"FACIAL RECOGNITION AND DETECTION USING AI IN AUTOMATIVE INDUSTRY"

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***i*MSc(IT)**

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FACIAL RECOGNITION AND DETECTION USING AI IN AUTOMOTIVE INDUSTRY

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FACIAL RECOGNITION

WHAT IS FACIAL RECOGNITION AND DETECTION

Facial recognition is a way of identifying or confirming an individual's identity using their face. Facial recognition systems can be used to identify people in photos, videos, or in real-time.

Face detection is a computer technology being used in a variety of applications that identifies human faces in digital images. Face detection also refers to the psychological process by which humans locate and attend to faces in a visual scene. [1]

HOW DOES IT WORK?

Facial Recognition work by identifying and measuring facial features in an image.Facial recognition can identify human faces in images or videos, System is a high-quality camera with which different facial expressions like eye, mouth, and head movements are captured.

Face detection also called facial detection is an artificial intelligence (AI) based computer technology used to find and identify human faces in digital images. Face detection technology can be applied to various fields including security, biometrics, law enforcement, entertainment and personal safety to provide surveillance and tracking of people in real time. [2]

Uses in automotive industry

The detected face is then processed in the system which will recognize. The recognized face is then used as input to the Arduino, which connected to the automotive relay to active the engine's starter vehicle. Viola-Jones method is applied as a method to detect and crop face area of the face image. [3]

