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Face recognition using Neural Network

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إهداء

أهدي تخرجي هذا إلى من علمني العطاء وإلى من أحمل اسمه بكل افتخار وأرجو من الله أن يمد في عمرك لترى ثمارا قد حان قطافها بعد طول انتظار "والدي العزيز" وإلى ملاكي في الحياة وإلى معنى الحب والحنان والتفاني وإلى بسمة الحياة وسر الوجود وإلى من كان دعائها سر نجاحي أغلى الحبايب "أمي الحبيبة" وإلى من له الفضل الكبير في تشجيعي وتحفيزي ومن منة تعلمت المثابرة والاجتهاد وإلى من بهم أكبر وعليهم أعتمد وإلى من بوجودهم أكتسب قوة ومحبة لا حدود لها وإلى من عرفت معهم معنى الحياة "إخوتي وأخواتي" وإلى من تحلوا بالإخاء وتميزوا بالوفاء والعطاء وإلى من برفقتهم في دروب الحياة السعيدة والحزينة سرت وإلى من كانوا معي على طريق النجاح والخير "أصدقائي الأعزاء" بتوفيق من الله، وبدُعاء من الأم لم يبق سوى خطوات قليلة لإنهاء مسيرتي الدراسية، شكرًا لكل من مد لي يد العون

.

زينب

إهداء

أشكر الله العلي القدير الذي أنعم عليَّ بنعمة العقل والدين. القائل في محكم التنزيل "وفوق كل ذي علم عليم" سورة يوسف آية 76.... صدق الله العظيم

أهدي تخرجي هذا إلى من علمني العطاء وإلى من أحمل اسمه بكل افتخار وأرجو من الله أن يمد في عمره "والدي العزيز" وإلى ملاكي في الحياة وإلى معنى الحب والحنان والتفاني وإلى بسمة الحياة وسر الوجود.

وإلى من كان دعائها سر نجاحي أغلى الحبايب "امي الحبيبة" حفظها الله،

وإلى صديق الأيام جميعًا بحلوها ومرّها، أريد أن أشكرها على كل شيء، ومن حلّت بركة وجودهم في حياتي، ومن ملأت ضحكاتهم الجميلة عمري

إلى الابتسامات التي تغدق عليّ الأمل

إلى زوجي الغالي

وإلى من عرفت معهم معنى الحياة "إخوتي وأخواتي"

و الى كل الزملاء والأصدقاء خاصة سندس وزينب وطه وأواب ولكل من ساندني ووقف معي ولو بكلمة أو دعوة صادقة في ظهر الغيب أهديكم تخرجي وفرحتي وأدعو الله أن يحفظكم جميعًا .

وئام

إهداء

أهدي تخرجي إلى من جرع الكأس فارغا ليسقيني قطرة حب ألى من حصد الأشواك عن دربي ليمهد لي طريق العلم (أبي)

إلى من سهرت ليالي طويلة من أجل راحتي ومن استيقظت فجرا من أجل الدعاء لي ... أمي الحبيبة

اختلطت دموع فرحتي بتخرجي وحزني بوداع أحبتي في غمضة عين مرت أيامنا وهانحن اليوم نجني قطافها ونودع أحبتنا والمكان الذي ضمنا هذه سنة الحياة بالأمس التقينا واليوم افترقنا ولكن فرحنا بتخرجنا ينسينا ألمنا.

شكرا لمن ساندني طوال مسيرتي الدراسية زملائي بعطوط علي أواب و بن عبد الله عبد الرحمان طه و عتوسي وئام وبوسالم زينب وعائلتي الكريمه وأخوتي وأخواتي وكل دفعة 2023.

سندس

ABSTRACT:

Biometrics refers to the automated identification and verification of an individual's unique characteristics, such as face.

Our project aims to create a facial recognition system that utilizes image-based data to identify individuals within a group. Our technology uses convolutional neural networks to analyze facial features, and we will be implementing our framework through the MATLAB program.

Keywords: Face recognition, neural network, Convolutional Neural Network, MATLAB**.**

Résumé:

La biométrie fait référence à l'identification et à la vérification automatisée des caractéristiques uniques d'une personne, telles que le visage.

L'objectif de notre projet est de créer un système de reconnaissance faciale qui utilise des données basées sur l'image pour identifier les individus au sein d'un groupe. Notre technologie utilise des réseaux neuronaux convolutées pour analyser les traits du visage, et nous allons mettre en œuvre notre cadre via le programme MATLAB.

Mots clés: Reconnaissance faciale, réseau de neurones, Convolution Neural Network, MATLAB**.**

ملخص:

تشير القياسات الحيوية إلى التحديد الآلي والتحقق من الخصائص الفريدة للفرد ، مثل الوجه.

الهدف من مشروعنا هو بناء نظام التعرف على الوجه الذي يستخدم البيانات القائمة على الصور لتحديد الأفراد داخل المجموعة. تستخدم تقنيتنا الشبكات العصبية التلافيفية لتحليل ملامح الوجه ، وسنقوم بتنفيذ إطار العمل الخاص بنا من خلال برنامج MATLAB..

الكلمات المفتاحية: التعرف على الوجوه ، الشبكة العصبية ، الشبكة العصبية الالتفافية ، ماتلاب.

List of acronym

CNN	***Convolutional neural networks***
FAR	***false acceptance rate***
FRR	***false rejection rate***
RNNs	***recurrent neural networks***
TP	***True Positive***
TN	***True Negative***
ANNs	***Artificial neural networks***
AI	***artificial intelligence***
DL	***Deep Learning***

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General Introduction

General Introduction

Biometric identification systems have gained significant attention in recent years due to their potential to enhance security and provide reliable authentication methods. Among various biometric modalities, face recognition has emerged as a prominent and widely utilized technology. The ability to recognize and authenticate individuals based on their facial features offers numerous practical applications, ranging from access control to surveillance systems.

The first chapter of this dissertation provides an overview of biometric systems, their properties, and various modalities. The importance of face recognition is discussed, along with its definition and the need for accurate identification in today's digital world. The chapter further explores the components and functioning of a typical face recognition system.

In the second chapter, the focus shifts to neural networks, this has become a key tool in various machine learning applications. The chapter starts by defining neural networks and explores different types. Special attention is given to Convolutional Neural Networks (CNNs), a specific type of neural network particularly suited for image processing tasks. The architecture and layers of CNNs are explained in detail, highlighting their effectiveness in face recognition.

The third chapter delves into the practical aspect of the dissertation, where a simulation was conducted to evaluate the performance of the proposed face recognition system. The chosen software, MATLAB Online, is introduced, and its suitability for the simulation is discussed. The training process of the system is then described, including the modifications made to improve its accuracy.

