Faculty of Engineering
Credit Hours System
CCEC Department

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Image Processing Project

Emotion Detection

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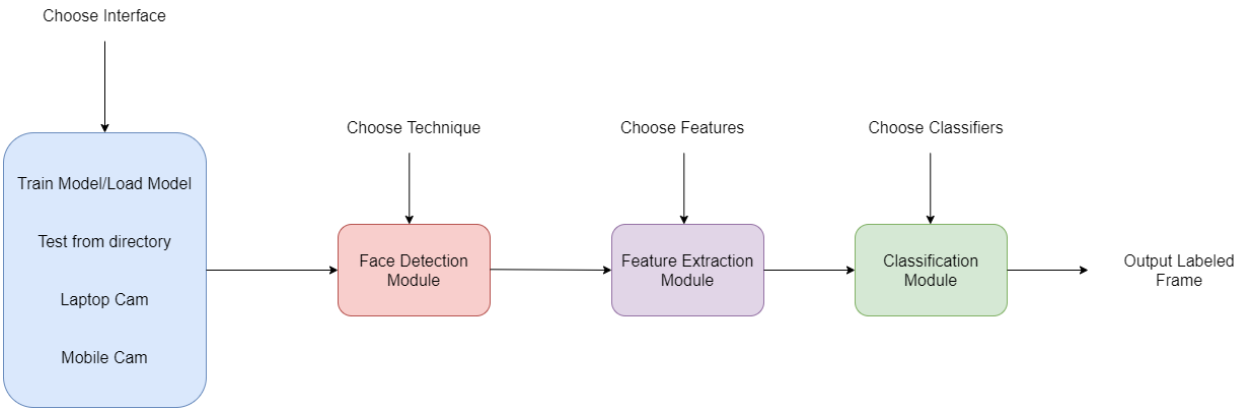
Introduction:

Focusing on emotional health is one important point to improve quality of life as ignoring it may lead to social or mental health problems. To improve them, we need to recognize their current emotional states.

In this project we implemented an emotion detection system focusing on feature extraction and the classification of emotion detection by facial expressions, applying the concepts and ideas learnt through Image Processing & Computer Vision (CMPN 446).

Block Diagram:



Used Algorithms

Face Detection Module:

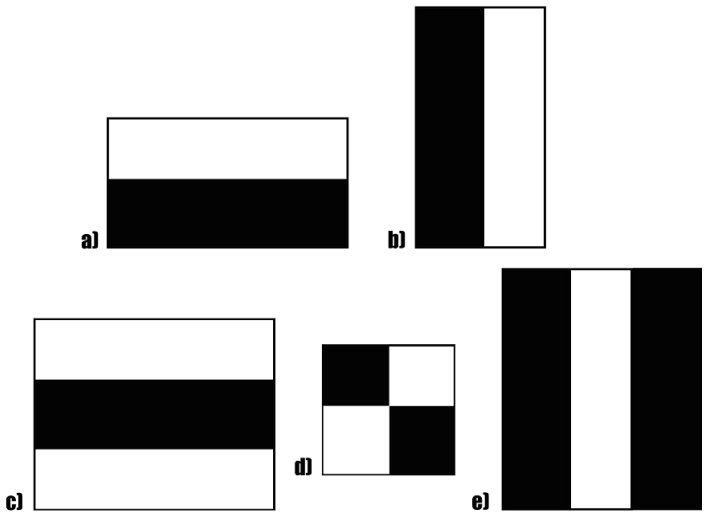
In this module we tried two main approaches to detect the face:

1) HOG
2) Viola & Jones

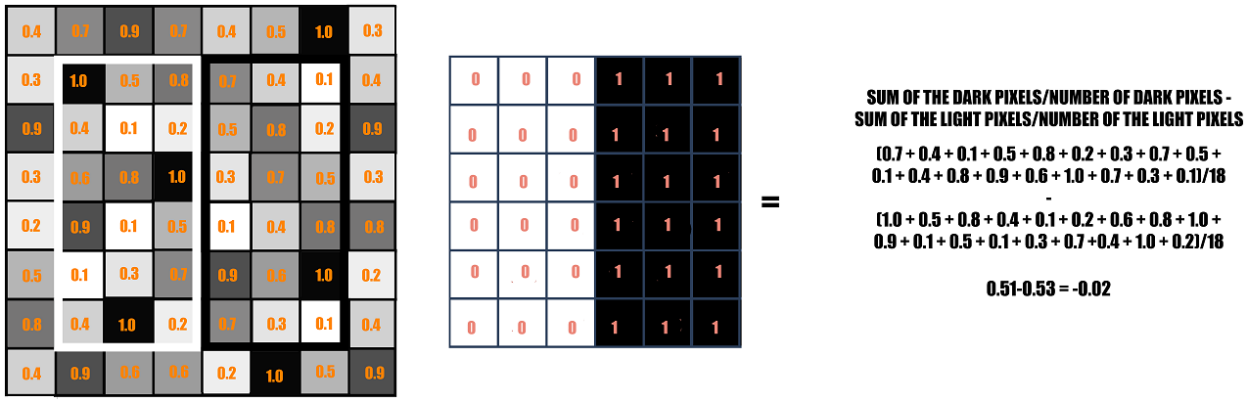
Viola & Jones

Face Detection, a widely popular subject with a huge range of applications. Modern day Smartphones and Laptops come with in- built face detection software, which can authenticate the identity of the user. There are numerous apps that can capture, detect, and process a face in real time, can identify the age and the gender of the user, and can apply some cool filters. The list is not limited to these mobile apps, as Face Detection also has a wide range of applications in Surveillance, Security and Biometrics as well. But the origin of its Success stories dates to 2001, when Viola and Jones proposed the first ever Object

Detection Framework for Real Time Face Detection in Video Footage. Viola and jones which is known as Haar cascades is an Object Detection Algorithm used to identify faces in an image or a real time video. The algorithm uses edge or line detection features proposed by Viola and Jones in their research paper



The first contribution to the research was the introduction of the haar features shown above. These features on the image makes it easy to find out the edges or the lines in the image, or to pick areas where there is a sudden change in the intensities of the pixels.



A sample calculation of Haar value from a rectangular image section has been shown here. The darker areas in the Haar feature are pixels with values 1, and the lighter areas are pixels with values 0. Each of these is responsible for finding out one feature in the image. Such as an edge, a line, or any structure in the image where there is a sudden change of intensities. For ex. in the image above, the Haar feature can detect a vertical edge with darker pixels at its right and lighter pixels at its left.

The objective here is to find out the sum of all the image pixels lying in the darker area of the Haar feature and the sum of all the image pixels lying in the lighter area of the Haar feature. And then find out their difference. Now if the image has an edge separating dark pixels on the right and light pixels on the left, then the Haar value will be closer to 1. That means, we say that there is an edge detected if the Haar value is closer to 1. In the example above, there is no edge as the Haar value is far from 1.

This is just one representation of a particular Haar feature separating a vertical edge. Now there are other Haar features as well, which will detect edges in other

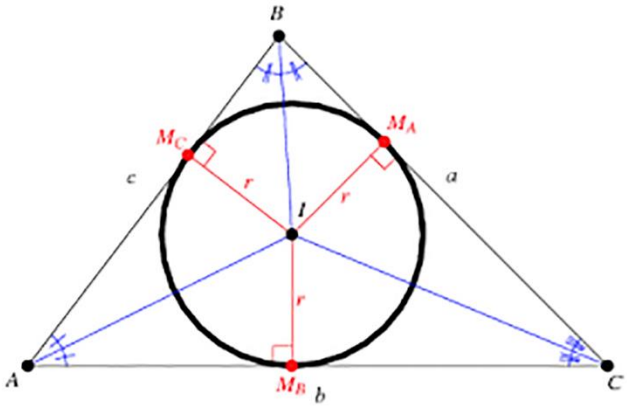
directions and any other image structures. To detect an edge anywhere in the image, the Haar feature needs to traverse the whole image.

Feature Extraction Module:

In this module we tried a variety of features to compare between them and their combinations.

1) **Triangular Features**

   The area of the triangle (AoT), Inscribed circle circumference (ICC), and the Inscribed circle area of a triangle (ICAT) are extracted from 5 different triangles between facial key points and are considered as features to classify the facial emotions.



2) **Face LBP**

   Computing a Local Binary Pattern histogram for the whole face.

3) **Eye & Mouth LBP**

   Applying the previous method but on eyes and mouth only.