Techniques in Automotive Industry

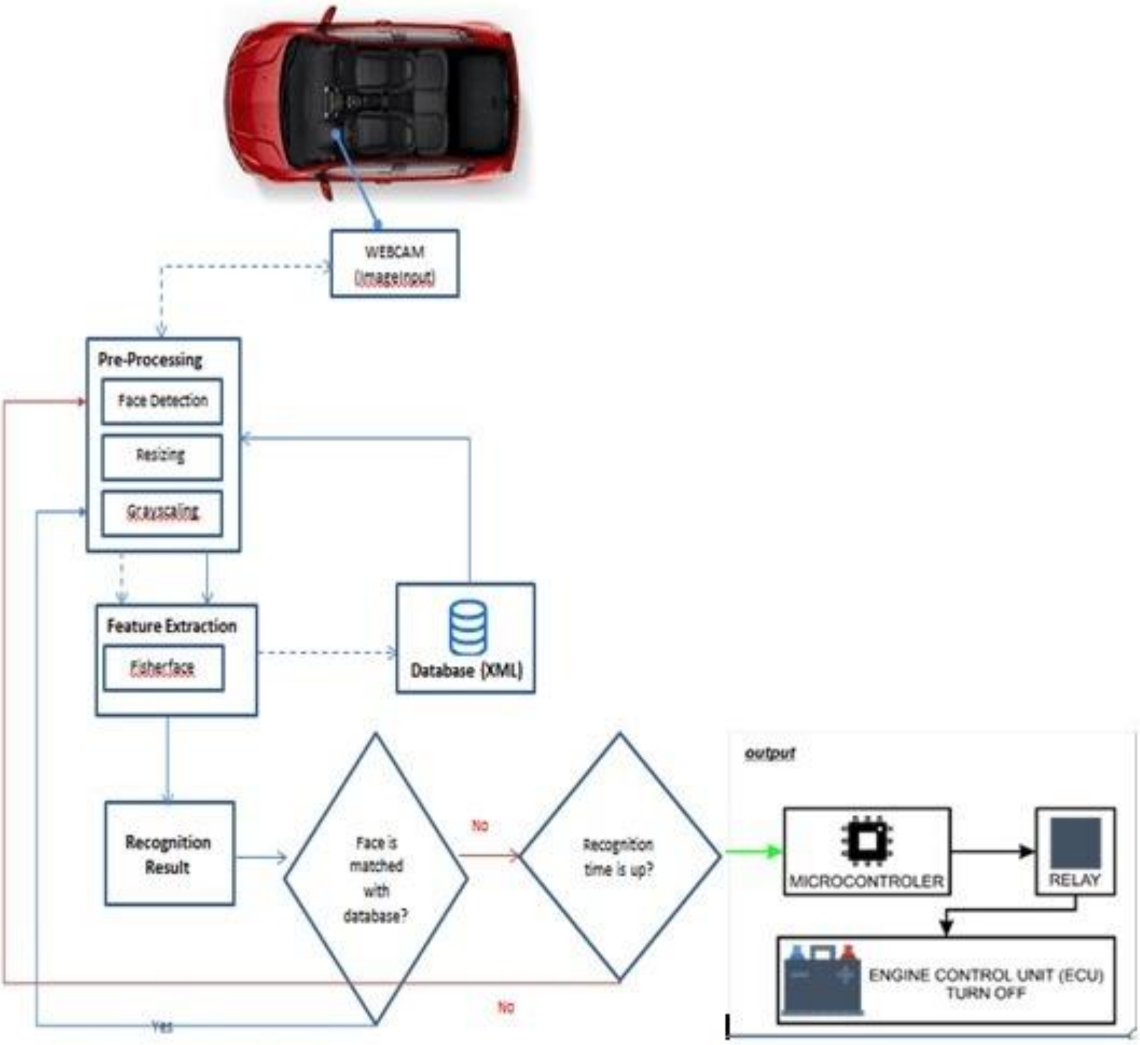
1. Fisher face Method

The results show that the fisher face method performs well with an accuracy of 83.04%. The results indicate that the facial recognition application using the fisher face method is one of the most effective solutions in improving car security systems. Facial recognition with biometric technology is the solution to create a better security system of a car. [4]

- METHODOLOGY:

  In the face detection module, color segmentation is performed to obtain a part of the input image that has skin color.

  In the last module, the identity recognition process was carried out by comparing the required fisher face weights to reconstruct the input images to the images in the training set.



General architecture

❖ Image input

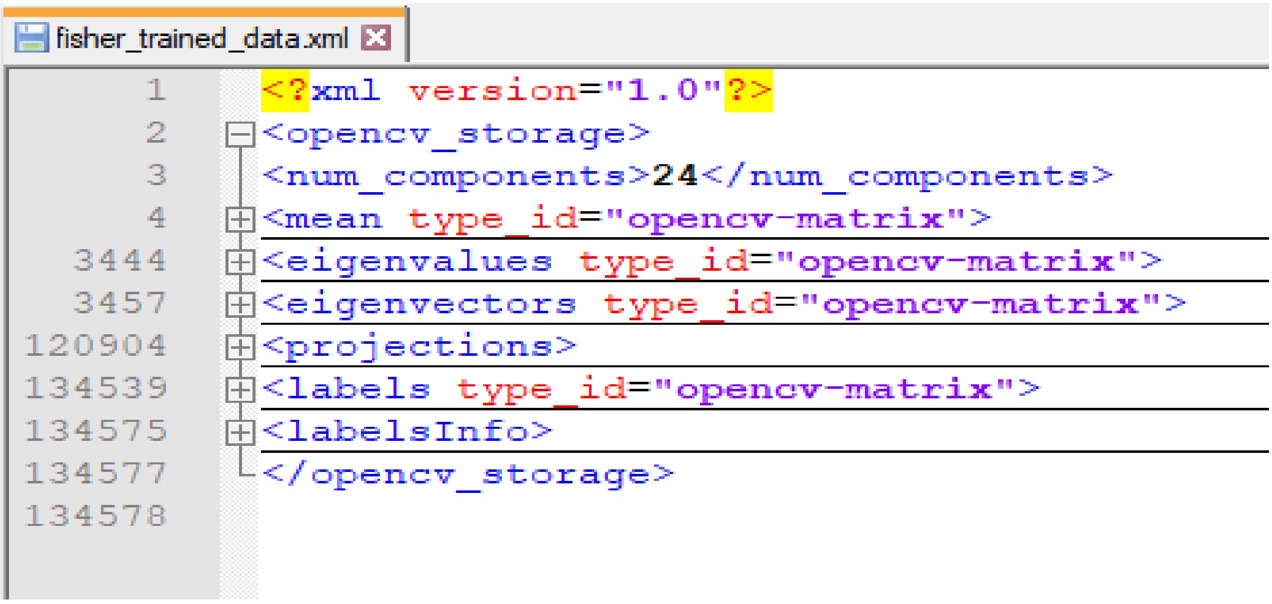
Image inputs were taken for training data and test data
Image inputs were taken for training data and test data using web cam camera in real-time. The Parameter for data acquisition is the time in seconds.

❖ Pre-processing

a. *Face detection* b. *Resizeing* c. *Grayscalling*

After acquiring the input, the next step is preprocessing. Firstly, the system will detect faces on the input images using the haar-cascade detection method that is available in the Open-CV library with an XML file format. Feature extraction.

In the process of retrieving training data, the feature extraction stage will take the extraction value of the facial image and save it to the database in an XML file with the file name of fisher_trained_data.xml.



❖ Dataset

The data of this study are facial images obtained using a webcam camera. Facial image data divided into training data and test data.

