Face Recognition System
White Paper

Face Recognition has received significant attention and adoption in the past couple of years due to a varied range of use cases such as identity verification in the digital space, public surveillance, security and monitoring, modelling in multimedia domain, targeted marketing, medical analysis and much more.

This white paper explores the solution's features, architecture and operating principles, and finally, we will present the results of our experiments which we have conducted over publically available data-sets as well as proprietary image data sets captured from traditional CCTV surveillance cameras.

Introduction

Over the past few decades, Image Analysis Systems have seen many commercial applications and have become a popular area of research in the field of Computer Vision and Machine Learning. One of the most real-world and successful applications of Image Analysis has been Machine Learning Powered **Face Recognition Systems** that use Deep Learning algorithms to compare an incoming digital image to the stored **Faceprint** to verify an individual's identity. Faceprint systems typically involve measurement and statistical analysis of an individual's unique physical and behavioural characteristics to recognize a subject based on the intrinsic physical or behavioural attributes.

Experiment

The input for a face recognition system is either an image or a video stream. The output is an identified or verified subject (or subjects) in the image or video stream. The experiment was conducted in three phases - Face Representation Phase, Face Detection phase and Face Recognition Phase.

Algorithms in past were majorly based upon 2D measurements. Despite this being a reasonable method, results can be deeply affected by the angle of view, changes in light conditions or orientation, different facial expression. These factors can significantly reduce the effectiveness of a system's accuracy, leading to a high rate of failure. 3D face recognition can be used in low light conditions and has the ability to recognize a subject from different view angles and orientations. Thus, they deliver a high degree of accuracy in results. We did a series of experiments on 3D Face Recognition and applied various techniques like Deep Learning, Transfer Learning with the Inception V3 model, Amazon Rekognition on publicly available datasets as well as our proprietary employee datasets.

The experiment involved following high level stages to create a systematic, operational and measurable function:

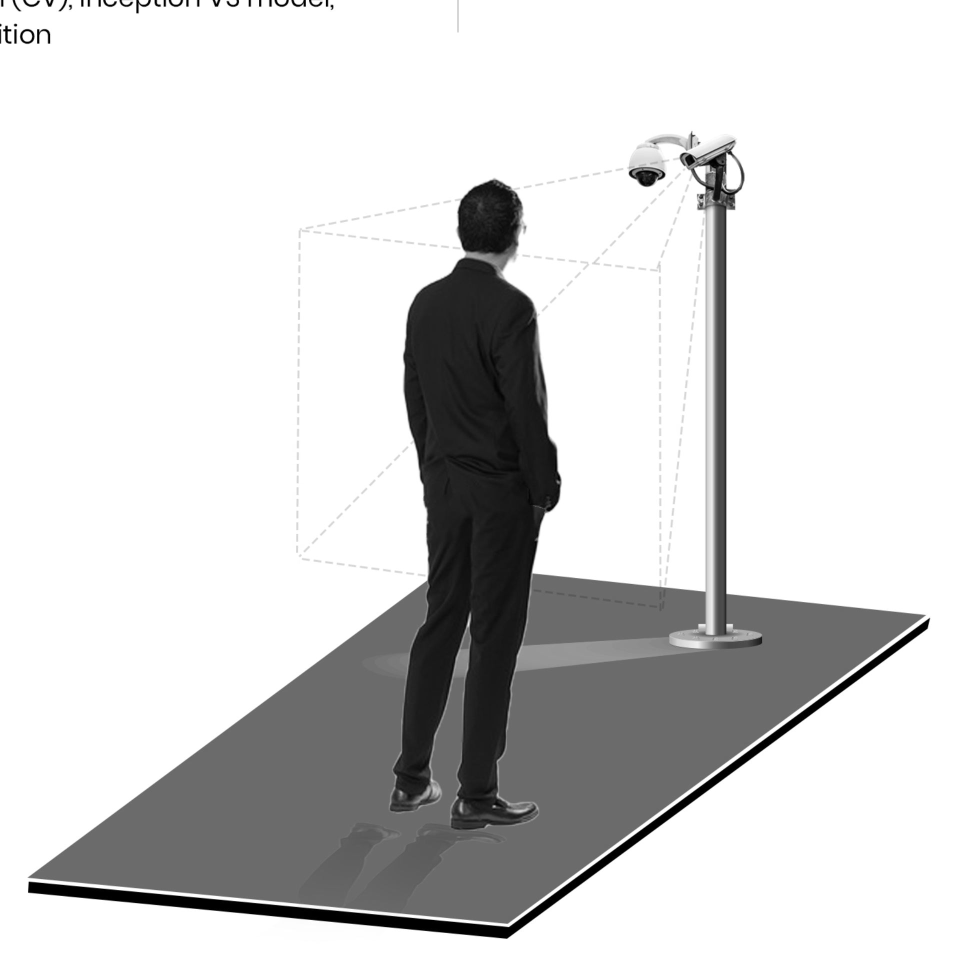
1. Starts with extracted all the faces from video stream by using Face Extraction Model
2. Created a cluster of all the faces extracted so that cropped images are grouped and stored into their respective directories according to their similarities
3. Images were enhanced and augmented to improve quality. Synthetic data was additionally created to increase the amount of input images for better results
4. Model Training on the cropped images
5. Performed verification and testing of our model on sample videos, documented the observations and performed necessary algorithmic refinements
6. Applied the model with real data and observed results

