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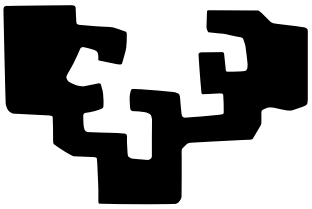

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AI in Face Recognition

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1 Introduction

A facial recognition system is a technology capable of matching a human face from a digital image or a video frame against a database of faces, typically employed to authenticate users through ID verification services, works by pinpointing and measuring facial features from a given image. Our brains can recognize different faces really easily because we are used to seeing different people and it is something natural, but for this technology it is not trivial to do so.

Face recognition has been one of the most challenging topics among computer vision researchers for decades. It has evolved on the fast track due to the development of artificial intelligence (AI). Face recognition-based attendance systems have more advantages than traditional card recognition, iris recognition and fingerprint recognition. They include high concurrency, noncontact and user-friendly, which are really important for the time we are living (Covid-19 pandemic), especially noncontact. The face recognition system has multiple applications such as employment in the government sector, public facilities, security, e-commerce, retailing and many other fields that will be mentioned in a future section.

The development of deep learning architecture has played an important role in the advancement of facial recognition techniques. For the development of deep learning models for facial recognition, large datasets are available.

These datasets are many images that have been collected from different social networks and search engines. The availability of these datasets and massive computational resources in modern computing systems like multi-core processors (PCs) and Graphical Processing Units (GPUs) has enabled deep learning algorithms. The most important contribution of these algorithms is Convolutional Neural Network (CNN) as a feature extractor.

2 Techniques

During the history of this techonology, many techniques have been used to develop facial recognition systems. In the 1990's, for example, some of the most popular ones were the following.

- **Geometrical features**. Features were extracted from based on ratios of distance and a set of geometrical features were computed. Some of those features could be distance between nose and chin, or between eyes. It requires considerable computational capacity.
- **Eigenfaces**. A basis set was computed from the faces on the training set, some kind of average face was estimated, and different features were extracted, called eigenfaces. Then, new faces were compared to the ones on the training set, this is, new faces were presented as the average face with different percentages of eigenfaces. It's advantages are speed and efficiency, but it fails as the difference between probes and new faces gets bigger.
- **Template matching**. Direct correlation between segments is performed. This technique is only useful when all the pictures have the same scale, orientation and illumination.

3 Convolutional Neural Networks

Nowadays there are a lot of facial recognition algorithms, but the most popular one for the image recognition is the Convolutional Neural Networks. It is a normal neural network with new layers, the convolutional layer and the pooling layer.

The first layer always is going to be the convolutional layer, it consist of making a nxn filter and applying it to all pixels of the input image. This will output a slightly smaller image than the original and with a filter applied . The second layer is the pooling one, this only makes the image smaller, simply to reduce the amount of parameters to work with. We can apply three different type of pooling: the max pooling, this extract the max value from a nxn sub-matrix; the average pooling, calculate the average of nxn sub-matrix; and the sum pooling, taking a nxn sub-matrix the result is going to be the sum of all the elements.

Those two layers can be repeated as many times as you want, but at the end is going to be the fully-connected layers. This is the standard neural networks layers, all the neurons are connected with all the neurons in the next layer. Having this last layer, the images will become a vector and by processing that vector we get the result of the image. As we can see in the figure 1, here is were the image is classified.

Every image can be represented as a matrix of pixels values, this is going to be the input data. Then the image go trough the different layers described above. After applying that process, the images generated pass tough the full-connected layer generating the output result.

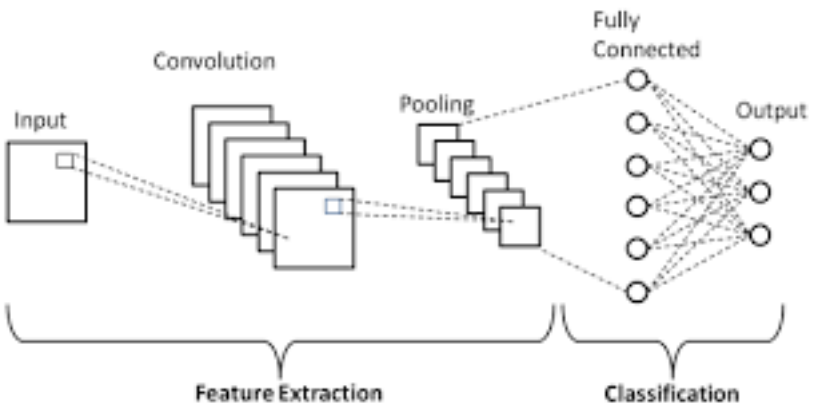

Figure 1: Training process of CNN

4 Applications

Facial recognition has many applications, here are some of the ones we found interesting.