No.	Dataset	Number of Identifiers	Amount of Image	Amount of Data
1	Training Data 1	10	20	200
2	Training Data 2	15	40	600
3	Testing Data	26	10	260
	Total Data			1060

❖ Evaluation method

An evaluation method is required to see how well the fisher face method in conducting facial recognition. In this study, the proposed evaluation method is the confusion matrix method.

❖ Result

The system testing is divided into two parts, which are face detection testing and facial recognition testing. Facial recognition testing was conducted three times.

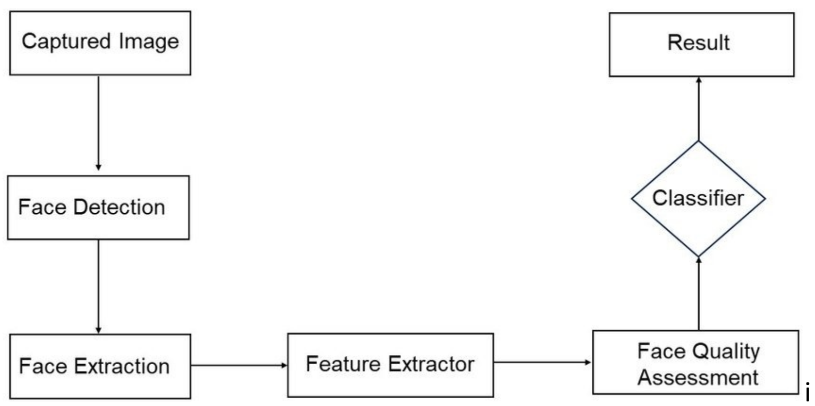
2. Convolutional Neural Networks (CNN)

To deal with the issue of human face recognition on small original dataset, a new approach combining convolutional neural network (CNN) with augmented dataset is developed.

A CNN can have multiple layers, each of which learns to detect the different features of an input image. A filter or kernel is applied to each image to produce an output that gets progressively better and more detailed after each layer.

In the lower layers, the filters can start as simple features. How does CNN work for image recognition? A CNN can have multiple layers, each of which learns to detect the different features of an input image. A filter or kernel is applied to each image to produce an output that gets progressively better and more detailed after each layer. In the lower layers, the filters can start as simple features. [5]

❖ Related Work



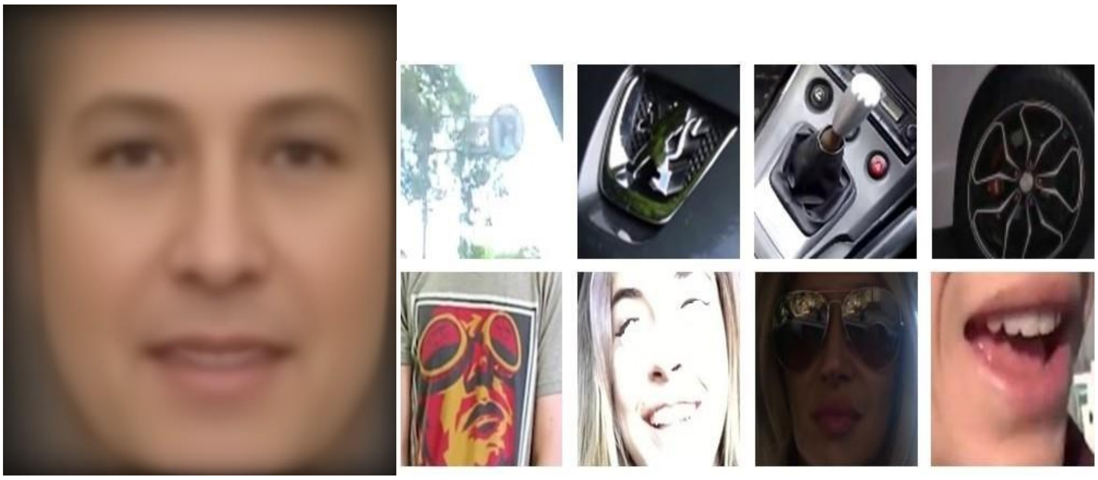
❖ Face detection and extraction:

For detecting the face region, we use the Dlib frontal face detector. This detector uses a Histogram of Oriented Gradients (HOG) feature, combined with a linear classifier, an image pyramid, and a sliding window detection scheme. [6]

❖ Feature extraction

We use pre-trained convolutional neural networks as feature extractors. The pre-trained VGG-Face CNN descriptors described in were used with fine-tuning paradigm.