Equipment and System Used :

- A high resolution Camera with 25 to 30 frame per sec.
- Ubuntu OS with i5 processor
- Computer Vision (CV), Inception V3 model, Amazon Rekognition

Setup :

- Camera was installed at eye level where light conditions were suitable.
- The surveillance camera and the camera being used in making of video data-set was same.

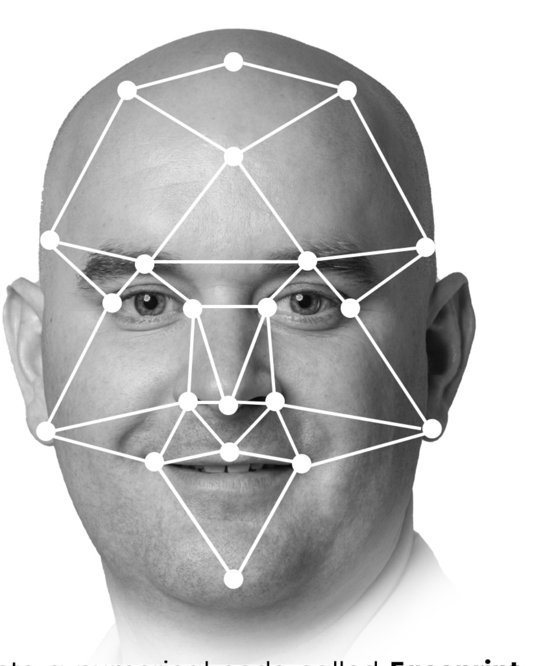


The Process

Once the algorithm detects a face, it determines the position of the head, its dimensions, pose, and some unique physiognomies. Every human face has several distinguishable features — the different characteristics that make up unique facial expression and features. These features are called **"Nodal points"** and represent certain variables of a person's face. Modern Facial recognition algorithms are highly advanced and able to identify over 80 nodal points on a human face.

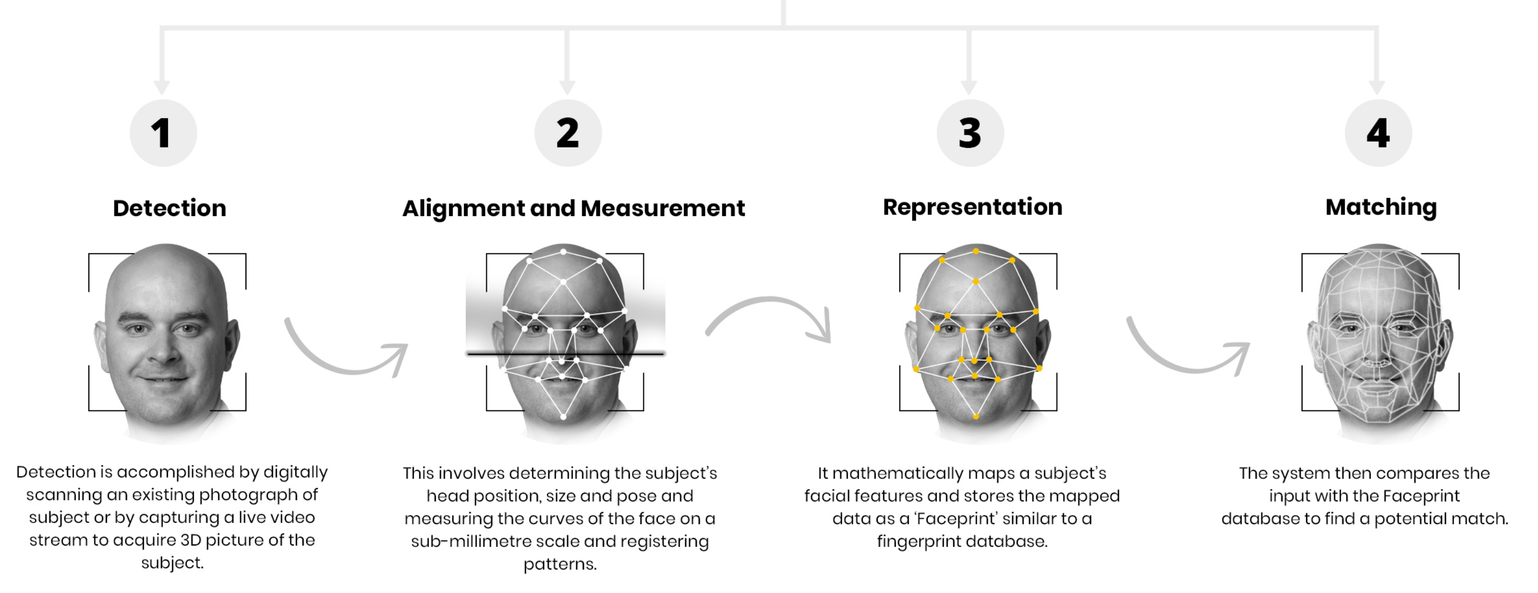
Some of the nodal points measured by the Face Recognition algorithm include :

