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Deep learning methods for medical Image Classification

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Dedication Djokna Noura

First of all, we thank ALLAH who helped us and provided us with patience and courage during these years of study.

This thesis is dedicated to:

my dear mother **Fatima**, who always encouraged me and was a source of love and tenderness that there are no words to describe and express. And my dear father : **Tayeb** my support, my strength and my pride in this world God bless you and grant you health and long life.

To my sisters : **Chaima, Mbarka, Salsabil**. And to my brothers **Abdelmalk, Djamal**, For their support and patience with me and to all my family .

I also dedicate this work to my Colleague **Imane Chafia Dakmoussi** Thank you for your patience and your help. To my all friends who helped us and stood with us. Special thanks to my friend **Chaima Latreche** , for always supporting me. And a special thank you **Abimouloud Mohamed Laid, Lakhdari Abdessalam** for your helps, God bless you.

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Dedication Dakmoussi Chafia Imane

Praise be to God, with whose grace good deeds are accomplished, and prayers and peace be upon the most honorable messengers.

I dedicated this modest work to:

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My mother, the most precious thing I have is the well of my inexhaustible love.

My father, the beloved of my heart and my support in this life.

I pray to God to protect them and take care of them for me, and that their lives will be long and full of health and wellness.

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Abstract

After the emergence of the Coronavirus, which shook the entire world, it became necessary to work on its early detection, and after adopting artificial intelligence in the medical field. we propose this work to detect corona cough accurately and early, using spectrogram images and deep learning which is a set of machine learning algorithms to train neural networks. In our experience, we have used convolutional neural networks as one of the basic structures for deep learning because they get the best results in image analysis, Through the use of transfer learning (pre-trained convolutional neural networks models), we compared them with each other and finally concluded get the best model with the epoch of 70 and 128 batch size with an accuracy of 0.9474 and loss of 0.1956 for that the accuracy value was high compared to the rest of the models, and the loss value was low compared to the rest. This project aims to compare these models and facilitate the development of an AI-based system for early recognition of COVID-19 from voice signal with the best effectiveness.

Keywords

Artificial Intelligence, Machine Learning, Deep Learning, Convolutional Neural Network, Pre-trained model ,Transfer Learning ,Covid -19.

Résumé

Après l'émergence du Coronavirus, qui a secoué le monde entier, il est devenu nécessaire de travailler sur sa détection précoce, et après l'adoption de l'intelligence artificielle dans le domaine médical. nous proposons ce travail pour détecter la toux corona de manière précise et précoce, en utilisant des images de spectrogramme et l'apprentissage en profondeur qui est un ensemble d'algorithmes d'apprentissage automatique pour former des réseaux de neurones. Dans notre expérience, nous avons utilisé les réseaux de neurones convolutifs comme l'une des structures de base pour l'apprentissage en profondeur car ils obtiennent les meilleurs résultats en analyse d'image, Grâce à l'utilisation de l'apprentissage par transfert (modèles de réseaux de neurones convolutifs pré-formés), nous les avons comparés les uns aux autres et avons finalement conclu obtenir le meilleur modèle avec l'époque de 70 et 128 taille de lot avec une précision de 0,9474 et une perte de 0,1956 pour que la valeur de précision était élevée par rapport au reste des modèles, et la valeur de perte était faible par rapport au reste. Ce projet vise à comparer ces modèles et à faciliter le développement d'un système basé sur l'IA pour la reconnaissance précoce du COVID-19 à partir du signal vocal avec la meilleure efficacité.

Mote Clé

Intelligence Artificielle,Apprentissage Automatique,L'apprentissage en profondeur, Réseau de Neurones convolutifs,Modèle pré-formé ,Apprentissage par transfert ,covid -19.

المخلص

بعد ظهور فيروس كورونا الذي هز العالم بأسره ، أصبح من الضروري العمل على الكشف المبكر عنه ، وبعد اعتماد الذكاء الاصطناعي في المجال الطبي. نقترح هذا العمل لاكتشاف سعال الكورونا بشكل دقيق ومبكر باستخدام صور المخطط الطيفي والتعلم العميق وهو عبارة عن مجموعة من خوارزميات التعلم الآلي لتدريب الشبكات العصبية. في تجربتنا ، استخدمنا الشبكات العصبية التلافيفية كأحد الهياكل الأساسية للتعلم العميق لأنها تحصل على أفضل النتائج في تحليل الصور ، من خلال استخدام التعلم بالنقل (نماذج الشبكات العصبية التلافيفية المدربة مسبقاً) ، قمنا بمقارنتها مع بعضها البعض واستنتجنا أخيراً الحصول على أفضل نموذج بعصر ٧٠ و ١٢٨ حجم دفعة بدقة ٩٤٧٤.٠ وفقدان ١٩٥٦.٠ لذلك. كانت قيمة الدقة عالية مقارنة ببقية النماذج ، وكانت قيمة الخسارة منخفضة مقارنة بالباقي. يهدف هذا المشروع إلى مقارنة هذه النماذج وتسهيل تطوير نظام قائم على الذكاء الاصطناعي للتعرف المبكر على ثوطييض ٩١ من الإشارات الصوتية بأفضل فعالية.

الكلمات الدلالية: الذكاء الاصطناعي ، تعلم الآلة ، التعلم العميق ، الشبكة العصبية التلافيفية ، النماذج المدربة مسبقاً ، التعلم النقل ، كوفيد ١٩

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Acronyms

AI	Artificial Intelligence
ANN	Artificial Neural Network
CNN	Convolutional Neural Network
DL	Deep Learning
FC	Fully Connected
GPU	Graphic processing unit
ML	Machine Learning
NN	Neural Network
ReLU	Rectified Linear Unit
SARS-CoV	Severe acute respiratory syndrome coronavirus
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
STFT	Short-Time Fourier Transform
TL	Transfer Learning
VGG	Visual geometry group

General Introduction

The COVID-19 pandemic has caused enormous health, social and economic burdens. The virus that causes this disease, Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), affects multiple body structures and organs. And it quickly spread to over 200 countries around the world. The main symptoms include fever, dry cough, sore throat, shortness of breath, fatigue, headache and, in severe cases, multiple organ failure. Repeated dry coughs can affect changes in the vocal cords and affect voice quality. Therefore, all of these respiratory diseases caused by COVID-19 can make patients' voices unique and produce identifiable vocal features. Deep learning is a method in artificial intelligence AI that teaches computers to process data in a way that is inspired by the human brain. Deep learning models can recognize complex patterns in pictures, text, sounds, and other data to produce accurate insights and predictions. It makes it faster and easier to interpret large amounts of data and form them into meaningful information.

This memory includes three chapters:

In the first chapter, We present general information about artificial intelligence, machine learning, deep learning, CNN architecture, pre-trained models and Transfer Learning (TL),.

In the second chapter, We have identified coronavirus and we provided information about the COSWARA database we have used.

In the last chapter, We present the results of this work, where we compared different models (vgg16,vgg19, google net and Alex net) and see which one is better.

The main goal In this work is to facilitate the classification of whether or not a person has COVID-19 by spectrogram using deep learning techniques and CNN models.

1

Deep learning, Convolutional Neural Networks and Transfer Learning

1.1 Introduction

The concept of DL is not new. It's a hype topic these days because before we didn't have a lot of processing power and a lot of data. Over the last 20 years, processing power has increased significantly, in this chapter we will first introduce concepts related to deep learning. [1] Moreover, it has gradually become the most widely used computational approach in the field of ML, achieving outstanding results on several complex cognitive tasks, matching or even beating those provided by human performance. One of the benefits of DL is the ability to learn from massive amounts of data. [2]

In this chapter, we present the idea of deep learning methods CNN and we will be interested in the CNN pre-trained model.