❖ Face quality assessment



❖ Face tracking

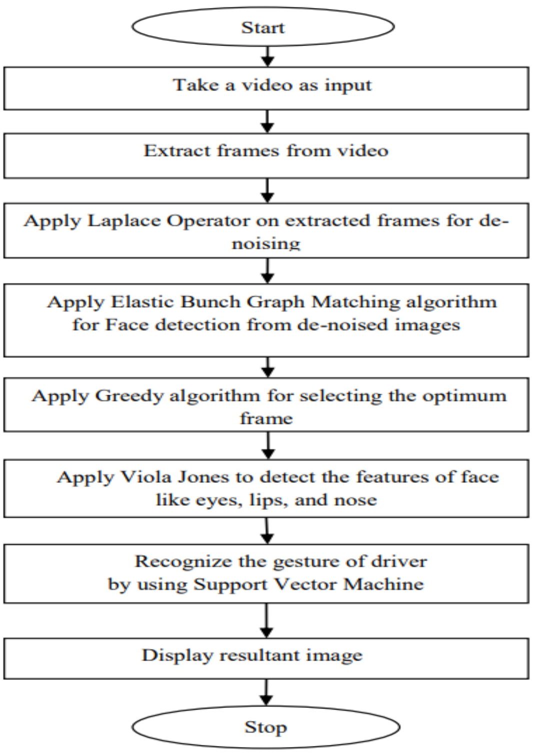
Once we get a positive feature classification result, we track the face during the upcoming frames so as to reduce the computation workload. The facial region's bounding box serves as input for our correlation tracker.

3. Vehicle's Driver Face Recognition using Viola Jones and Support Vector Machine (SVM)

Facial expressions are crucial features of non-verbal communication. The main objective of those techniques is to detect face from the complex backgrounds. Consequently, a new technique is collaborate five different techniques such as a place operator, elastic bunch graph matching, greedy algorithm, viola jones, and support vector machine to detect the expressions of the person from video streaming. [7]

❖ METHODOLOGY

At the first stage the video is loaded and divided into frames. The de-noising is through Laplace operator and Face detection by using Elastic Bunch Graph Matching algorithm. The Greedy algorithm, Viola Jones, and Support Vector Machine are used for quality optimization, face localization and classification of facial expressions respectively.



Flow chart

- Face quality assessment

Fast Fourier Transform is applied as a feature extraction technique to extract the segmented face image. The extracted image is then used as input to the Artificial Neural Network (ANN) in order to recognize the face of the authorize person. Experimental results show the training and testing accuracy of 100 % and 100 %, respectively.

- Literature review

  - Face detection:- In this stage, the image is taken from the camera sensor, the face image is the detected based on Viola-Jones method [15]. Viola-Jones detector was chosen as a detected image because of its high detection rate, and its ability to run in real time.

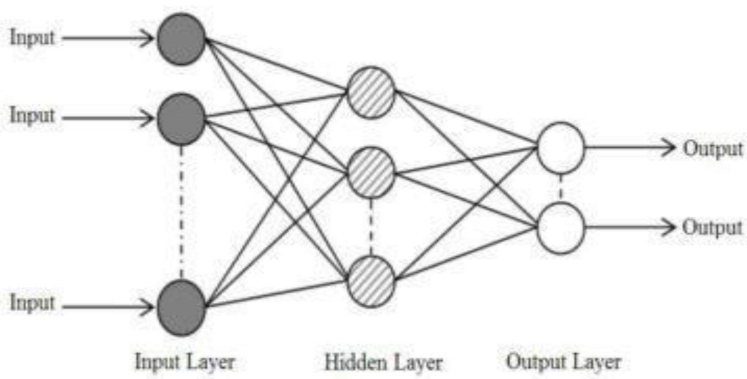
  - Segmentation image:- Segmentation process using Canny Edge method. Generally acknowledged as the best ‘all-round’ edge detection method developed to date.

- Feature extraction of the image

Feature extraction process using Fast Fourier Transform (FFT). FFT helps to decompose an input 2D image into real and imaginary components which is a representation of the image in the frequency domain.