Chapter I:

Face recognition and Biometric system

I.1. Introduction

Biometry, an evolving technology, has gained significant prominence in our everyday lives. Its primary objective is to establish a person's identity with utmost accuracy and reliability by utilizing their unique biological features. This technological advancement has revolutionized the safety measures implemented in public places, ensuring enhanced security and protection for individuals.

I.2. Biometric:

I.2.1 Definition of biometric:

The term “biometric” refers to a measurable and unique biological or behavioral characteristic possessed by an individual. Biometrics involves the use of these distinctive features for identification, authentication, or recognition purposes. Biometric data can include physical traits such as fingerprints, facial features, iris patterns, or physiological characteristics like DNA or voice patterns. It can also encompass behavioral traits such as signature dynamics, gait analysis, or typing patterns. Biometric systems utilize advanced technologies to capture, analyze, and compare these characteristics, providing a reliable and secure means of establishing or verifying an individual’s identity [1].

I.2.2 Properties of a biometric modality:

Biometric modalities possess several key properties that contribute to their effectiveness and suitability for identity verification and authentication. Here are some important properties of biometric modalities:

- **Universality:** A biometric modality should be present in every individual. For example, everyone has a unique set of fingerprints, making it a universal modality.

- **Uniqueness:** Each individual should possess a distinct and non-reproducible pattern or characteristic within the chosen modality. This property ensures that no two individuals have identical biometric data.

- **Permanence:** Biometric characteristics should remain stable and unchanged over an extended period. While some modalities may evolve slightly with age, they should generally remain consistent throughout an individual’s lifetime. Collectability: Biometric data should be easily and reliably collectible in a non-intrusive manner. The acquisition process should be feasible without causing discomfort or inconvenience to the individuals being enrolled or verified [2].

- **Performance:** Biometric modalities should provide accurate and reliable results. High performance is measured by metrics such as recognition rate, false acceptance rate (FAR), false rejection rate (FRR), and overall error rates.

- **Resistance to circumvention:** Biometric characteristics should be difficult to replicate or spoof, ensuring that the system is robust against fraudulent attempts to deceive or bypass the authentication process.

- **Acceptability:** Biometric modalities should be widely accepted by individuals and not raise significant privacy or cultural concerns. Public acceptance and trust in the technology are crucial for its successful implementation.

- **Compatibility:** Biometric systems should be compatible with existing infrastructure, technologies, and databases, allowing seamless integration into various applications and systems.

I.2.3 Biometric modalities:

There are several biometric modalities that leverage different biological or behavioral characteristics for identification and authentication purposes.

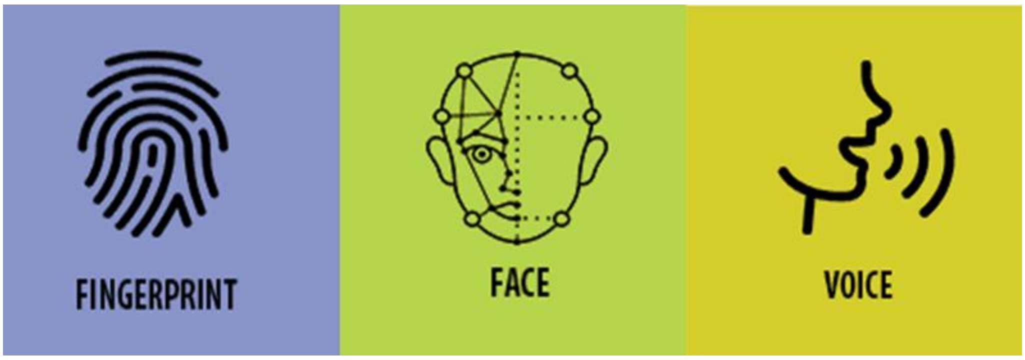

Figure I.1: Main Biometric Modalities [3].

- **Fingerprint Recognition:** This modality analyzes the unique patterns formed by ridges and valleys on an individual's fingertips. Fingerprint recognition is widely deployed due to its high accuracy and ease of acquisition [4].

- **Voice Recognition:** Voice recognition analyzes an individual's unique vocal characteristics, including pitch, tone, and speech patterns. It is commonly used in speaker verification and access control systems.

- **Facial Recognition:** Facial recognition utilizes facial features, such as the arrangement of eyes, nose, and mouth, to identify individuals. It has gained popularity in applications like surveillance, access control, and Smartphone unlocking.

I.3. Face Recognition:

Face recognition is a cutting-edge technology that enables the identification and verification of individuals based on their facial features. It has gained widespread attention and application in various domains, including security systems, access control, surveillance, and personal devices.

At its core, face recognition involves the use of computer algorithms to analyze and compare unique facial characteristics, such as the arrangement of eyes, nose, and mouth, or the texture and patterns of the face. By capturing and processing facial data, the system creates a mathematical representation, known as a face template, which serves as a digital identifier for each individual.

The process of face recognition typically entails capturing an image or video of a person's face, followed by detecting and extracting the key facial features. These features are then compared against a database of pre-existing face templates to identify or verify the individual's identity.

Face recognition technology offers numerous advantages, such as non-intrusiveness, convenience, and speed. It can operate in real-time, allowing for quick and seamless identification in various scenarios. Furthermore, it can adapt to changes in appearance, such as variations in lighting, facial expressions, or aging.

However, it is important to consider potential ethical and privacy implications associated with face recognition. Striking a balance between security and individual privacy is crucial to ensure responsible and ethical deployment of this technology. With ongoing advancements in artificial intelligence, machine learning, and computer vision, face recognition continues to evolve and improve in accuracy and performance. It holds great potential for enhancing security, personalization, and efficiency in a wide range of applications, contributing to a safer and more convenient future [5].

I.3.1 What is Face Recognition:

Face recognition is a biometric technology that involves the identification and verification of individuals based on their facial features. It utilizes computer algorithms to analyze and compare unique characteristics of a person's face, such as the arrangement of eyes, nose, mouth, and other facial landmarks. By capturing and processing facial data, face recognition systems create mathematical representations known as face templates, which are used to identify or authenticate individuals. This technology has applications in various fields, including security systems, access control, surveillance, and personalized user experiences.

I.3.2 The need of face recognition:

Face recognition is needed for various reasons and has become increasingly important in many areas of society. Here are some key reasons why face recognition is valuable:

- ✓ **Security and Access Control:** Face recognition provides a robust and convenient means of ensuring security and access control in various environments. It can be used to authenticate individuals and grant access to restricted areas, secure facilities, or digital systems. This technology helps prevent unauthorized access and enhances overall safety.