- **Photography**. In some recent digital cameras or phones, face detection is used for autofocus. It is also useful for selecting regions of interest. It is also used for smile detection, this helps to take a photograph at the best moment.
- **Healthcare**. There are some applications of facial recognition technology that are used in hospitals, especially in those working in assisted living. The software serves to keep track

of everything that is going on within a hospital, ensuring patients are safe. If a patient wanders away from the care-giving facility with no identification, facial recognition can help quickly identify and find them quickly to prevent any harm from coming to them.

- **Identify people on social media platforms**. Many social networks use facial recognition techniques to identify people, one of the most common ones can be Facebook. Facebook uses this technology to automatically recognize when Facebook members appear in different photos. This makes it easier for people to find photos they are in and can suggest when particular people should be tagged or not in photos.

- **Help the blind**. Listerine (mouthwash brand), has developed a groundbreaking facial recognition application that helps the blind people using face recognition. As these people can not see, it is difficult for them to know how a person is feeling. The app recognizes when people are smiling and alerts the blind person with a vibration. This can help them better understand social situations.

- **Find missing people**. Face recognition is also used to find missing children and victims of human trafficking. It works as follows: as long as missing people are added to a database, law enforcement can become alertes as soon as they are recognised by face recognition. Thanks to this, 3000 missing children were discovered in four days in India.

- **Unlock a mobile phone**. A large variety of phones including the latest iPhone are now using face recognition to unlock phones or applications. This is a powerful way to protect personal data and ensure that, if a phone is stolen, private information will remain inaccessible. However, there is a big problem nowadays because of the compulsory use of the mask. If a person removes the mask, it will increase the risk of novel virus infection. This is the reason why new algorithms are being implemented and images of people with and without masks are being used in the datasets.

- **Identify and track criminals**. Facial recognition is also used to enable police to track and identify past criminals suspected of perpetrating an additional infraction. Because of this, police can also take preventive actions. By using an image of a known criminal (from a database, a video or an external picture) operators can detect matches in live video and react before it is too late.

5 Disadvantages and Controversies

Facial recognition provides us with many improvements and facilities in our daily lives but it also has some disadvantages, as will be mentioned below.

- **Imposes on personal freedom**. People can feel insecure and like they are always being watched because they are being recorded and scanned by facial recognition technology.

- **Violates personal rights**. In some countries with limited personal freedoms, for instance,North Korea, China and Iran commonly use facial recognition to spy on citizens and arrest those deemed troublemakers.

- **Racist algorithms**. The training process of any deep learning model is key to its performance, and the biases it inherits. There have appeared some applications struggling while recognising an African American man or women, specially it happens with women.

The issue is with the training dataset used to train the face recognition models. To give an example, if a person has never seen apples before or has seen it once in his life, that person will find it difficult to recognise apples in the future, because they have not seen enough apples to see how they look. To solve this, we need to show por apples to the person. It happens exactly the same with the apples. What we need to do to stop this big problem is come up with more inclusive and balanced datasets for training the models.

Facial recognition algorithms have high classification accuracy (over 90%), but these results are not universal. There are different researches that show there are different error rates among different demographic groups, with the poorest accuracy found in subjects who are female, black and 18-30 years old. In the "Gender Shades" project an intersectional approach was applied to appraise three gender classification algorithms, including those developed by IBM and Microsoft. They made four categories for the subjects: darker-skinned females, darker-skinned males, lighter-skinned females, and lighter-skinned males. All three algorithms performed the worst on darker-skinned females, with error rates up to 34% higher than for lighter-skinned male.

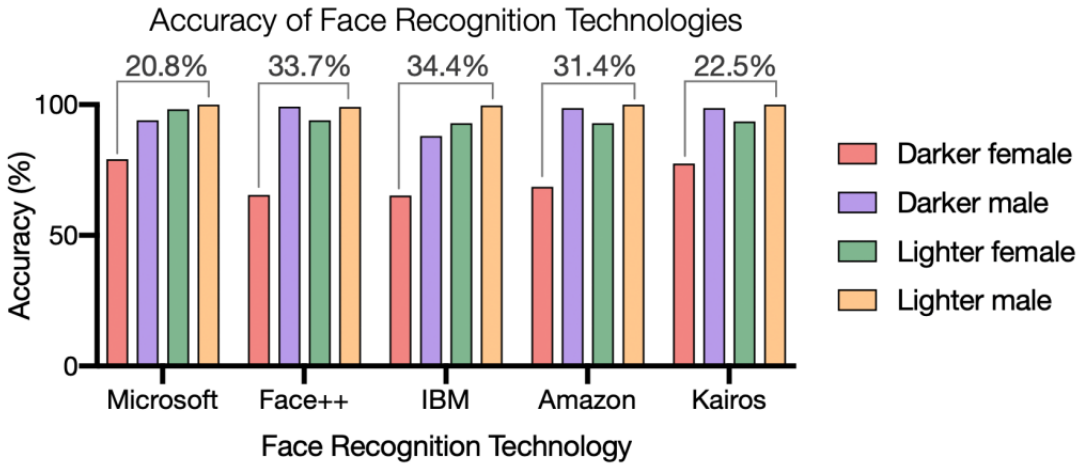

Figure 2: Accuracy of Face recognition

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