1.2 Artificial Intelligence (AI)

Is a branch of computer science. It involves developing computer programs to complete tasks which would otherwise require human intelligence. AI algorithms can tackle learning, perception, problem-solving, language understanding and logical reasoning. Artificial Intelligence AI is used in many ways within the modern world, from personal assistants to self-driving cars. AI is evolving rapidly. While science fiction every so often portrays AI as robots closely as possible to humans. [3]

They are many applications of AI and our application as show in figure 1.1

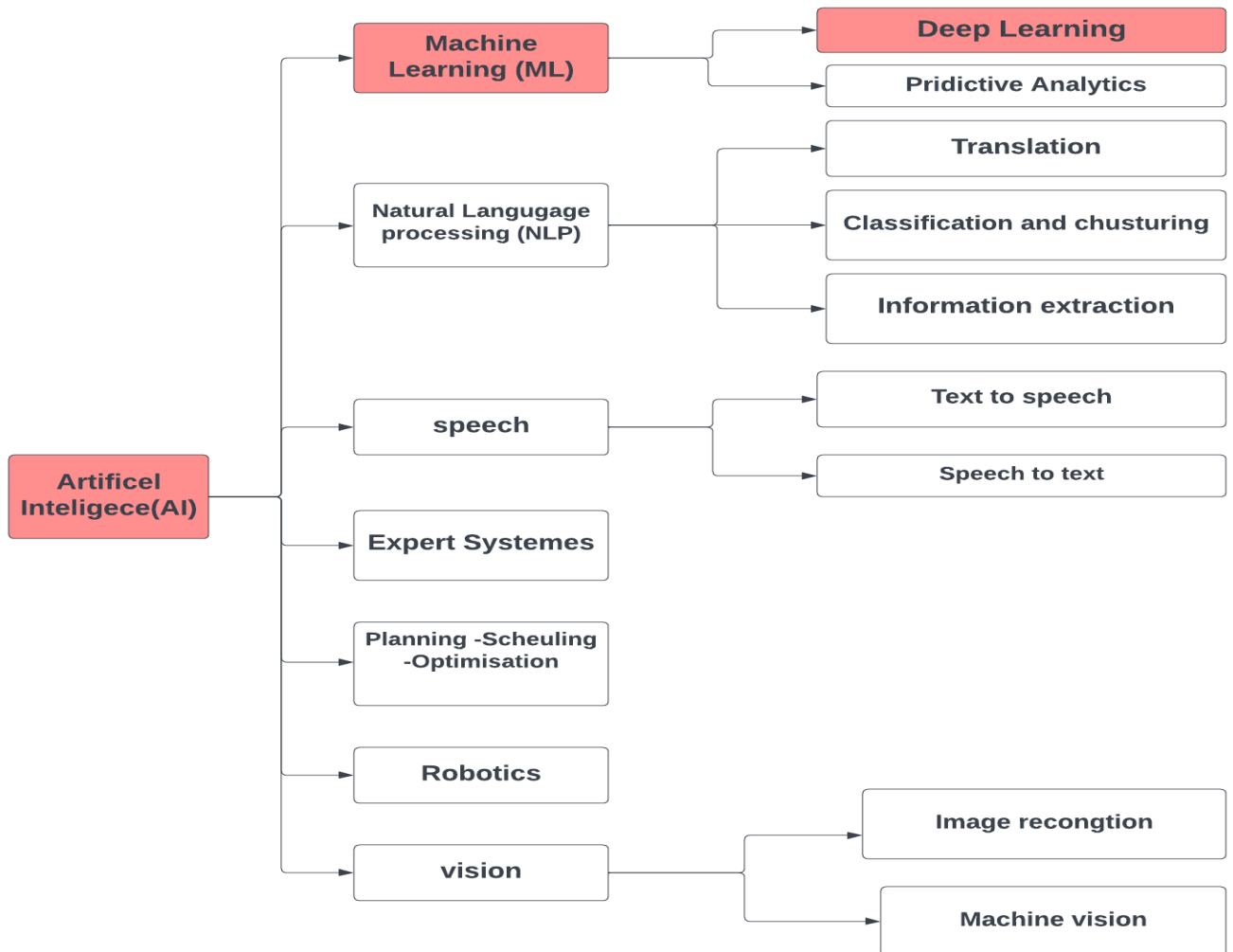


Figure 1.1: AI Branches

1.2.1 A Brief History of AI

The concept of Artificial Intelligence is not as modern as we think it is. This traces back to as early as 1950 when Alan Turing invented the Turing test. Then the first chatbot computer program, ELIZA, was created in the 1960s. [4] IBM deep blue was a chess computer made in 1977 to beat a world chess champion in two out of six games, one was won by the champion and the other three games were drawn. [5] In 2011, Siri was announced as a digital assistant by Apple. Elon Musk and some others founded OpenAI in 2015. [6]

1.3 Machine Learning (ML)

Is the scientific study of algorithms and statistical models that computer systems use to perform a specific task without being explicitly programmed. Learning algorithms in many applications that we make use of daily. Every time a web search engine like Google is used to search the internet, one of the reasons that work so well is because of a learning algorithm that has learned how to rank web pages. These algorithms are used for various purposes like data mining, image processing, predictive analytics, etc. to name a few. The main advantage of using machine learning is that, once an algorithm learns what to do with data, it can do its work automatically. [7] The difference between ML and classical programming as show in figure 1.2

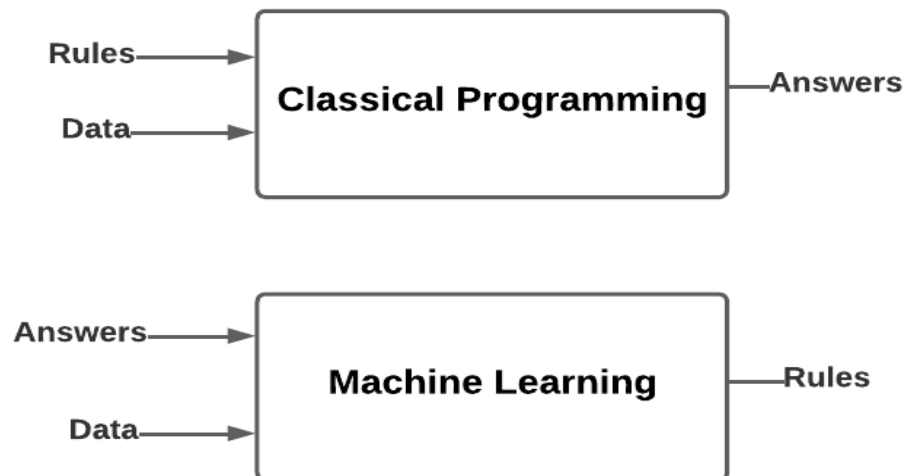


Figure 1.2: The difference between ML and classical programming

1.3.1 Types of Machine Learning

Machine Learning ML can be divided according to the nature of the data labelling into supervised, Machine Learning Types as shown in figure 1.3

A) Supervised Learning

A training set of examples with the correct responses (targets) is provided and, based on this training set, the algorithm generalises to respond correctly to all possible inputs. This is also called learning from exemplars. Supervised learning is the machine learning task of learning a function that maps an input to an output based on example input-output pairs. [8]

B) Unsupervised Learning

Unsupervised learning is a type of machine learning algorithm used to draw inferences from datasets consisting of input data without labelled responses. In unsupervised learning algorithms, classification or categorization is not included in the observations. There are no output values and so there is no estimation of functions. Since the examples given to the learner are unlabeled, the accuracy of the structure that is output by the algorithm cannot be evaluated. [8]

C) Semi-supervised Learning

These algorithms provide a technique that harnesses the power of both supervised learning and unsupervised learning. In the previous two types output labels are either provided for all the observations or no labels are provided. There might be situations when some observations are provided with labels but majority of observations are unlabeled due to high cost of labeling and lack of skilled human expertise. In such situations, semi-supervised algorithms are best suited for model building. [9]

D) Reinforcement Learning

Is regarded as an intermediate type of learning as the algorithm is only provided with a response that tells whether the output is correct or not. The algorithm has to explore and rule out various possibilities to get the correct output. It is regarded as learning with a Critic as the algorithm doesn't propose any sort of suggestions or solutions to the problem. [9]