- ✓ **Law Enforcement and Forensics**: Face recognition plays a vital role in law enforcement and forensics. It aids in identifying suspects or persons of interest from surveillance footage or crime scene images. It helps law enforcement agencies in investigations, tracking down criminals, and ensuring public safety.

- ✓ **Identity Verification**: Face recognition is utilized for identity verification in various applications, such as banking, e-commerce, and online transactions. It offers a secure and convenient way to confirm the identity of individuals, reducing the risks of identity theft and fraud.

- ✓ **Personalized User Experience**: Face recognition can enhance personalized user experiences in devices like smart phones and tablets. It allows for features like facial unlocking, personalized settings, and tailored recommendations based on individual preferences.

✓ **Attendance and Time Management**: Face recognition can streamline attendance and time management processes in educational institutions, workplaces, and events. It provides an efficient way to track and record attendance, reducing manual efforts and potential errors.

✓ **Customer Experience and Marketing**: Face recognition can be used to analyze customer demographics, behaviors, and engagement in retail environments. It helps businesses understand customer preferences, optimize store layouts, and deliver personalized marketing campaigns.

✓ **Surveillance and Public Safety**: Face recognition technology assists in monitoring public spaces, airports, transportation hubs, and other critical areas. It helps identify potential threats, track individuals of interest, and enhance overall public safety.

✓ **Humanitarian and Social Applications**: Face recognition has potential applications in humanitarian efforts, such as assisting in finding missing persons, identifying individuals in disaster scenarios, or aiding in refugee management.

I.3.3 Face Recognition System:

A face recognition system is a technology that is designed to identify and verify individuals based on their facial features. It utilizes computer algorithms and artificial intelligence techniques to analyze and compare unique characteristics of a person's face.

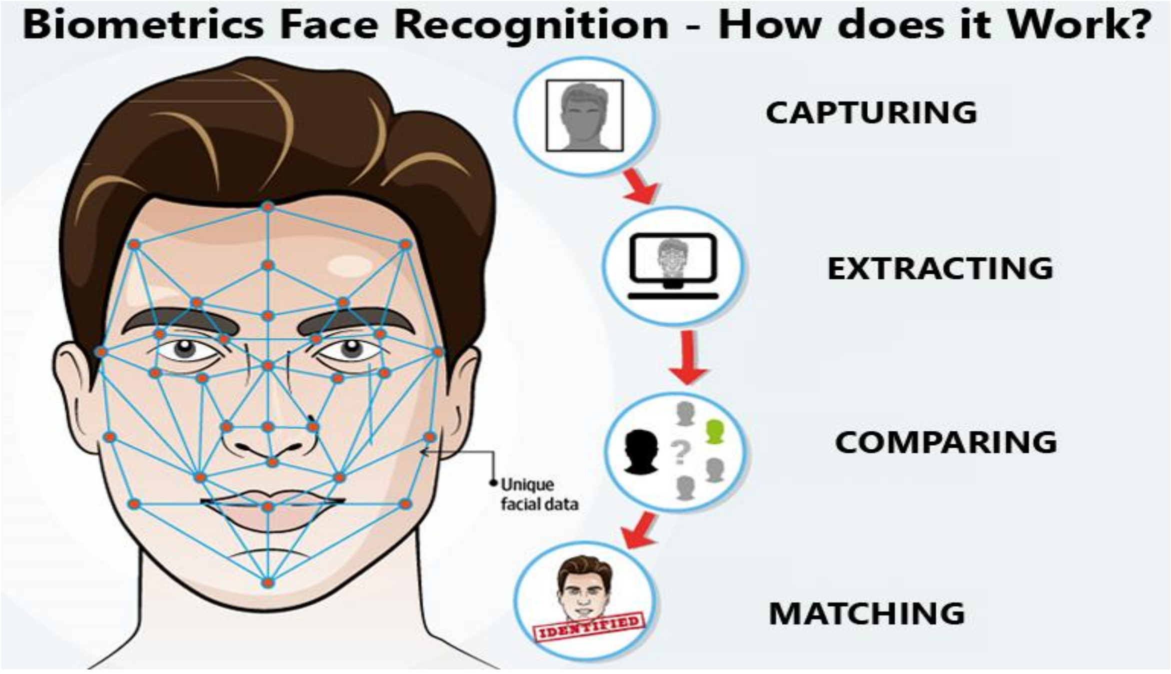

Figure I.2: How Face Recognition System Works [6]

A typical face recognition system consists of several key components:

- ❖ **Image Acquisition**: The system captures images or video frames containing faces using cameras or other imaging devices.

- ❖ **Face Detection**: The system employs face detection algorithms to locate and extract facial regions from the captured images or video frames. This step identifies the presence and position of faces within the visual data.

- ❖ **Feature Extraction**: Once the faces are detected, the system extracts distinctive facial features, such as the arrangement of eyes, nose, mouth, and other facial landmarks. These features are often transformed into mathematical representations, such as vectors or numerical codes, known as face descriptors or embeddings [7].

- ❖ **Database Creation**: The extracted facial features or face templates are stored in a database. This database serves as a reference repository for comparison and identification purposes.

- ❖ **Matching and Recognition**: When a new face is presented to the system, its facial features are compared against the stored templates in the database. The system utilizes matching algorithms to determine if there is a match or similarity between the input face and the stored templates.

- ❖ **Decision Making**: Based on the matching results, the system makes a decision regarding the identity of the input face. This decision could be a positive identification, rejection, or a confidence score indicating the likelihood of a match

- ❖ **Performance Evaluation**: Face recognition performance evaluation is conducted to assess how well a face recognition algorithm can correctly identify a person within a given population. The evaluation can be carried out using various methods, including accuracy, precision, recall, and False Acceptance Rate

- ❖ **True Positive (TP):** The number of correctly identified positive samples (i.e., correctly recognized faces) [8].

- ❖ **True Negative (TN):** The number of correctly identified negative samples (i.e., correctly rejected non-matching faces).

❖ **False Positive (FP):** The number of incorrectly identified negative samples (i.e., incorrectly recognized non-matching faces).

❖ **False Negative (FN):** The number of incorrectly identified positive samples (i.e., incorrectly rejected matching faces) [9].

- **Accuracy:** This metric indicates the percentage of correctly identified faces. It is calculated by dividing the number of correct identifications by the total number of faces.

Accuracy = (TP + TN) / (TP + TN + FP + FN)

- **Precision:** This metric measures the proportion of true positive identifications among the total number of identifications. It indicates the accuracy of positive predictions and is calculated by dividing the number of true positives by the sum of true positives and false positives.