4) **Wrinkles**

5) **Eyebrow Curvature**

6) **Gabor Filters**

   Applying Gabor for 4 different orientations and 5 different scales on the input face

Classification Module:

In this module we tried a variety of classifiers and compared between them to reach the optimum accuracy.

1) KNN
2) SVM
3) Random Forests
4) Neural Networks
5) LDA

Work division

	Viola & Jones	HOG	Triangular Features	LBP	Eyebrow Curvature	Wrinkles	Gabor	Pipeline
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Aya								
Bassem								
Ziad								

Accuracy & Performance

Classes:

1) Surprise
2) Happiness
3) Sadness
4) Disgust
5) Anger
6) Fear
7) Neutral

Class	Features	Classifier	Accuracy
1 2 3 4 5	Gabor Resize: (80,60) 4 orientations 5 scales	SVM	**92.5%**
1 2 3 4 5	Gabor Resize: (80,60) 4 orientations 5 scales	RF	**89.0%**
1 2 3 4 6	Gabor Resize: (80,60) 4 orientations 5 scales	SVM	**90.9%**
1 2 3 4 6	Gabor Resize: (80,60) 4 orientations 5 scales	RF	**91.5%**
1 2 3 4 5 6	Gabor Resize: (80,60) 4 orientations 5 scales	SVM	**84%**

1 2 3 4 5 6	Gabor Resize: (80,60) 4 orientations 5 scales	RF	**79.2%**
1 2 3 4 5 6 7	Gabor Resize: (80,60) 4 orientations 5 scales	SVM	**80.0%**
1 2 3 4 5 6 7	Gabor Resize: (80,60) 4 orientations 5 scales	RF	**76.8%**
1 2 3	ICC	KNN	**93.75%**
1 2 3	ICC	SVM	**93.75%**
1 2 3	ICC	RF	**97.30%**
1 2 3	ICC	NN	**93.75%**

Experimental Analysis & Performance

In this project we faced some tradeoffs. One tradeoff is between accuracy and size/time of the model. For example, using ICC will result for a fast and small model, but a bad accuracy. In contrast, using Gabor filters to train the model leads to great accuracy, but the model is huge compared to other models as it may reach 500 MB at some points. In addition, models trained on Gabor filters takes more time to fit/predict.

One more obstacle we faced, is that some emotions have similar features so the model cannot distinguish between them easily. To get more insights about what emotions have the same features we calculated the following confusion matrices.

	Surprise	Happiness	Sadness	Disgust	Anger	Fear	Neutral
Surprise	32	0	2	0	0	11	1
Happiness	0	41	0	2	0	0	0
Sadness	0	2	25	0	2	1	4
Disgust	0	2	0	30	0	0	0
Anger	1	0	3	1	37	1	2
Fear	6	0	1	1	1	16	2
Neutral	0	0	1	0	0	0	2

	Surprise	Happiness	Sadness	Disgust	Anger	Fear
Surprise	34	0	2	0	0	7
Happiness	0	35	0	2	0	0
Sadness	0	1	24	0	1	1
Disgust	0	2	0	35	0	0
Anger	1	0	7	0	32	1
Fear	6	0	3	0	1	22

	Surprise	Happiness	Sadness	Disgust	Anger
Surprise	45	0	2	0	0
Happiness	1	35	0	0	0
Sadness	1	0	30	0	1
Disgust	0	1	0	27	0
Anger	1	0	6	1	37

Future Work

Unfortunately, due to the limited time scope, we did not have enough time to apply all the trials and concepts we planned to. One thing that we may do later, is using the confusion matrices to merge two different classes and use cascaded classifiers to overcome the obstacle of confusing between them. One more thing, is trying to train a CNN to predict the emotion. One final thing, is trying this pipeline on different dataset to analyze more the weaknesses of the architecture.

References

Gabor:

https://github.com/duycao2506/Gabor-Filter-Face-Extraction/blob/master/FaceRecognizer.py

HOG:

https://learnopencv.com/histogram-of-oriented-gradients/

https://www.analyticsvidhya.com/blog/2021/12/implementing-computer-vision-face-detection/

https://www.youtube.com/watch?v=4ESLTAd3IOM

https://www.youtube.com/watch?v=0Zib1YEE4LU&t=78s

Viola & Jones:

https://code.google.com/archive/p/jviolajones/issues

Triangular Features:

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0247131#pone.0247131.ref049