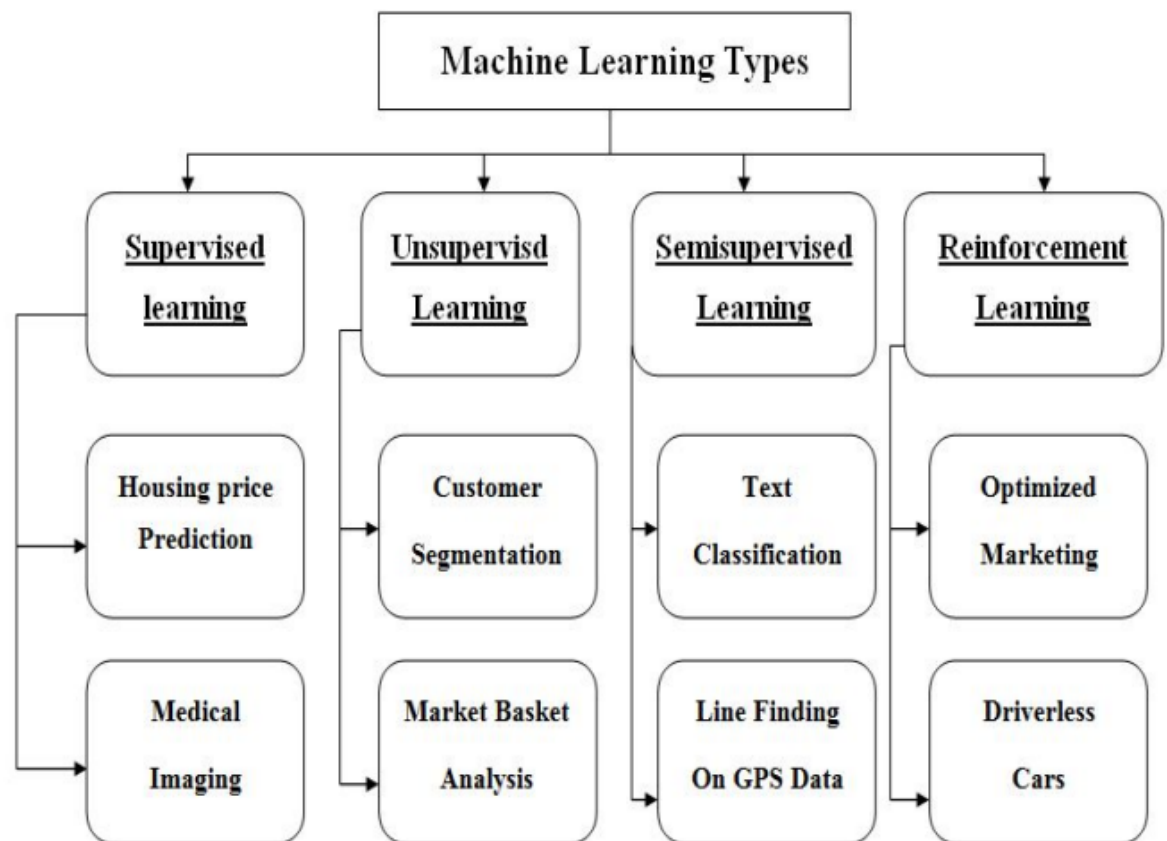


Figure 1.3: The Machine Learning Types

1.4 Deep Learning (DL)

Is a function of AI that mimics the functioning of the human brain in processing data and creating models for use in decision-making. DL is a subset of machine learning in AI that has networks capable of learning unsupervised from unstructured or unlabeled data. Also known as deep neural learning or deep neural network . [1]

DL based applications can learn without human supervision, relying on both unstructured and unlabeled data. We present in this part the types of existing DL as well as the known architectures . [10]

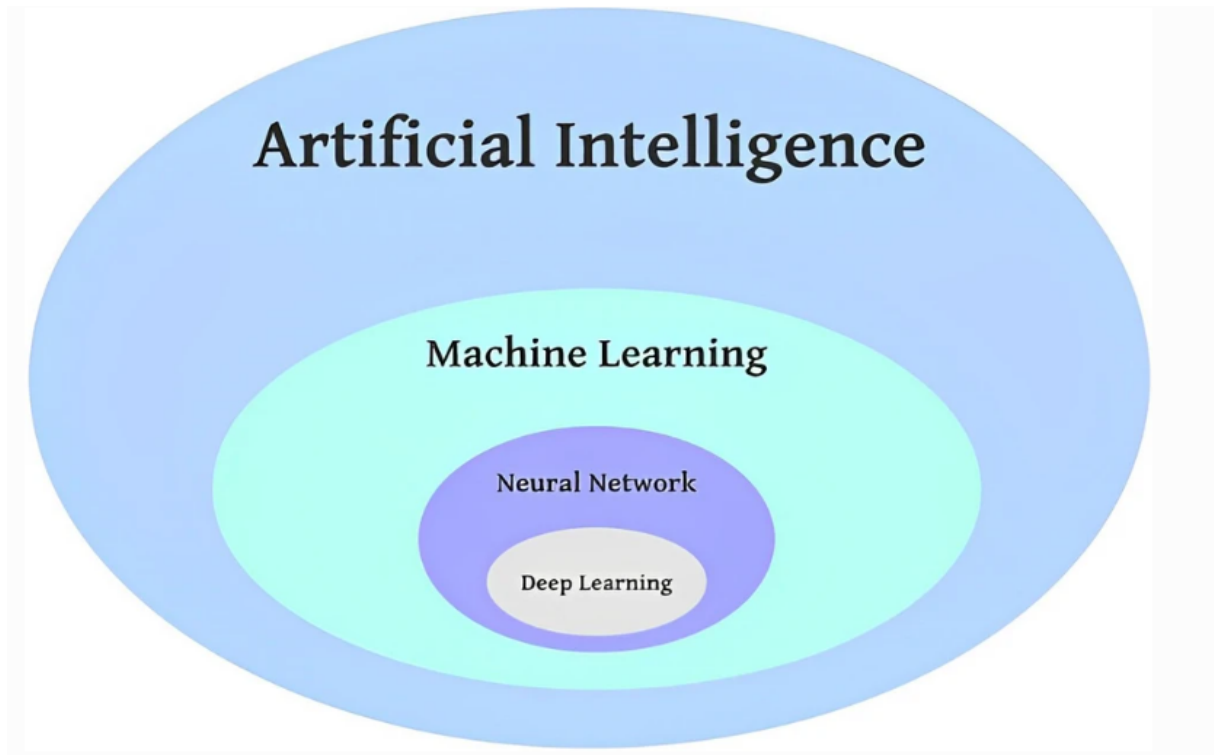


Figure 1.4: Relationship between AI,ML,NN , and DL approach

1.4.1 Application Areas of Deep Learning

Deep learning technology is one of the most widely used techniques in many fields, including:

A) Facial Recognition

It will first be a question of giving a certain number of images to the algorithm, then by dint of training, the algorithm will be able to detect a face on an image.

B) Natural Language Processing

Natural language processing is another application of DL. Its goal is to extract the meaning of words, even sentences to do sentiment analysis.

C) Self-Driving Cars

Companies that build such types of driver assistance services, must teach a computer to master certain essential parts of driving using digital sensor systems instead of the human mind. To do this, companies usually start by training algorithms using large amounts of data.

D) Voice Search and Voice-Activated Assistants

One of the most popular areas of use of DL is voice search and voice-activated smart assistants. With the big tech giants have already made significant investments in this area.

E) Machine Translation

This is a task in which words, phrases or sentences given in one language are automatically translated into another language. Machine translation has been around for a long time, but DL achieves the best results in two specific areas:

- Machine translation of text .
- Machine translation of images.

F) Marketing Research

In addition to researching new features that may improve your application, DL can also be useful in the background. Market segmentation, marketing campaign analysis and many more can be improved using regression models and DL classification . [11]

1.4.2 The difference between Machine learning and Deep learning

Machine learning is a subset of AI that involves teaching computers to learn patterns in data and make decisions based on that learning. It is a data-driven approach, where the computer

is given a set of data and algorithms to learn from that data. The algorithms are designed to identify patterns and relationships in the data, and then make predictions or decisions based on those patterns. DL, on the other hand, is a subset of machine learning that involves the use of deep neural networks. Neural networks are designed to mimic the way the human brain works, with layers of interconnected nodes that process and transform information. Deep neural networks have many layers, allowing them to learn and model complex patterns in data, making them particularly effective in areas such as image and speech recognition. In summary, machine learning is a broader field that encompasses many different techniques for teaching computers to learn from data, while deep learning is a specific subset of ML that involves the use of deep neural networks.

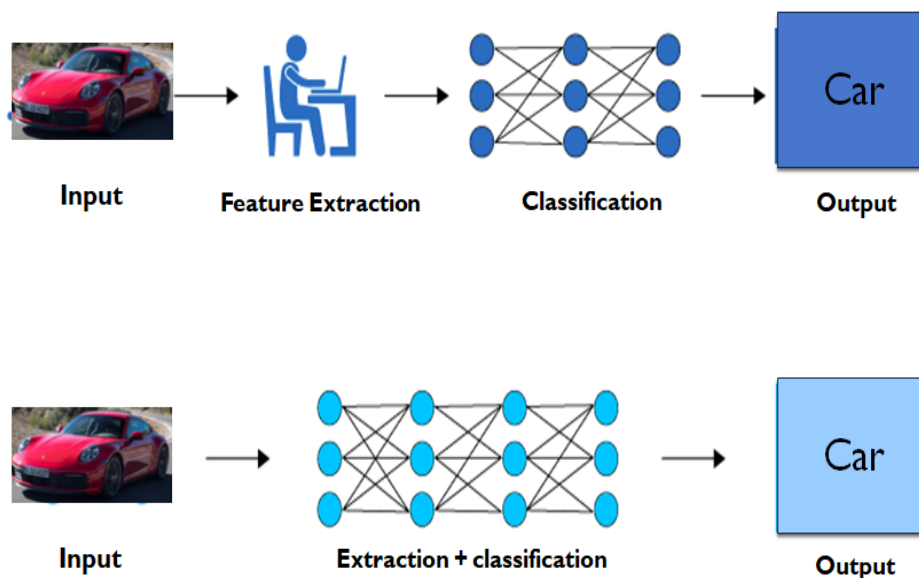


Figure 1.5: The difference between Machine learning and Deep learning

1.5 Artificial Neural networks

1.5.1 Biological Neural

The Artificial Neural networks is inspired by the architecture of biological neurons such as the human brain. The human brain is composed of a very large number of interconnected neurons. Each neuron is a cell that performs a simple task, such as a response to an input signal.