Precision = TP / (TP + FP)

- **Recall:** This metric calculates the proportion of true positive identifications among the total number of actual positives in the population. It indicates the ability of the system to identify all positive instances, and it is calculated by dividing the number of true positives by the sum of true positives and false negatives. [9]

Recall = TP / (TP + FN)

- False Acceptance Rate (FAR): The proportion of non-matching faces incorrectly recognized as matches:

FAR = FP / (FP + TN)

Other metrics that can be used to evaluate face recognition performance include receiver operating characteristics (ROC) curves, confusion matrices, and average recognition rates. These metrics are useful for comparing different face recognition algorithms and for optimizing system parameters [10].

I.4. Conclusion:

In conclusion, the chapter on biometric systems for face recognition highlights the growing significance and widespread application of this technology in our daily lives. Face recognition serves as a reliable and efficient means of identifying and authenticating individuals based on their facial features. The chapter introduces the concept of biometric systems, which aim to establish the identity of a person using their biological or behavioral characteristics. The chapter showcases the process involved in face recognition, starting from capturing an image of a person's face to identifying the individual within it. The steps covered include face detection, alignment, feature extraction, face template creation, database comparison, and decision making. Overall, the chapter emphasizes the increasing relevance and potential of face recognition technology in our society. It showcases its wide range of applications and highlights the need for continued research, development, and responsible implementation to ensure its effectiveness, accuracy, and ethical usage.

Chapter II:

Convolutional Neural Network

II.1. Introduction:

The world is filled with objects that almost all of us can understand and that make us react without thinking too much. For example, a "Stop" sign partly covered with snow remains a "Stop" sign, and a chair five times larger than a classic chair remains a place where to sit. However, for standard computers, this type of intuitive logic is out of the ordinary. scope. Today, machine learning is able to offer this advantage to computers thanks to its advanced technology. Machine learning is a sub-field of artificial intelligence (AI). In General, the goal of machine learning is to understand the structure of data and to integrate them into models that can be understood and used by the world. Although machine learning is a field of computer science, it differs from traditional IT approaches. Indeed, in the latter, the algorithms are explicitly programmed instruction sets used by computers to calculate or solve problems. Machine learning algorithms enable computers to train on data inputs and use statistical analysis to produce values that are within a specific range.

For this reason, machine learning makes it easier to use computers in building models from sampling data to automate decision based on data entered in machine learning, tasks are usually classified into large categories. These categories are based on how learning is received or how the Feedback on learning is given to the developed system. Two of the methods the most widely adopted machine learning are supervised learning and unsupervised learning.

II.2. Neural Network:

Artificial neural networks (ANNs) are computational models inspired by the structure and functioning of biological neural networks in the human brain. They consist of interconnected nodes, called artificial neurons or "nodes," organized in layers. A representation of a real neuron and an artificial neuron are shown in the following two figures (**Figures 3.1 and 3.2**) ANNs have gained significant popularity due to their ability to learn from data, recognize patterns, and make predictions without being explicitly programmed. [11]

The practice of all DL (Deep Learning) algorithms is Artificial neural networks. Neural Networks are models information processing that simulates the functioning of a nervous system biological. This is similar to how the brain manipulates information at the operation. All neural networks are made up of interconnected neurons that are organized in layers [11].

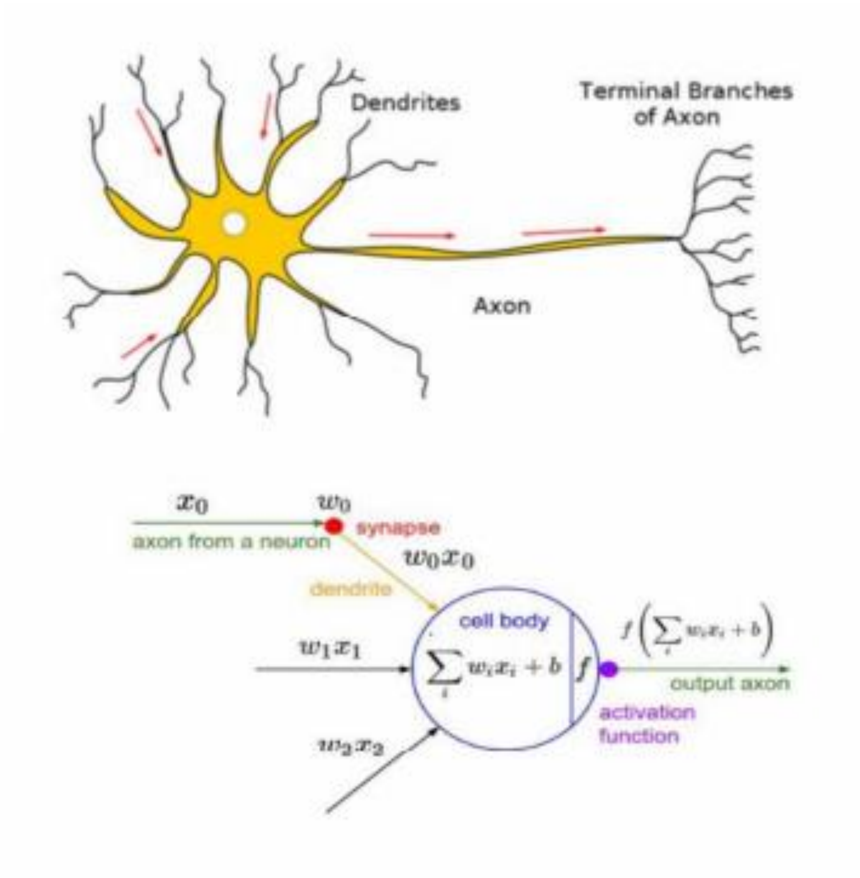

Figure II.1 Diagram of NEURON [12]

II.3. The architecture of an artificial neural network

The architecture of an artificial neural network refers to the arrangement and connectivity of its components. It determines how information flows through the network and how computations are performed. The basic architecture consists of three types of neuron layers: input, hidden, and output layers as shown in Figure **II.2.**[13]

The description of the typical architecture of an artificial neural network is as follows:

1. Input Layer:
   - The input layer is the first layer of the neural network.
   - It receives input data, such as features or attributes, and passes it to the subsequent layers.
   - Each node in the input layer represents a specific input feature.
   -

2. Hidden Layers:
   - Hidden layers are located between the input and output layers.
   - They perform computations and transformations on the input data.
   - Multiple hidden layers can be present in a neural network, and the number of nodes in each layer can vary.
   - Each node in a hidden layer receives inputs from all the nodes in the previous layer and computes an output based on the weights, biases, and activation function.
3. Output Layer:
   - The output layer is the final layer of the neural network.
   - It produces the output or prediction based on the processed information from the hidden layers.
   - The number of nodes in the output layer depends on the specific task of the neural network, such as binary classification, multi-class classification, or regression.