- Face recognition image

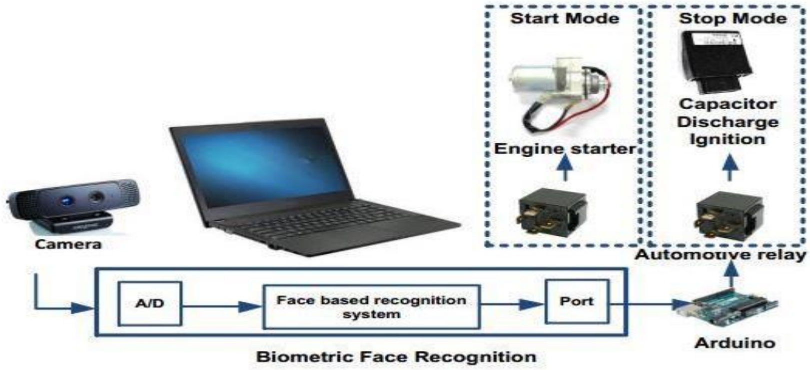
In this section, the method applied for recognized the face data using Artificial Neural Network (ANN). ANN can be trained to perform a particular function by updating the value of connections (weight) between elements. Commonly ANN are trained, so that particular input leads to a specific target output



❖ Experimental work

This section presents the performance of the proposed to Automotive start-stop engine based on face recognition system. This section consists of three important sub-sections, they are experimental setup, experimental result and experimental analysis.

❖ Experimental setup

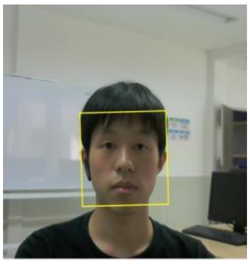


Proposed system for starter engine.

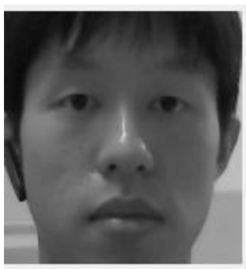
❖ Experimental setup

The system basically consists of three main components, namely external camera, Arduino, and two automotive relays. One relay is to turn on a starter motor and the other is to turn off a capacitor discharge ignition (CDI) pulse to an ignition coil. A camera used for tracking and capturing a face image person.

❖ Experimental results



Face Detection



Grayscale image

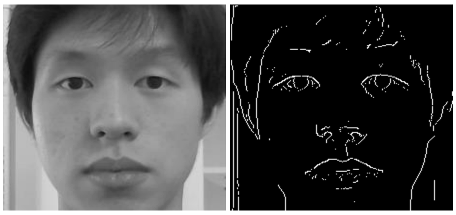


Image before and after segmentation step of the

- Experiment analysis

  Overall evaluation of the proposed face recognition system has been presented in this chapter. The face recognition system which composes of face detection, segmentation, feature extraction, and face recognition. The result of face recognition system that if the person is recognized, the engine will start.

4. Implementation of viola jones' algorithm

There are many approaches to implement facial detection, and they can be separated into the following categories:

- Knowledge Based :
  - Rule based (Ex: X must have eyes, x must have a nose)
  - Too many rules and variables with this method.

- Feature Based
  - Locate and extract structural features in the face
  - Find a differential between facial and non facial regions in an image

- Appearance Based
  - Learn the characteristics of a face
  - Example: CNN's
  - Accuracy depends on training data (which can be scarce)

- Template
    - Using predefined templates for edge detection
    - Quick and easy
    - A trade-off for speed over accuracy

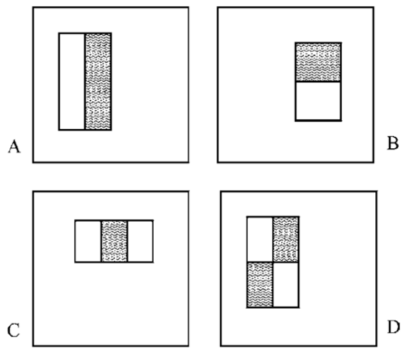
- The approach we are going to be looking at is a mix between feature based and template based. One of the easiest and fastest ways of implementing facial detection is by using Viola Jones Algorithm. [8]

HAAR-LIKE FEATURE:

Haar-like features are digital image features used in object recognition. Haar Wavelets — Haar Wavelets were proposed by mathematician Alfred Haar in 1909 and are used in applications such as signal and image compression in electrical and computer engineering.

Haar Features are essentially collections of pixels in rectangular shapes. these features are created programmatically. The rationale of haar features is that if you apply a feature to an area in the image, and subtract the un-shaded region of pixels values from shaded region of pixel values it will give you certain delta values.