However, when a network of neurons are connected together, they can perform complex tasks, such as speech and image recognition, with amazing speed and accuracy. Usually, it takes a few hundred milliseconds for a human to complete a task such as recognizing a face, while the brain's individual neuron has a computing speed of a few milliseconds. This shows that the brain takes just a hundred computing steps to perform such task [11] compared to millions of steps needed for a computer to perform a similar task. Such short processing time implies that the information transmitted between neurons must be very small. Unlike the traditional computer, the whole information is not passed from neuron to neuron but encoded in the complex interconnection of the neuron network. This is why neural network is also called connectionism. A neuron is consisted of dendrites, a cell body, and an axon as shown in Fig 1.6 . The cell body, also called the soma , contains the nucleus, just like other cells. The dendrites are branches that connected to the cell body and extended in space to receive signals from other neurons. The axon is the transmitter of the neuron. It sends signals to neighboring neurons. The connection between the end of one neuron's axon and the neighboring neuron's dendrites is called the synapse , which is the communication unit between two neurons. Electrochemical signals are transmitted across the synapse. When the total signal a neuron received is greater than the synapse threshold, it causes the neuron to fire, that is, send an electrochemical signal to neighboring neurons. It is postulated that the altering of the strength of the synaptic connection is the basis of memory. [12]

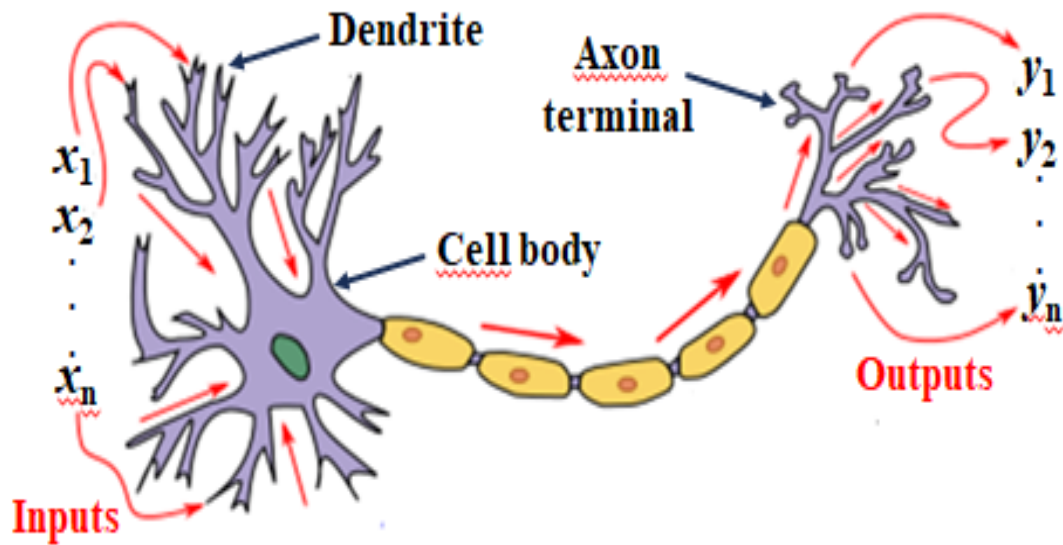


Figure 1.6: A sketch of biological neuron

1.5.2 Artificial Neural

The Artificial Neural Network (ANN) is modelled on the biological neural network. Like the biological neural network, the ANN is an interconnection of nodes, analogous to neurons. Each neural network has three critical components: node character, network topology, and learning rules. Node character determines how signals are processed by the node, such as the number of inputs and outputs associated with the node, the weight associated with each input and output, and the activation function. Network topology determines the ways nodes are organized and connected. Learning rules determine how the weights are initialized and adjusted. [12]

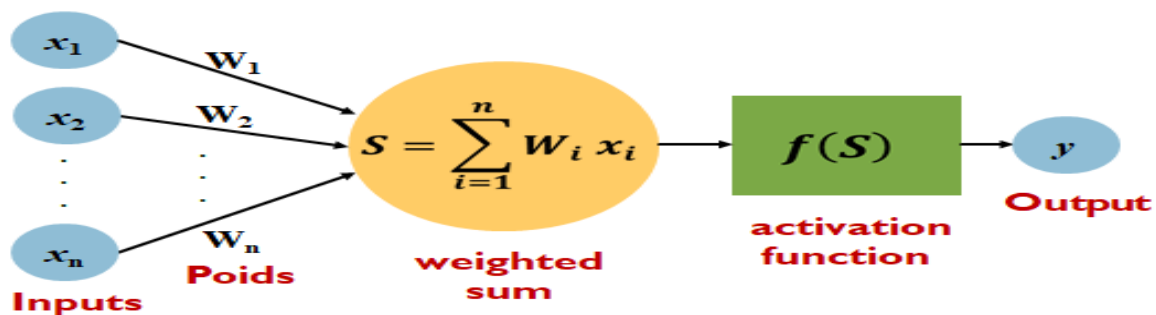


Figure 1.7: A basic model of a single node

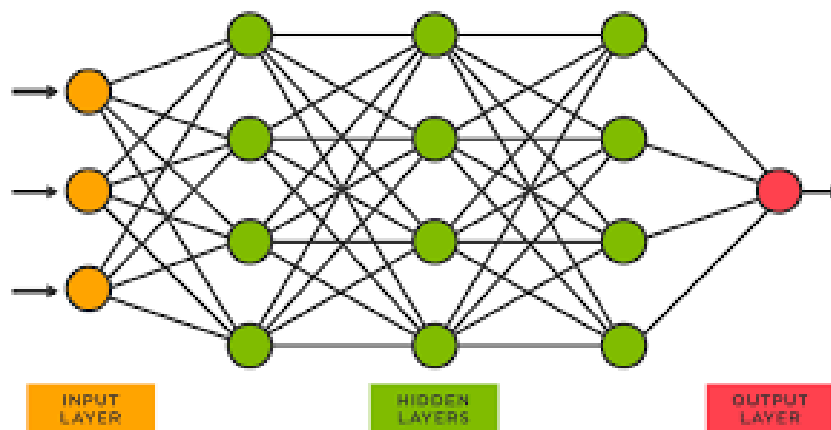


Figure 1.8: Example of le réseau de neurone artificielle

1.6 Convolutional Neural Network

Computer vision is rapidly changing day by day. One of the reasons is the development of deep learning. When we talk about computer vision, a term convolutional neural network. Designated by the acronym CNN for English Convolutional Neural Network, they have two very distinct parts: The first part of a CNN is the convolutional part strictly speaking. It works as an image feature extractor. An image is passed through a succession of filters, or convolution kernels, creating new images called convolution maps. Some intermediate filters reduce the resolution of the image by a local maximum operation. Finally, the convolution maps are

flattened and concatenated into a feature vector, called CNN code. This CNN code at the output of the convolutional part is then connected to the input of a second part, made up of fully connected layers. The role of this part is to combine the characteristics of the CNN code to classify the image. The output is a final layer with one neuron per category. The values a probability distribution over the categories. [1]

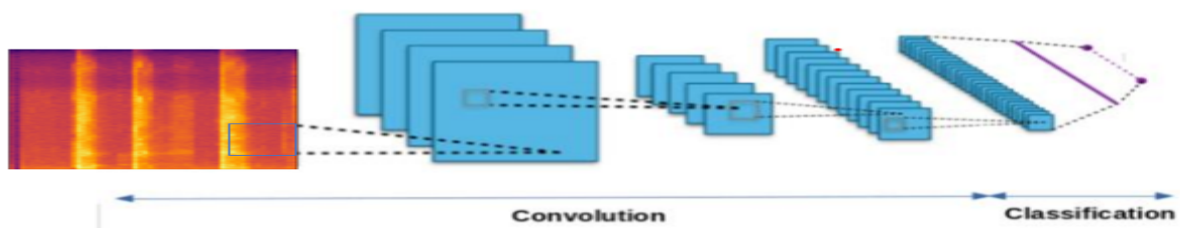


Figure 1.9: Convolutional neural networks

1.6.1 Layers of Convolutional Neural Networks

There are several different layers in CNN . [13]

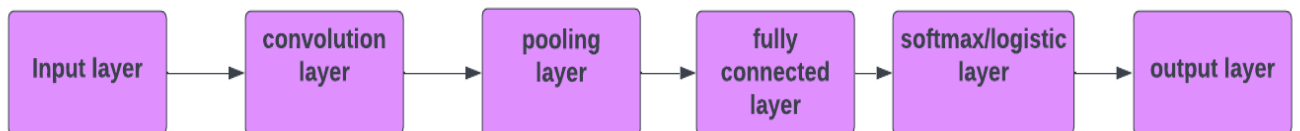


Figure 1.10: CNN layers

A) THE Convolutiona Layer (CONV)

It is the most important layer and the heart of the building blocks of the convolutional network, and it is also the one that performs the most heavy calculations, because the features of the image are extracted in this layer. [1]