The architecture of an artificial neural network can be further customized and extended based on the specific problem and application. Different types of neural networks, such as feedforward neural networks, convolutional neural networks (CNNs), and recurrent neural networks (RNNs), have unique architectures tailored to their respective tasks and data types [14].

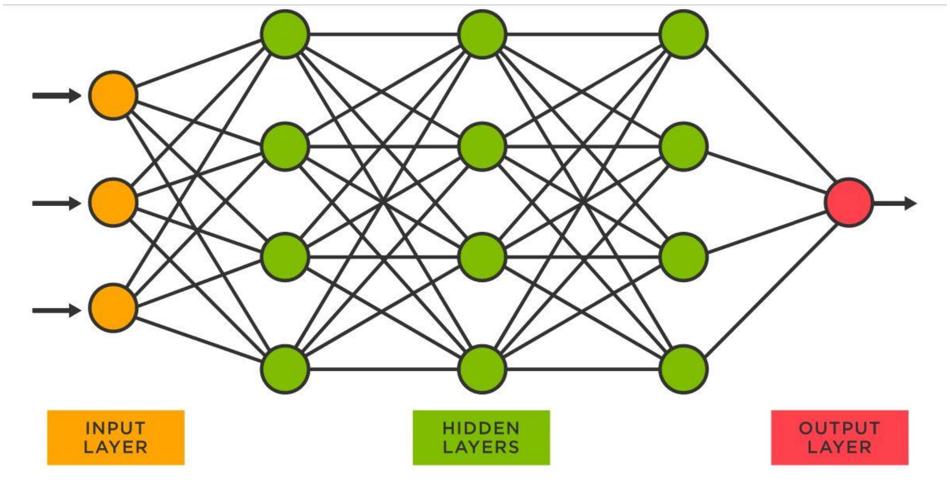

Figure II.2 Diagram of an artificial neural network [15]

II.4. Artificial Neural Networks to face recognition:

In the context of face recognition, ANNs have shown remarkable performance and have become a popular choice for building face recognition systems. The application of ANNs to face recognition involves training a neural network on a large dataset of labeled face images. The network learns to extract relevant features from the images and map them to specific individuals.

One commonly used approach in face recognition is the Convolutional Neural Network (CNN), which is well-suited for image processing tasks. CNNs consist of multiple convolutional layers that apply filters to extract meaningful features from the input images. These features are then passed through fully connected layers to make predictions about the identity of the person in the image.

1. What is CNN:

CNN stands for Convolutional Neural Network. It is a type of artificial neural network specifically designed for analyzing visual data such as images and videos. It is inspired by the structure and functioning of the human visual system.

2. Why CNN for face recognition:

Convolutional Neural Networks (CNNs) have been widely used for face recognition due to several reasons:

- Spatial Invariance: CNNs are designed to capture spatial relationships in images. CNNs utilize convolutional layers that scan the input image with small filters, allowing them to detect local features like edges, textures, and shapes. This spatial invariance property is crucial for face recognition, as faces can vary in pose, scale, and orientation [16].

- Hierarchical Feature Learning: CNNs are capable of automatically learning hierarchical representations of the input images. In face recognition, lower-level CNN layers learn simple features like edges and textures, while deeper layers learn more complex and abstract facial features. This hierarchical feature learning helps CNNs to capture important discriminative information in faces, allowing for better discrimination between different individuals.

- Parameter Sharing: CNNs exploit parameter sharing across the spatial dimensions of the input. Faces have similar patterns that can occur in different parts of the image, such as eyes, nose, and mouth. CNNs take advantage of this property by using shared weights and biases across different spatial locations. This parameter sharing significantly reduces the number of parameters in the network, making CNNs more efficient and easier to train compared to fully connected networks.

- Transfer Learning: CNNs can leverage pretraining on large-scale datasets, such as ImageNet, to initialize their weights. This pretraining allows CNNs to learn general features like shapes, textures, and object categories, which can be relevant for face recognition. By starting with pretrained weights, CNNs can be fine-tuned on smaller face datasets, resulting in improved performance even with limited face-specific training data [17].

- Robustness to Variations: CNNs have shown robustness to variations in facial appearance, such as changes in illumination, occlusion, and partial face occlusion. Through the learning process, CNNs can capture invariant features that are useful for recognizing faces under different conditions. Additionally, techniques like data augmentation can be used to artificially introduce variations into the training data, further improving the robustness of CNNs.

- Scalability: CNNs can handle large-scale face recognition tasks efficiently. Once trained, CNN models can be used to process face images in real-time or in batch mode. Moreover, CNNs can be trained to recognize a large number of individuals in face identification scenarios, making them suitable for applications like surveillance, access control, and law enforcement.

How does CNN works?

CNNs, or Convolutional Neural Networks, work by leveraging the principles of convolution and pooling operations to process input data, typically images, and extract meaningful features. A simplified explanation of how CNNs work is shown in Figure **II.** :

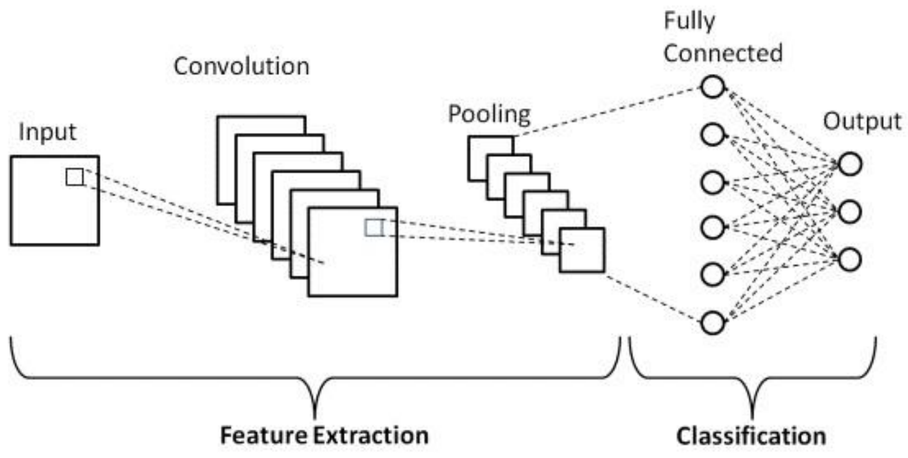

Figure II.3 Example of the Convolutional Neural Network CNN [18]

Step 1: Before training an image, we need to process the dataset.

Step 2: Neural networks are like layers. Each layer of neural network contains nodes which calculates some values based on characteristics or weights. Activation function are Relu for hidden layers and either sigmoid or SoftMax for output layers [19].