- Distance between the eyes
- Depth of the eye sockets
- Width of the nose
- Length of the nose
- The shape of the cheekbones
- The length of the jaw line



The algorithm captures and translates these nodal point measurements into a numerical code called **Faceprint**, whichrepresents these features on a subject's face that can be processed and compared to faces stored in the data-set, similar to a Fingerprint database.

Steps involved in a 3D Face Recognition system



Performance and Results

Once the model was trained, our data science team conducted a series of tests on different resolutions, lighting conditions, temperatures, distances and poses. The summary of results is presented below:

Face Enrollment Phase

- 85% successful automatic enrollments
- 10% manual enrollments
- 5 % failed to enroll
- Average time to enroll: 8 Seconds

Face Verification Phase

- False Accept Rate (FAR) < = 0.1%
- False Reject Rate (FRR) < = 2%
- Average time to match < = 3 Seconds

Technologies

Python | **Computer Vision** | **Inception V3 model** | **Amazon Rekognition**

Use Cases

Face Recognition Systems can be employed for a wide range of use cases including identity verification, crime prevention, targeted marketing, personalized services for customers, forensic and medical analysis and much more. We are presenting some real life use cases where a Face Recognition System can be used to make the world smarter, safer and a better place.

- **Automatic Attendance System**
  A Face Recognition System can be deployed at offices, schools or colleges to automatically record attendance of individuals at entry points. The attendance data can then be used for other administrative operations such as payroll or student regularity report.
- **Biometric Access Control**
  It can be used to allow or restrict physical entry or resource access to an individual. A control can be automated so that only authenticated and authorized individuals have access to a given asset.
- **Shoplifting and Organized Retail Crime Prevention solutions**
  The solution can be deployed at retail establishments to instantly identify when a known shoplifter, organized retail criminals or individuals with a history of fraud enter. Faceprints of individuals can be matched against a large databases of criminals and security professionals can instantly be notified when such an individual or a group enters a retail store. This can also help by providing them contextual data that informs them who they are dealing with and whether they need to proceed with caution.
- **Smart Advertising**
  Commercial advertising can be made more targeted, personalized and precise by making educated guesses with the data collected by a Face Recognition System about a customer's age, gender and physical traits.
- **Hospitality Applications**
  Ability to accurately recognise and identify your most valuable clients and VIPs immediately and able to respond to their needs seamlessly delivering a luxury experience for them.
- **Medical Analysis**
  Face Recognition Systems can be used in medical diagnoses by sensing detectable changes in appearance of a patient under medical treatment and providing valuable recommendations for the line of treatment.
- **Finding Missing Persons**
  Face Recognition Systems can also be used to find and locate missing children or the victims of human trafficking if their data is available in a database. Police and law enforcement agencies can be alerted as soon as they are identified or detected by the Face Recognition System.
- **Physical Security Information Management**
  It can help monitor an individuals' movements in and around a facility to control access and raise automated alarms.
- **Forensic Analysis for Crime Investigations**
  Conducting video analysis during a forensic investigation to identify subjects more precisely and automatically in security footage or surveillance systems. This can also be used to identify deceased or unconscious individuals at crime spots.

Conclusion

Face recognition systems are part of image processing applications and their significance as a research area has increased recently in past few years. They use biometric information of humans and map that data mathematically to store it as a **"Faceprint"**. These systems can be used for surveillance, crime prevention, person identification, and similar use cases.

The data science team at Fullestop has evaluated several techniques and algorithms in the area of Facial Recognition and conducted series of experiments by adjusting thresholds of different parameters to fine tune the algorithm and achieve better accuracy levels. The system that was designed did a fairly good job with good input data. However, there is room for significant improvement to push the accuracy to even higher levels. The tested system has an acceptable performance in recognizing faces within intended limits.

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