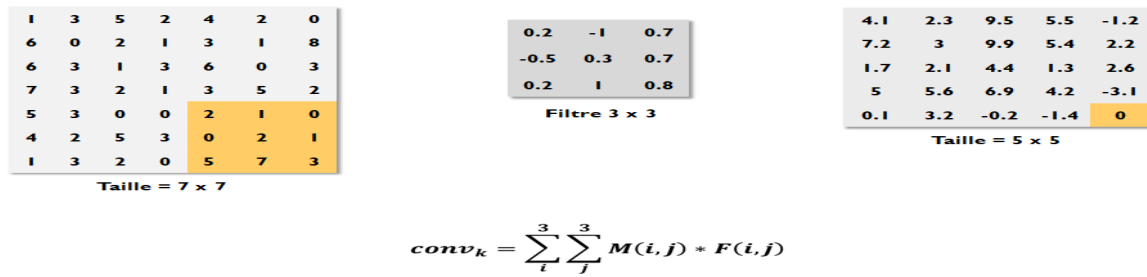


Figure 1.11: Example of convolutional filter principle

B) Padding

Zero-padding refers to surrounding a matrix with zeroes. This can help preserve features that exist at the edges of the original matrix and control the size of the output feature map. [14]

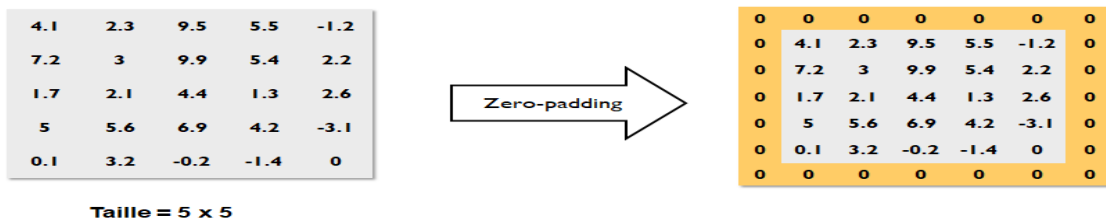


Figure 1.12: Example of convolutional filter principle

C) Rectified Linear Unit (ReLU)

The Rectified Linear Unit (ReLU) layer is a function of activation, which makes every negative input equal to zero. Because of which the training process and other calculations speed up and helps elude the gradient issue. If x is the neuronal input, this function can be represented by the following formula:

$$f(x) = \max(0, x) \quad (1.1)$$

[14]

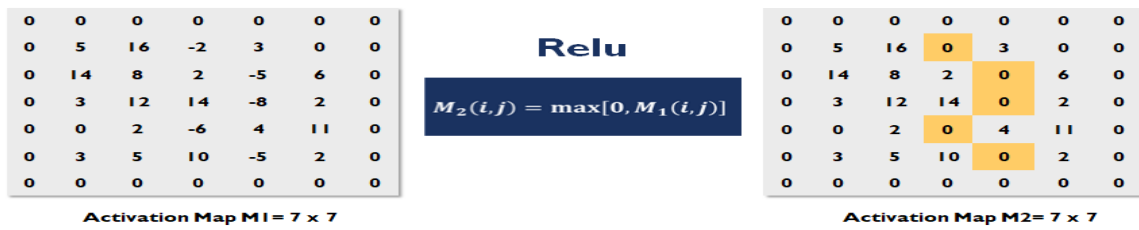


Figure 1.13: Example of RELU

D) The Pooling Layer

It receives as input several feature maps and applies the pooling operation to each of which. Pooling operation consists of reducing the images sizes while preserving their significant features by using a filter (usually of size 2×2 and a stride of the same length). Max pooling is the most popular pool layer. It is applied to the input volume and outputs the maximum value in every subregion that the filter convolves around. Average pooling is other kinds for pooling layers [15]. The pooling layers reduce the map parameters which reduces calculations in the network in order to prevent over learning. [16]

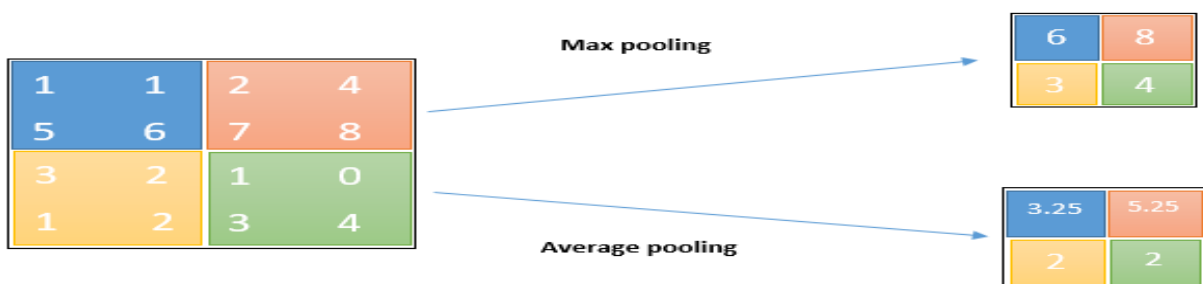


Figure 1.14: the Pooling operation

E) Fully Connected Layer (FC)

After several layers of convolution and max-pooling the high-level reasoning in the neural network is done via fully connected FC layers .It connects neurons in one layer to neurons in another layer. It is used to classify images between different categories by formation. [17]

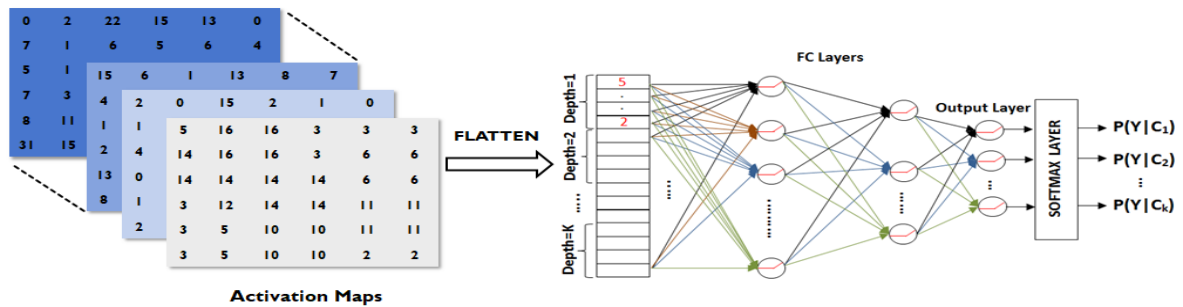


Figure 1.15: FC layer principle

1.7 Transfer Learning

The deep CNNs are still extensively employed in current research. They offer innovative support to overcome several classification challenges. The lack of training data is a common problem in employing deep CNN models which require a large amount of data to perform well. Furthermore, collecting a large dataset is tedious, and it even now continues. Therefore, the TL technique is currently employed to overcome the small dataset issue [18]. This technique is extremely effective in solving the problem of a lack of training data. TL is a mechanism where CNNs models are trained on dataset with large amount of data, and then the models are finetuned to train on a small desire dataset [19], as show in figure 1.16

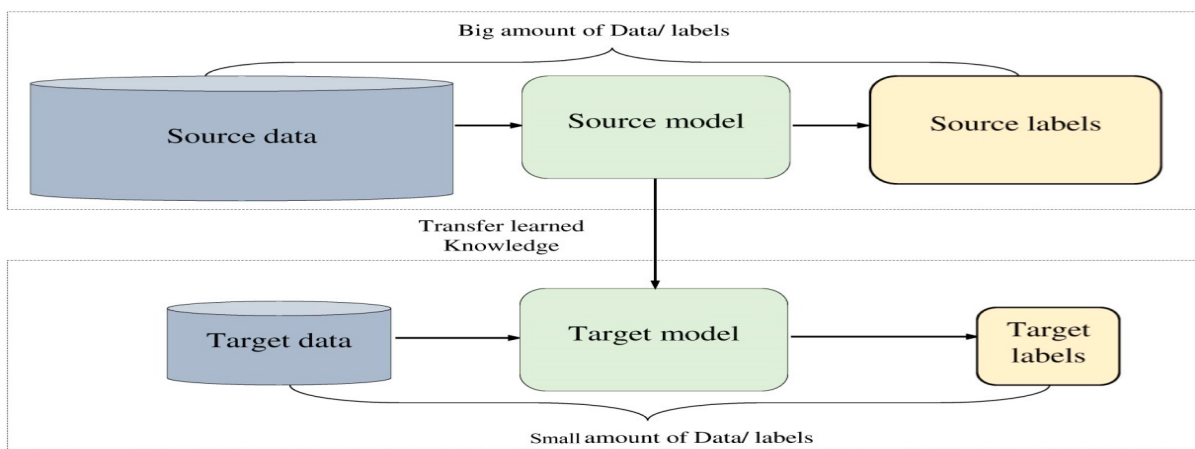


Figure 1.16: Transfer learning technique.