Step 3: Convolution layer is a fundamental mathematical operation that is highly useful for to detect features of an image. Each convolutional layer consists of multiple filters or kernels, which are small matrices of weights.

Step 4: Max Pooling operation involves sliding a 2- dimensional filter over each channel of features map and extract maximum features from image. Pooling layer used to reduce the dimension of feature map. It reduces the number of parameters to learn and amount of computation to perform. Pooling layer summarizes the feature present in a region of the feature map generated by the convolution layer.

Step 5: Fully Connection Layer It is one of the fully feed forward neural network. It formed by last few layers. Once the image is convolved, pooled and flattened, the result is a vector. This vector act as the input layer for an ANN which then works normally to detect the image. It assigns random weights to each synapse; the input layer is weight adjusted and put in to an activation function. Every single neuron has a connection to every single neuron in next layer. The output is then compared with true values and the error generated is back-propagated, i.e., the weights are re-adjusted and all the processes repeated. This is done until the error is reduced or get correct output. [20]

II.5. Conclusion:

We know that CNNs are the most popular and best neural networks for dealing with image identification and pattern detection because of their characteristics after getting a general understanding of how CNNs generally function and their significance in the deep learning area.

The following chapter covers the various components of our project's hardware and software.

Chapter III:

Simulation and Results

III.1. Introduction:

This chapter focuses on training a simple face recognition system and examines the effects of adjusting the number of epochs, handling diverse image types, and modifying the pixel range. We delve into the impact of epoch variations on the model's performance, we explore the issues encountered with different image types, such as lighting conditions, poses, expressions, and occlusions. Furthermore, we investigate the effects of modifying the pixel range on the system's accuracy and robustness. By investigating these factors, we aim to improve the performance and reliability of the face recognition.

III.2. Software and Tools

- **Matlab Online:**

Matlab is a software that needs to be downloaded and installed on a computer or a device. However, there is an online version of Matlab called Matlab Online. Matlab Online is a cloud-based Matlab environment that allows users to run Matlab code through a web browser. This means that users can access Matlab from anywhere with an internet connection without having to install the software on their own devices. Matlab Online offers a range of features including: - Access to the Matlab workspace and variables - Ability to run Matlab scripts and functions - Integration with other Matlab tools such as Simulink and Control Systems Toolbox - Support for plotting and visualization - Collaboration and file sharing options

III.3. Training A simple Face recognition System

In this experiment, we will outline the steps involved in training a simple face recognition system using Convolutional Neural Networks (CNN). The process involves collecting a database of facial images and using CNN to train the system to recognize and identify individuals based on their facial features. Here is an overview of the steps involved:

1. Data Collection: Gather a dataset of facial images that will be used for training the face recognition system. This dataset should include a diverse set of individuals with different facial features, poses, and lighting conditions.
2. Data Split: Divide the dataset into two subsets: a training set and a validation set. The training set will be used to train the CNN, while the validation set will be used to assess the performance.

3. CNN Architecture: Design the architecture of the CNN. This typically involves stacking multiple convolutional layers, pooling layers, and fully connected layers to extract meaningful features from the facial images.
4. Training: Train the CNN using the training set. During training, the CNN learns to recognize facial features and map them to specific individuals.
5. Hyperparameter Tuning: Adjust the hyperparameters of the CNN. This helps optimize the performance of the model.
6. Evaluation: Evaluate the trained model using the validation set to assess its accuracy and performance.
7. Testing: Finally, test the trained model on a separate test set to assess its generalization ability and overall performance in recognizing individuals' faces.

III.3.1. Face recognition system:

The basic architecture of face recognition is shown in the next figure (**Figure III.1)** :

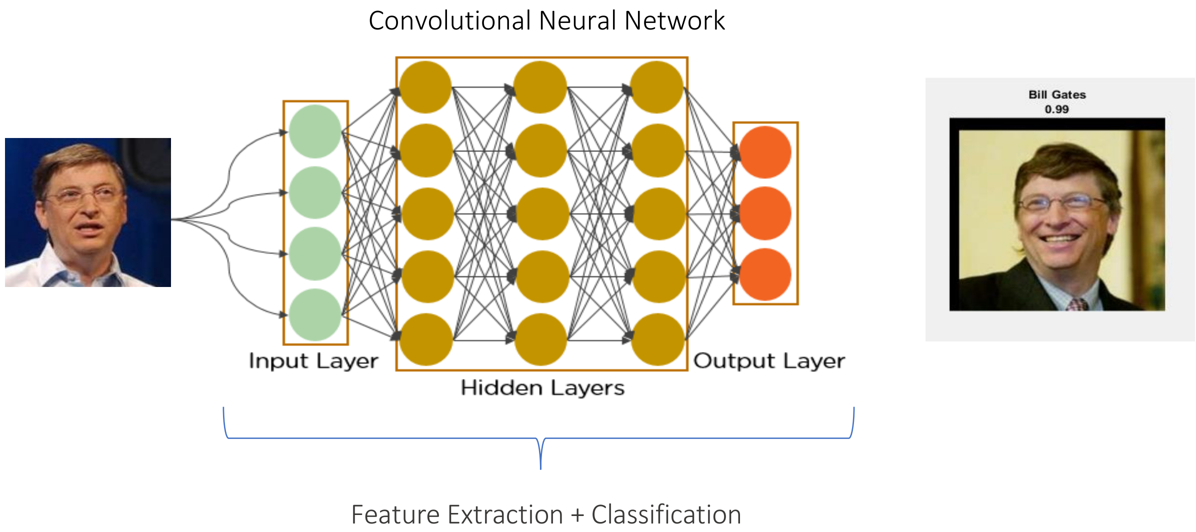

Figure III.1 Face recognition system

III.3.2. Dataset:

In order to create a facial system, we gather a dataset of facial images with corresponding identity labels. The dataset contains 170 images, 10 for each individual to facilitate accurate recognition. The image was taken in different lighting conditions, poses, facial expressions, and other factors that might affect facial appearance.

Our data set is going to be divided into training and test. 140 images for training and the rest which is 30 images for test

Figure III.2 Collected database

III.3.3. Deep learning:

In a face recognition system, CNNs are used to extract features from facial images and perform recognition. They utilize filters to convolve across the images, capturing local patterns. Activation functions introduce non-linearity to learn complex features. Pooling layers down sample the feature maps, reducing computational complexity. Fully connected layers perform high-level reasoning and produce a probability distribution over identities for recognition.

III.4. Training:

In this part we are trying to get the maximum accuracy we can get by manipulation in the number of epochs and fixing all the other option.