HAAR-FEATURE TYPES



- There are 2 other common features like HAAR-FEATURES

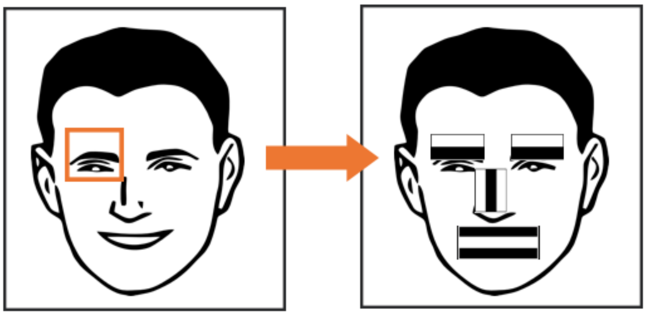
  - EDGE FEATURE:

    you have want to detect part of a face, in this case an eyebrow, naturally the shade of the pixels of on an eyebrow in an image will be darker and suddenly gets lighter (skin). Edge features are great for finding this.

  - LINE FEATURE:

you want to detect a mouth: naturally the shape of the lips region on your face go from light to dark to light again. For this, Line features prove to be the best.

The interesting thing about these features is that they can be used inversely. Meaning that they apply with a dark-light-dark and light-dark-light format.



- ❖ Problems with Only Using Haar Features

In real life scenarios images aren’t just collections of black and white pixels. Most likely the images you’ll be working with will be coloured (RGB) or grayscale. Meaning you wont be working with binary pixel intensities.

Summing up pixel values for all feature types in all images in your dataset can be very computationally expensive, especially depending on the resolution of your images.

There are over 160,000 possible feature combinations that can fit into a 24x24 pixel image, and over 250,000 for a 28x28 image.
This is where Viola Jones Algorithm comes in.

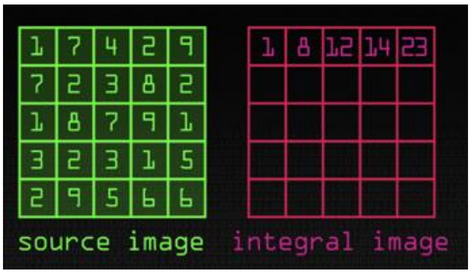
❖ Integral Image Explained

Viola and Jones introduced the concept of the Integral Image.

❑ The What?

- A precomputed version of the source image
- Store it in an intermediate form

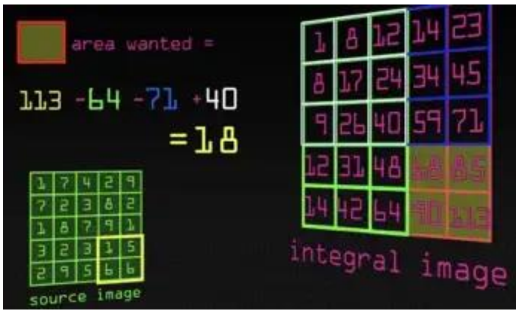
❑ The How?



Each point in the integral image is a sum of the pixels above and left of the corresponding pixel in the source image.

❑ The Why?

- Instead of doing additions for every pixel values for all features — use an integral image to make use of a few subtractions to get the same result.



https://youtu.be/uEJ71VlUmMQ

- Integral Imaging in Action

Source Image Pixel Values

1	2	4	6	7	9	10	11
21	2	2	4	3	2	1	1
1	2	1	3	4	5	9	10
1	2	7	8	9	2	27	1
2	3	7	8	9	1	1	1
1	3	2	2	2	7	22	21
21	7	3	9	10	11	17	18
1	1	1	4	9	8	7	2

Computed Integral Image

1	3	7	13	20	29	39	50
22	26	32	42	52	63	74	86
23	29	36	49	63	79	99	121
24	32	46	67	90	108	155	178
26	38	59	88	120	141	183	207
27	42	65	96	130	158	228	273
48	70	96	136	180	219	306	369
49	72	101	145	198	245	339	404

- **Here an example:**
  - For the first row of pixels:

    1= 1

    1+2 =3

    1+2+ 4 = 7

    and so on…

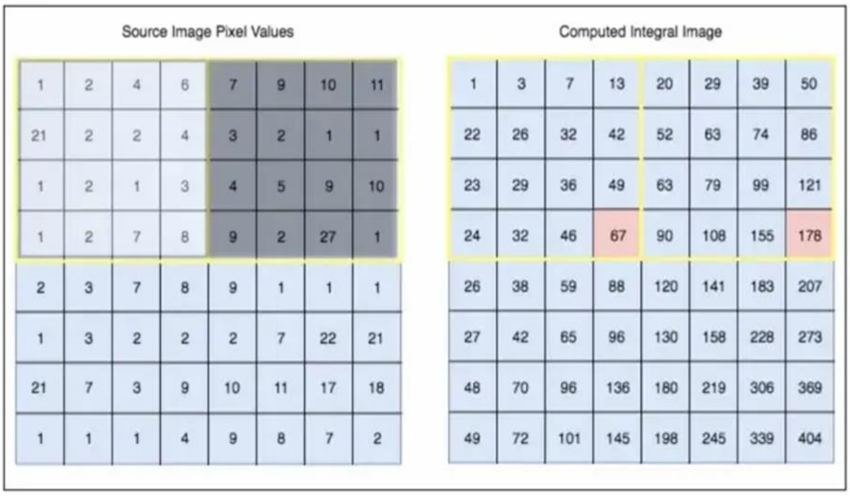
  - For the second row of pixels:

    21 + 1 = 22

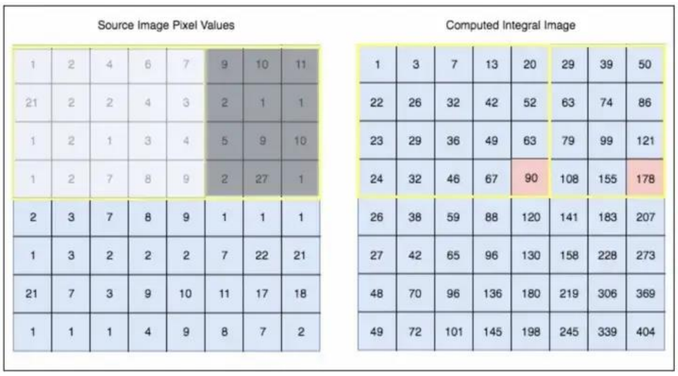
    22 + 2 + 2 = 26

    26 + 2 + 4 = 32

- Look at an example of getting a delta values using this edge feature seen above:



- You want to get the delta of both areas
- Instead of summing up, use the most bottom right corner values of each region in the integral image and subtract.
- 178 – 67 = 111 — this is the sum of pixels in the shaded area
- Delta = 111–67 = 44
- This will even work for all shapes and sizes of features, lets take a look at another example:



#Long way

1 + 2 + 4 + 6 + 7 + 21 + 2 + 2 + 4 + 3 + 1 + 2 + 1 +
3 + 4 + 1 + 2 + 7 + 8 + 9 = 90
9 + 10 + 11 + 2 + 1 + 1 + 5 + 9 + 10 + 2 + 27 + 1 = 88
Delta: 90 - 88 = 2

#Short Way

178 – 90 = 88
Delta = 90 – 88 = 2

In total we have reduced what would have been 31 addition operations down to just 2 subtraction operations, now that's fast! This may not seem like much for a computer, but take into account when you have a tens of thousands of images to compute, it is completely infeasible.

- Training:

An ensemble of Ada-Boost models are used for achieving the goal of Viola and Jones' algorithm. One classifier is created for each haar feature. Each one of these classifiers are considered as "weak" classifiers: Meaning that on their own they don't provide much predictive power, but when you combine a lot of them they become a strong classifier**.**

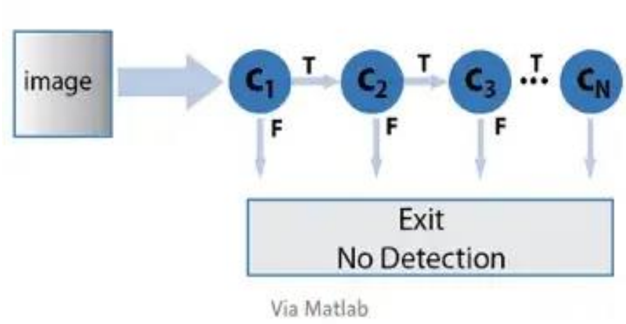
- How it works:

    - You have N number of features
    - Weights are randomly assigned to each feature classifier
    - One weak classifier is trained for each feature using Ada-Boost
    - Weights are adjusted and misclassifications are penalized higher than correctly classified ones
    - When training is complete: sort models based on the least error rate to the highest error rate (best models first)
    - Select the best weak classifiers based on a threshold value (drop the "useless" ones)

- Attentional Cascade

In a real life scenario, images aren't going to be 24x24 pixels. Also, it's not guaranteed images will only have one face present. You want a clever way to use the best classifiers in order to get the most accurate results. For this, you use a thing called an Attentional Cascade. Attentional Cascade are a series of the weak classifiers we trained, when used together to make a strong classifier. This decreases computation time on inference and allows for super fast detection.

