:/media/photos/db/olympus/pic.1009.jpg  
RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1       pic.0785 | 2       pic.0691 | 3       pic.0494 | 4       pic.0872 | 5       pic.1007 |
| A picture containing ground, outdoor, lighter  Description automatically generated | A picture containing tree, outdoor, plant, sign  Description automatically generated | Text  Description automatically generated | A picture containing outdoor, fence  Description automatically generated | A picture containing outdoor, grass, outdoor object  Description automatically generated |

From our output list, we see that 0.5 Lobster + 0.5 2D Texture and 0.75 Lobster + 0.25 2D Texture

have the more accurate results out of the five, taking both shape, texture and colour into consideration to grate a feature vector. This could be because finding specific objects usually involves a combination of other individual methods.

**Conclusion**

Using histograms for Content-Based Image Retrieval (CBIR) has been an active area of research in the field of computer vision. Histograms could be used to represent the visual content of an image by summarizing the distribution of colors or textures in the image. This allows for image comparison based on their visual content and retrieval of images that are similar to a given query image.

This project was intended to deepen understanding by offering a practical approach to the fundamentals of content-based image retrieval. It gave us the opportunity to explore the use of baseline matching, single and multi-histogram matching, texture, and color matching as well as the freedom to explore other methods of image filtering and retrieval from large databases.

For this project, we experimented with different combinations of features vectors that could potentially represent the images in the database, including color histograms, texture histograms, shape histograms, but researched about more complex features like SIFT or SURF descriptors.

Given room for exploration, we attempted the extension by adding two extra features; the HOG method of object detection as well as a custom subject extractor which focused on finding the “red lobster plushie and incorporated muti histogram matching as well as texture and shadow detection to obtain results.

In conclusion, we saw that different feature combinations could produce significantly different results in terms of retrieval accuracy and efficiency. As a result, the use of a combination of histograms in CBIR systems is now a well-established technique and continues to be the subject of ongoing research and development efforts by researchers.

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