- ❖ Mini batch size:5 (The mini-batch size refers to the number of training examples or data samples that are processed in each iteration or mini-batch during the training.)
- ❖ Validation Frequency:34 (Validation frequency refers to how often the model's performance is evaluated on a validation set during the training process.)
- ❖ Activation Function : sgdm (An activation function is a mathematical function allowing it

to learn and model complex relationships between inputs and outputs.)

- Learning Rate: 3.10^{-4} (The learning rate is a hyperparameter that determines the step size or the rate at which a machine learning algorithm adjusts its model parameters during training)

- Number of Convolutional layer : 144 (64*7*7*3)

- The epoch number refers to the number of times the entire training dataset is passed through the neural network during the training process.

- **Results and analysis**

In this experiment, we aimed to train a model using images with different file extensions, and to investigate the impact of varying the number of epochs while keeping all other options fixed. Unfortunately, we obtained poor results (**Figure III.2)**.

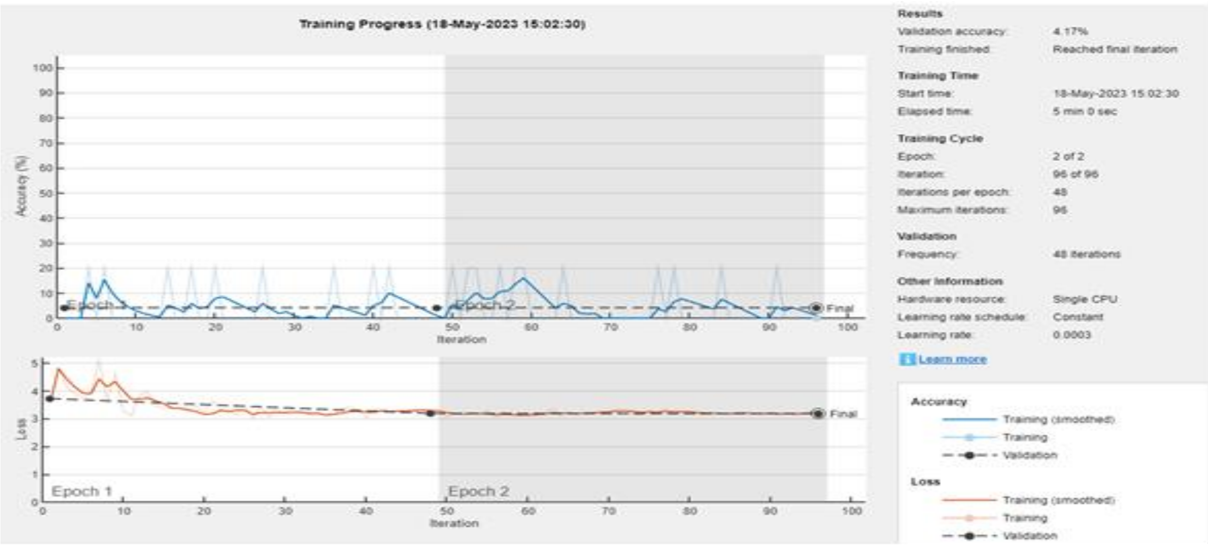

Figure III.3: Classification Accuracy

When training images with different file extensions, such as JPEG (JPG) and PNG, using deep learning, the difference in file formats can affect the accuracy for several reasons:

1. Data Representation: JPEG and PNG use different compression algorithms, resulting in variations in how the image data is stored. The differences in data representation can impact the neural network's ability to learn and generalize from the images.

2. Preprocessing Differences: Deep learning models typically require preprocessing steps to normalize and standardize the input data. When images with different file formats are used, additional preprocessing steps might be needed to handle the variations in color spaces, compression artifacts, or transparency information between JPEG and PNG. Failure to account for these differences can lead to inconsistencies during training and affect the model's accuracy.

After using only one type of image we got a better result; we investigate the influence of varying the number of epochs on achieving optimal accuracy.

The number of training epochs is then varied, with different values explored, such as 2, 5, 10, and accuracy is measured on validation dataset. The results are shown in Table III.2

Num of epochs	1	2	3	4	5	6	7	8	9	10
Accuracy	25%	75%	66.67%	75%	91.57%	83.33%	83.33%	91.47%	83.33%	91.67%

Table III.2: Classification results with epoch number variation

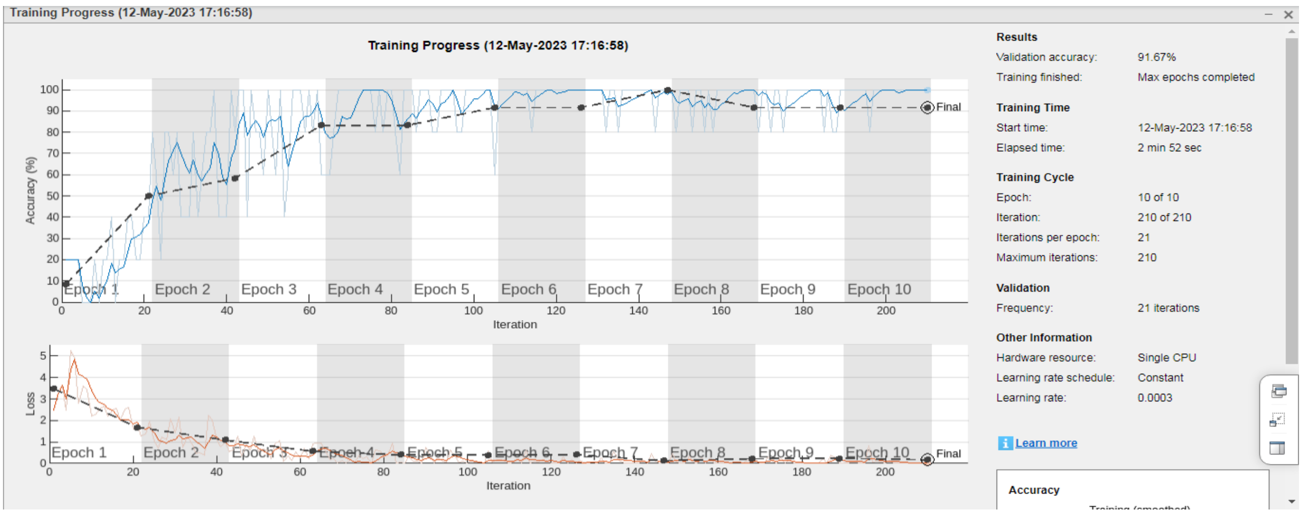

Figure III.4 Best classification result

Our results show that 10 as a number of epochs gave the best accuracy for our training with **91.67%** as shown in Figure III.3**,** above, can our training get better results?