1.7.1 Advantages of transfer learning

When comparing with traditional methods, advantage of TL is that it can do multi-task learning. Traditional models face different types of tasks and need to train multiple different models. While with TL, we can first implement simple tasks and apply the knowledge obtained from simple tasks to deal with more difficult problems so as to solve problems faster and better [20]

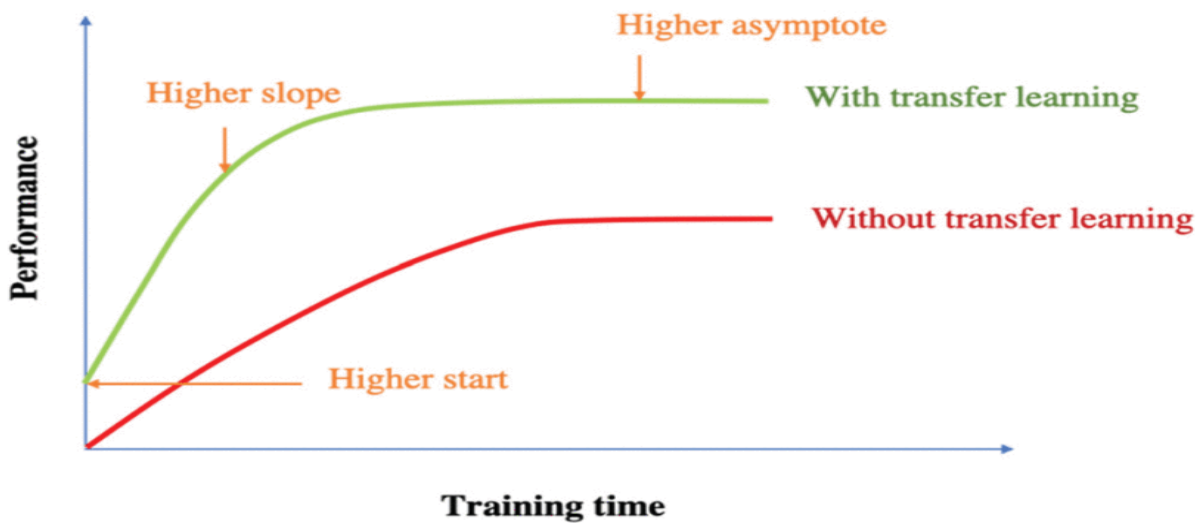


Figure 1.17: Advantages of transfer learning

1.7.2 Pre-trained CNN Networks

Several CNN designs Pre-trained have been proposed in the last ten years. The architecture of a model is an important aspect in increasing the performance of many applications. From 1989 until the present, several adjustments to CNN architecture have been made. Structure reformulation, regularization, parameter optimizations, and other changes are examples of such changes. On the other hand, it should be emphasized that the major improvement in CNN performance was primarily attributable to the restructuring of processing units and the development of new blocks. The utilization of network depth was used to conduct the most novel breakthroughs in CNN design. CNN architectures have made major contributions in a variety of domains. As a result, names like Alex Net, Visual geometry group (VGG), and Google Net. Currently, these networks are employed in the Classification and other tasks [16]. As a result,

we'll go through their designs in detail.

A) Alex net

Alex net includes five convolution layers and three fully connected layer and in total 8 layers. Several layers of convolutional filters are included in each convolutional layer, along with a nonlinear activation function called The Rectified Linear Unit layer maximum pooling is performed over the pooling layers, and the size of the inputs is fixed due to the presence of fully connected layers. It is mentioned that the input size is $224 \times 224 \times 3$, but due to some padding which occurs, it turns out to be $227 \times 227 \times 3$. Alexnet has an overall number of 60 million parameters. [21]

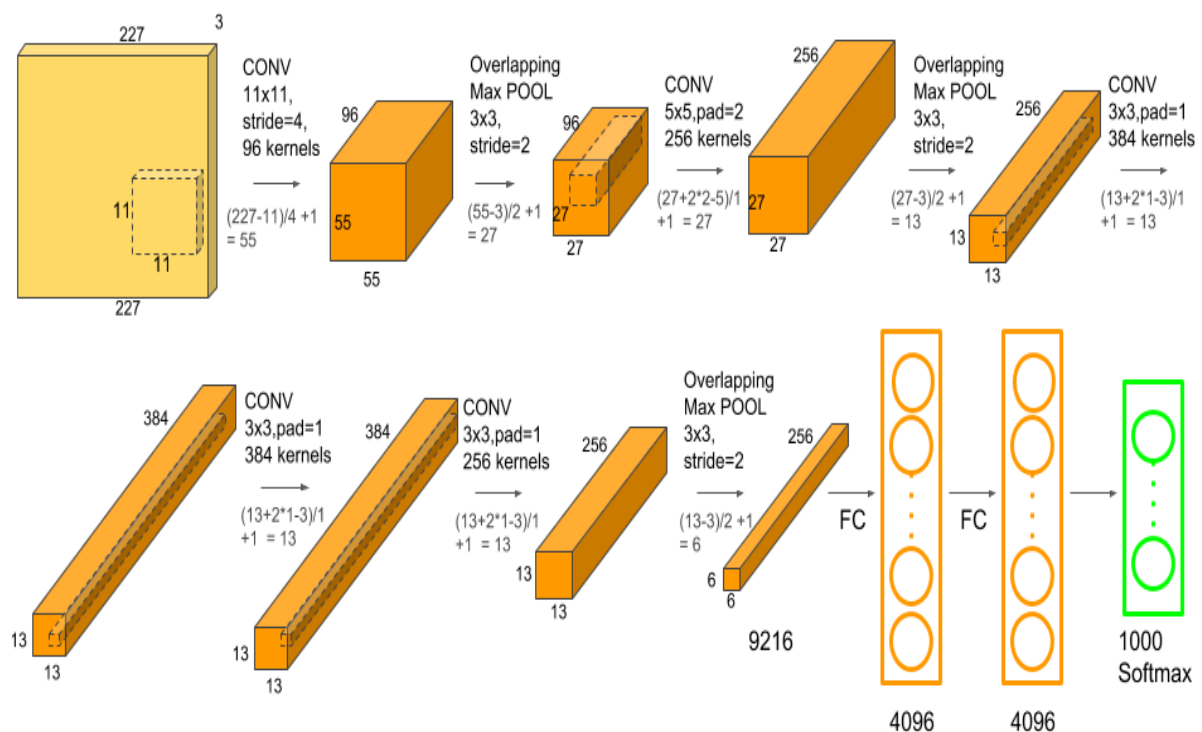


Figure 1.18: The Alex net Architecture

B) Visual Geometry Group (VGG 16)

Visual Geometry Group (VGG 16) is a CNN model designed by Simonyan and Zisserman. They achieved 92.7% top-5 test accuracy in the ImageNet dataset. It trained for weeks and was using NVIDIA Titan Black Graphic processing unit (GPU)s. (VGG 16) has 16 convolutional layers of 3x3 dimensions, average-pooling layers of 2x2 dimensions, and FC layers. The neural network's initial width is 64, then, the width is doubled after each pooling layer, Figure 1.19 presents (VGG 16) architecture. [22]

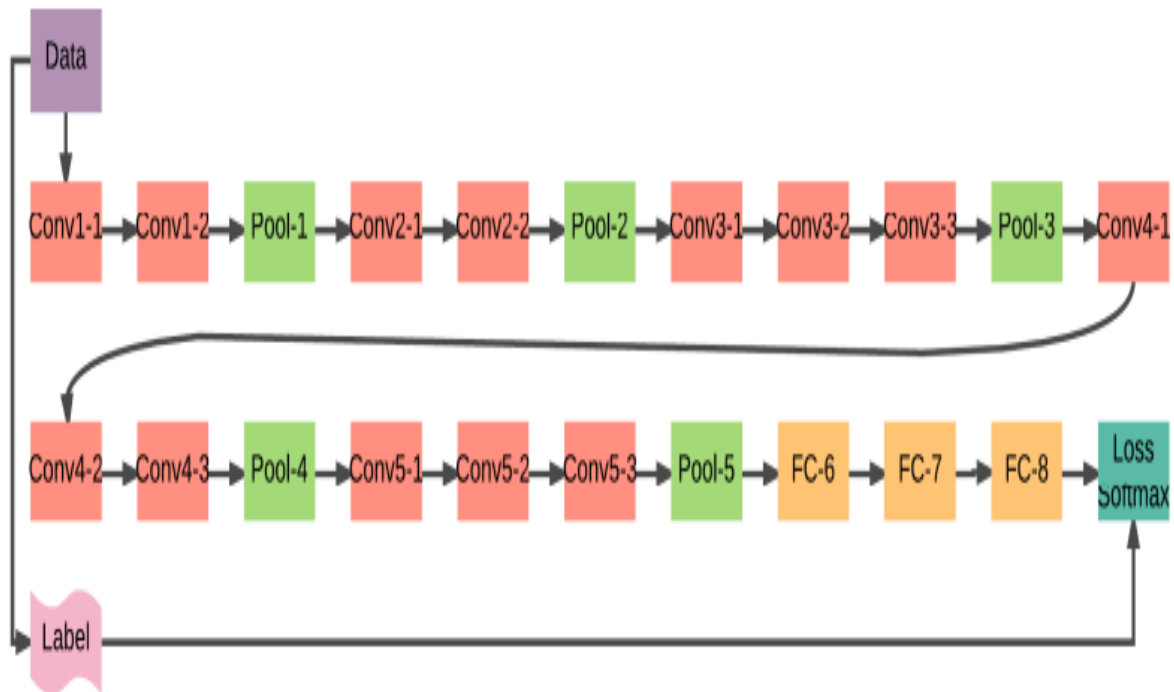


Figure 1.19: The VGG16 architecture

C) Visual Geometry Group (VGG 19)