We feed the source image to the cascade, and do inference on image regions using the best feature classifier first. If the image has that given feature, then move onto the next classifier. If it doesn't then it drops the image region and no further classification is done. These steps are repeated until we have run out of classifiers in the cascade. A region will only classify a region of an image as a face if all criteria is met, Meaning only if all features are found.



Advantages and Disadvantages:

❖ Advantages

- ➢ Detection is very fast.
- ➢ Simple to understand and implement.
- ➢ Less data needed for training than other ML models.
- ➢ No rescaling of images needed (like with CNN's).
- ➢ Much more interpretable than contemporary models.

❖ Disadvantages

- ➢ Training time is very slow.
- ➢ Restricted to binary classification.
- ➢ Mostly effective when face is in frontal view.
- ➢ May be sensitive to very high/low exposure (brightness).
- ➢ High true detection rate, but also high false detection rate.

CONCLUSION

Facial recognition and detection using AI have been rapidly advancing in recent years and have numerous applications in various industries, such as security, entertainment, healthcare, and retail.

Overall, facial recognition and detection using AI are powerful tools that have the potential to revolutionize various industries. However, it is essential to approach their development and implementation with caution, ensuring that they are used responsibly and ethically to minimize their potential negative impacts.

FUTURE SCOPE

Facial recognition and detection with Haar-like features have a lot of potential in the automotive industry. Here are some possible future applications:

Driver monitoring:
Facial recognition can be used to monitor drivers' attention levels and detect drowsiness or distraction. This could help prevent accidents caused by driver fatigue or inattention.

Personalization:
Facial recognition can be used to personalize the driving experience, adjusting settings like seat position, climate control, and music preferences based on the driver's identity.

Security:
Facial recognition can be used to enhance vehicle security, detecting unauthorized access attempts or identifying thieves.

Marketing:
Facial recognition can be used to gather data on drivers' demographics and emotional responses to ads and other marketing materials displayed in the car.

Access control:
Facial recognition can be used to grant access to certain features of the car, such

as adjusting the radio or climate control, only to authorized individuals.

Driverless cars:
Facial recognition can be used to identify passengers and adjust the vehicle's settings accordingly, such as adjusting the temperature or playing their preferred music.

Overall, the future scope of facial recognition and detection with Haar-like features in the automotive industry is vast, and we can expect to see many new applications emerge in the coming years.

Literature Review

Sr no.	Paper Name	Author	References	Findings
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2. [2]	work	Corinne Bernstein	https://aws.amazon.com/what-is/facial-recogntion/#:~:text=It%20works%20by%20identify-ing%20and,large%20collection%20of%20existing%20images. https://www.techtarget.com/searchenterpriseai/definition/face-detection	Face detection technology can be applied to various fields
3. [3]	E3S Web of Conferences 130,01020 (2019)	Lim William1 ,Astuti Winda2 , Dewanto Satrio2 , Tan Sofyan2 , and Mahmud Iwan Solihin3	https://www.e3s-conferen-en-ces.org/articles/e3sconf/pdf/2019/56/e3sconf_ic-amme2018_01020.pdf	Use in automotive industry
4. [4]	Facial Recognition for Car Security System Using Fisher face Method	R F Rahmat1, M P Loi1, S Faza1, D Arisandi1 and R Budiarto	https://www.researchgate.net/publication/334629343_Facial_'Recognition_for_Car_Security_System_Using_Fisherface_Method	Techniques Fisher Face Method
5 [5]	Human face recognition based on con-volutional neu-ral network and augmentedda-taset	Peng Lua, Baoye Songaand Lin Xu	https://www.tandfonline.com/doi/epdf/10.1080/21642583.2020.1836526?needAccess=true&role=button	CNN(Convolutional Neural Networks)

6. [6]	Face Recognition using CNN: A Systematic Review	Aneesa M P , Saabina N , Meera K	https://www.ijert.org/face-recognition-using-cnn-a-systematic-review#:~:text=The%20benefit%20of%20using%20CNNs,Neural%20Network%20for%20Image%20data.	CNN work
7. [7]	International Journal of Engineering Research & Technology (IJERT)	Ravinder Kaur, Manvi , Anupama Gupta	https://www.ijert.org/research/vehicles-driver-face-recognition-using-viola-jones-and-support-vector-machine-IJERTV6IS010313.pdf	Vehicle's Driver Face Recognition using Viola Jones and Support Vector Machine(SVM)
8. [8]	Facial Detection Understanding Viola Jones' Algorithm	Aron Ward	https://medium.com/@aaronward6210/facial-detection-understanding-viola-jones-algorithm-116d1a9db21	Implementation of viola jones' algorithm

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