Next part, we will investigate the impact of incorporating data augmentation techniques and adjusting the pixel range of images on the performance of our model.

Data augmentation is a technique used to increase the size and diversity of a training dataset by applying various transformations or modifications to the existing data samples.

The pixel range refers to the possible values that a pixel can have in an image.

Pixel Range	**Accurracy**
[-10, 10]	91.67 %
[-30, 30]	83.33 %

Table III.3: Accuracy of face recognition with parameter variation

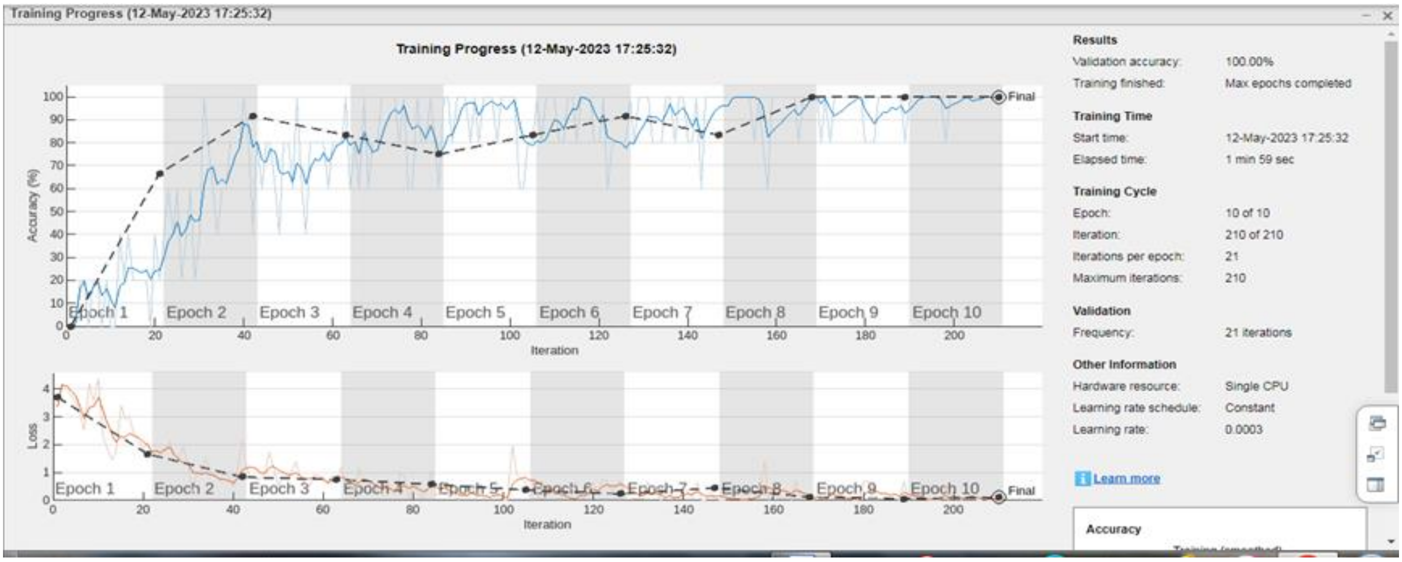

Figure III.5 The Optimal Accuracy

To effectively evaluate the performance of our trained facial recognition system on new face images. The results are shown in Figure III.5.

Figure III.6: Test results

Based on the results obtained, it appears that the facial recognition system achieved a high recognition percentage of approximately 100% for all the tested images. This suggests that the training of the system was successful in accurately identifying the individuals in the new face images. Achieving such a high recognition percentage indicates that the model has learned the necessary facial features and patterns to perform well on unseen data. This is an encouraging outcome and demonstrates the effectiveness of the training process. However, it's important to thoroughly validate the system's performance on a larger and more diverse set of images to ensure its robustness and generalization capabilities.

III.7. Conclusion:

In conclusion, this chapter has covered important aspects of training a simple face recognition system. The number of epochs was found to be a critical parameter for achieving optimal model performance. Handling diverse image types, including variations in lighting, poses, expressions, and occlusions, was addressed through preprocessing techniques and data augmentation methods, resulting in improved recognition capabilities. Modifying the pixel range enhanced the system's robustness to variations in image intensity. Overall, these findings contribute to the development of an accurate and reliable face recognition system for real-world applications. Future research could explore advanced techniques, such as domain adaptation and feature extraction, to further improve system performance in various scenarios

General Conclusion

General Conclusion

In conclusion, this dissertation provides a comprehensive study on the topic of biometric face recognition using neural networks with a particular focus on CNNs. The dissertation concludes with a practical implementation of a face recognition system, using MATLAB Online for simulation and training, and presenting the results obtained.

In conclusion, this chapter has provided valuable insights into training a simple face recognition system by considering the number of epochs, handling diverse image types, and modifying the pixel range. We have observed that adjusting the number of epochs is crucial for balancing model performance and avoiding over fitting or under fitting. By fine-tuning this parameter, we can optimize the system's accuracy and generalization abilities.

Additionally, we have addressed challenges related to various image types commonly encountered in face recognition, including variations in lighting conditions, poses, expressions, and occlusions. Preprocessing techniques and data augmentation methods can effectively handle these challenges, enhancing the system's ability to recognize faces under diverse conditions.

Moreover, we have explored the impact of modifying the pixel range on the system's performance. By normalizing the pixel values within a specific range, such as 0 to 1 or -1 to 1, we can improve the system's robustness to variations in image intensity.

By considering these factors and conducting thorough experiments, we can develop a more accurate and reliable face recognition system suitable for real-world applications. Future research could further explore advanced techniques, such as domain adaptation and feature extraction, to overcome additional challenges and enhance the system's performance in various scenarios

Through this research, valuable insights are gained into the field of biometric face recognition, offering a foundation for further advancements and applications.

Annexe

Annex 01

Google net is a convolutional neural network (CNN) developed by Google researchers in 2014. It is also known as Inception-v1 because of its inception module, which is a building block used in the network. Google net was designed to address two major challenges in CNNs: the trade-off between depth and width and the computational cost of training large models.

The inception module in Google net consists of 1x1, 3x3, and 5x5 convolutions, which allow the network to capture features at different scales and improve its performance. Additionally, it includes a technique called “bottleneck” that reduces the number of parameters and computations in the network.

Google net achieved state-of-the-art performance on the ImageNet Large Scale Visual Recognition Challenge (ILSVRC) in 2014, surpassing the previous winner, the AlexNet model. Since then, Inception models with deeper and wider architectures have been developed, such as Inception-v2, v3, and v4, which have improved performance and reduced computational complexity.

Overall, Google net and its variants have been widely used in various computer vision tasks, such as object detection, recognition, segmentation, and classification.

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