The VGG19 architecture is structured starting with five blocks of convolutional layers followed by three fully-connected layers. Convolutional layers use 3×3 kernels with a stride of 1 and padding of 1 to ensure that each activation map retains the same spatial dimensions as the previous layer. A rectified linear unit (ReLU) activation [23] is performed right after each convolution and a max pooling operation is occasionally used to reduce the spatial dimension. Max

pooling layers use 2×2 kernels with a stride of 2 and no padding to ensure that each spatial dimension of the activation map from the previous layer is halved. Two fully-connected layers with 4,096 ReLU activated units are then used before the final 1,000 fully-connected softmax layer [24]. The architecture is shown in figure 1.20

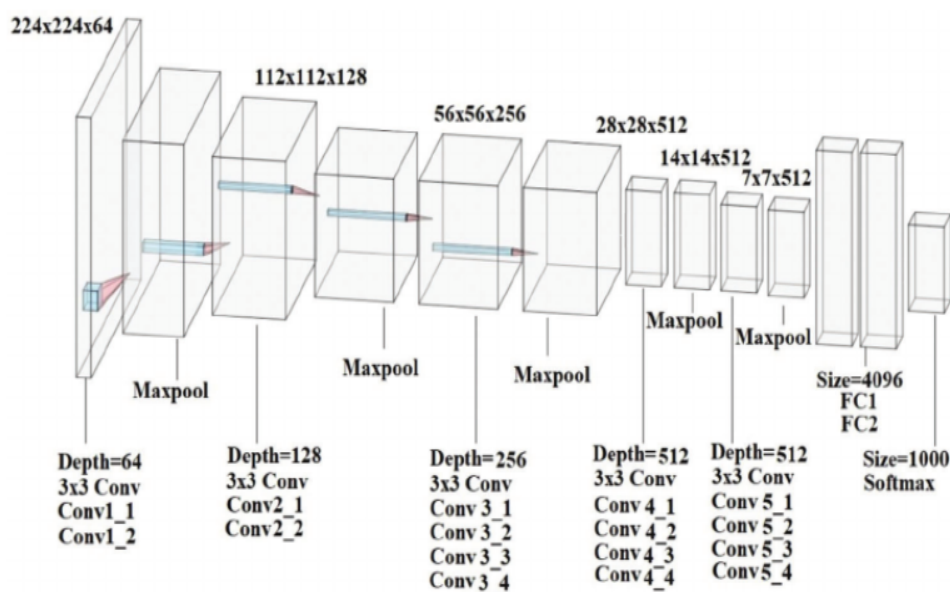


Figure 1.20: The VGG19 architecture

D) Google Net

GoogLe Net is a 22 layer architecture from google , having an error rate of 6.67% that is nearer to humal level performance . Inception module forms the important component of this deep neural network. GoogLeNet has nine inception modules.gives a detailed view of the inception module. GoogLeNet concentrates on the correlation between nearby pixels in an image. GoogLeNet employs 1×1 convolutions to increase the depth and width of the network and to reduce the dimensionality without compromising in performance. 1×1 convolution can help to reduce model size which can also somehow help to reduce the overfitting problem. The inception block is doing cross channel correlations by performing the 1×1 convlution. This is followed by 3×3 and 5×5 filters to perform cross-spatial and cross-channel correlations. In GoogLeNet the multi-level feature extraction is done on the same input with the help of inception module having multiple convolution filters. The results of these 1×1 , 3×3 and

5×5 convolutions are then concatenated. GoogLeNet eliminates large number of parameters by using average pooling instead of Fully Connected layers. It has only 4 million parameters whereas AlexNet has 60 million. [25]

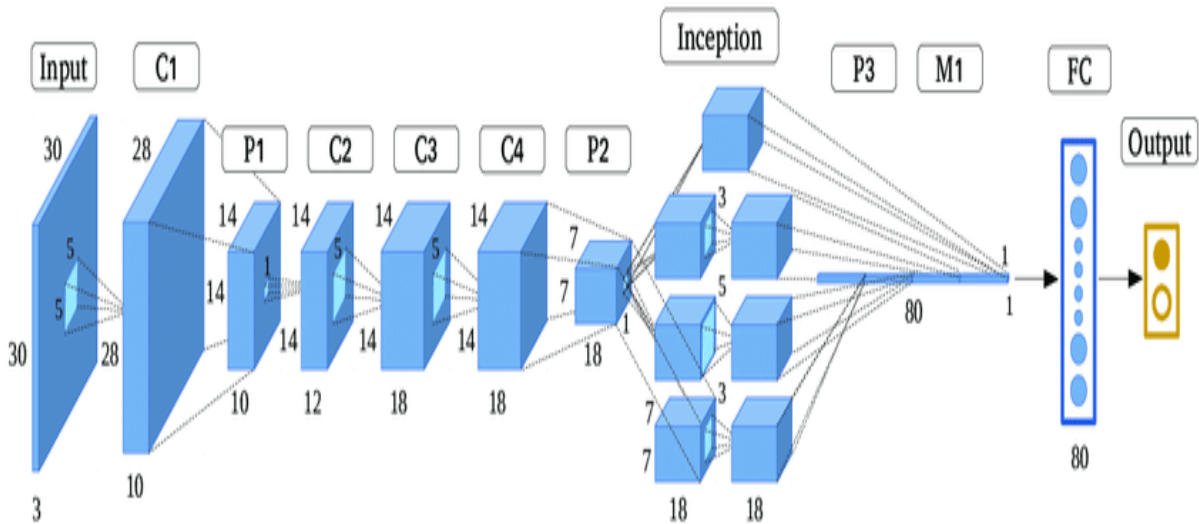


Figure 1.21: The google net architecture

1.8 Conclusion

In this chapter we discussed various principles related to DL .DL networks are ML methods based on neural networks. Then, using the methodology we used in our research, we determined the precise structure of a CNN , certain CNN pre-trained models, the layers of CNN , how they function, and how to advance to the TL process. Last but not least, we examined some well-known CNN designs. The following chapter introduces the many Covid-19 related subjects, including databases and classification.

2

Covid-19,Database and Classification

2.1 Introduction

COVID-19, also known as the Coronavirus, has been one of the most common diseases in the last three years, infecting over 534 million people and killing over 6.31 million. According to the World Health Organization, it has been labelled a pandemic in a survey of at least 200 nations. COVID-19 is considered one of the epidemics that cause serious respiratory infections, causing the loss of many lives recently all over the world, especially in countries with limited economic resources where they cannot provide the necessary capabilities to confront this pandemic . [26]

In this chapter, we focus on the Corona virus, where we provided an overview of this virus, classification, and how to prepare and complete the database.

2.2 Coronaviruses

Are a large family of viruses that cause illness ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome and Severe acute respiratory syndrome coronavirus (SARS-CoV) . A novel coronavirus is a new strain that has not been previously identified in humans. [27]

COVID-19 is caused by the novel SARS-CoV-2 coronavirus, and its emergence has propelled the scientific community towards action in search of treatment and prevention methods. Modifying known pharmaceutical treatments or developing new therapies are among the key goals in the fight against the rapidly evolving virus. Second, as a more permanent measure, the scientific and larger pharmacological sector have been challenged with developing, testing, and mass-producing a safe and effective vaccine to prevent further transmission and recurrence among the population. [28]

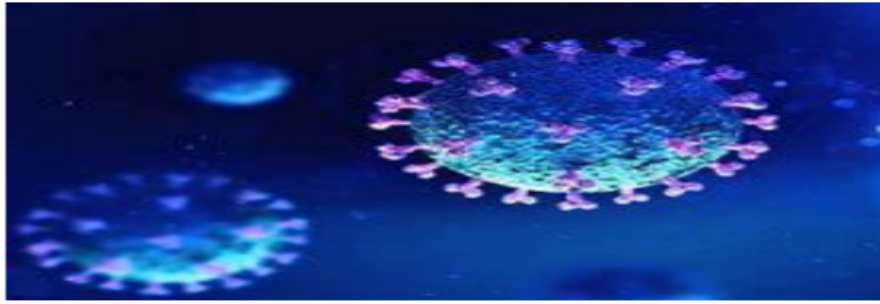


Figure 2.1: The image showing the shape of the coronavirus

2.2.1 Coronavirus spread

COVID-19 is most likely to spread from person-to-person through:

- Close contact with a person while they are infectious or in the 24 hours before their Symptoms appeared.
- Close contact with a person with a confirmed infection who coughs or sneezes.
- Touching objects or surfaces (such as door handles or tables) contaminated from a cough or sneeze from a person with a confirmed infection, and then touching your mouth or face. [29]

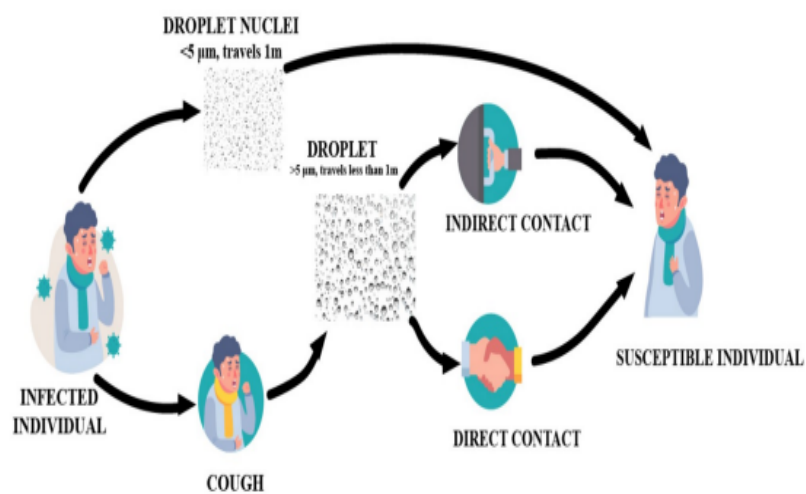


Figure 2.2: The schematic of Ways of transmission of covid-19

2.2.2 The symptoms of COVID-19

The symptoms of COVID-19 are similar to other colds and flus and include:

- Fever
- Sore throat
- Cough
- Tiredness
- Difficulty breathing.

While coronavirus is of concern, it is important to remember that most people displaying these Symptoms are likely suffering with a cold or other respiratory illness – not coronavirus. [29]

2.3 Database

2.3.1 Coswara database

The Coswara project is aimed at developing a diagnostic tool for COVID-19 based on respiratory, cough and speech sounds [30]. Public participants were asked to contribute cough recordings via a web-based data collection platform using their smartphones . The collected audio data includes fast and slow breathing, deep and shallow coughing, phonation of sustained vowels and spoken digits. Age, gender, geographical location, current health status and pre-existing medical conditions are also recorded. Health status includes healthy, exposed, cured or infected. Audio recordings were sampled at 44.1 KHz and subjects were from all continents except Africa, as shown in Figure 2.3 In this study, we have made use of the raw audio recordings and applied pre-processing .

The Coswara Dataset is sub-database created by IIScleap .This database consists of audio sound clips of heavy coughing from covid positive and covide negative patiens from various locations in the world (five continents: Asia(90%),North America (5%) ,south America (0.14%),Europe(2.5%) and Australia) from last two years (i.e. year 2020 to 2022) . The data is puplic to use under license attribution-non commercial-node rivatives 4.0 international, and allrights ,libilities and responsibilities related to the usage of database for research purpose de-

depends on the IISc. at the github repo .

This database (subset) is created in an intention to created a guide for extracting . pre-processing and executing various audio data features to classify covid-19 patient. [31]

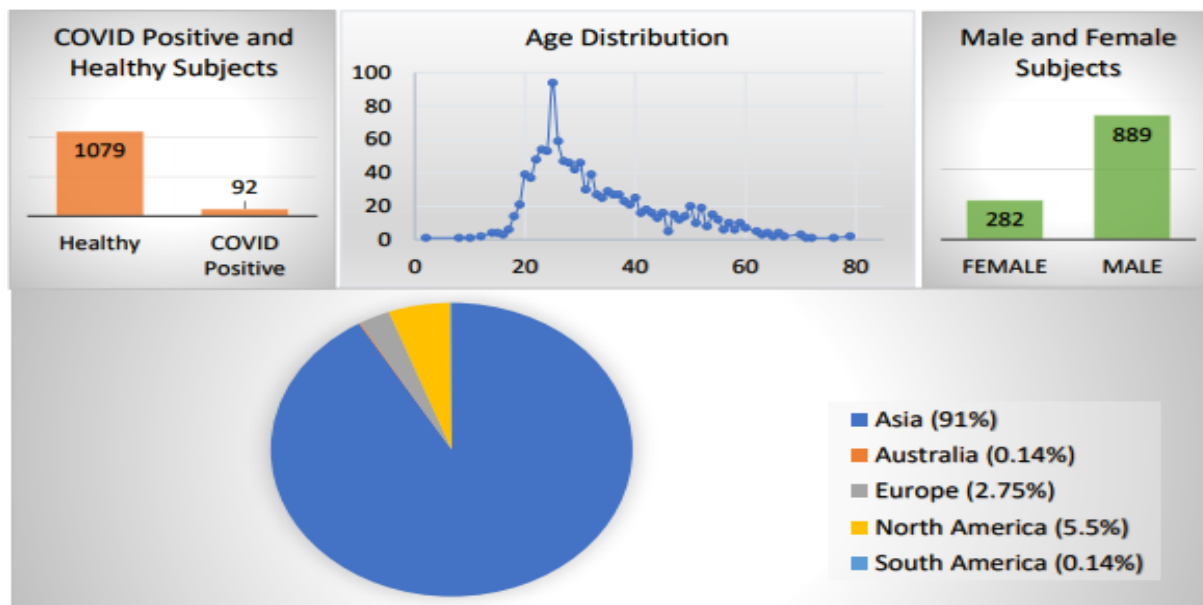


Figure 2.3: coswara database

All information about it is available in the following link : [32]

2.4 Analysing spectrograms

Spectrogram A speech waveform consists of a series of different events change over time. corresponding to this time-varying property Spectral properties that vary greatly over time. at last, A single Fourier transform cannot capture this speed Time-varying signals and Short-Time Fourier Transform (STFT)s are used instead [33]. STFT Consists of a single Fourier transform for part of the waveform under a sliding window. The spectrogram of the speech signal is then derived from the STFT.

$$S(w) = |X(m, wk)|^2 \quad (2.1)$$

Spectrograms can be the distribution of power density over time and frequency. The power density distribution of the speech signal varies greatly with time and frequency and can be

used to distinguish the normal and sick voice. It can also be seen from the figure that the power distribution of normal speech is uniform in time and frequency. However, it is also not uniform. [34]

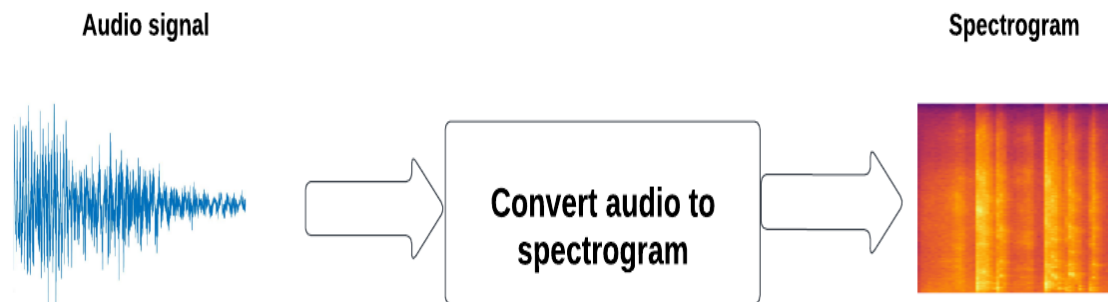


Figure 2.4: Diagram of Spectrogram

2.5 Classification

One of the first fields where DL was applied to the study of medical images was classification. In exam classification, several images (exams) are provided to the system as input. The output of the system is a single variable classifying the image as diseased or not diseased. In classification tasks, the machine learning program must draw a conclusion from observed values and determine to what category new observations belong. [35]

2.5.1 The objective of the classification

The objective of image classification is to develop a system capable of assigning an automatic classification of images. Thus, this system makes it possible to carry out a task of expertise which can prove to be expensive to acquire for a human being due in particular to physical constraints such as concentration, fatigue and the time required for a large volume of image data. [36]

2.6 Conclusion

In this chapter, we have mentioned the definition and we discussed covid-19 disease and how it can be transmitted between people and COSWARA database we used as well as an overview of classification and spectrogram. The experimental results will be discussed using a pre-trained model with different epochs and batch size, in the next chapter.

3

Results and Discussion

3.1 Introduction

This chapter presents the final experimental results for comparison Pre-trained CNN models (AlexNet, VGG16, VGG19 and GoogleNet). With epoch (50,60,70,80,90 and 100) and batch-size(16,32,64,128 and 256). The goal is to develop an AI based system for the most effective early detection of COVID-19 from sound.

3.2 Database Separation

To develop a deep learning model to detect Covid-19. For this work we chose the COSWARA database, In our practical work we split the data into two parts 80% with 373 images for training and 20% with 95 images for testing.

The database has been divided in the following way:

3.2.1 Learning images

Database consists of :

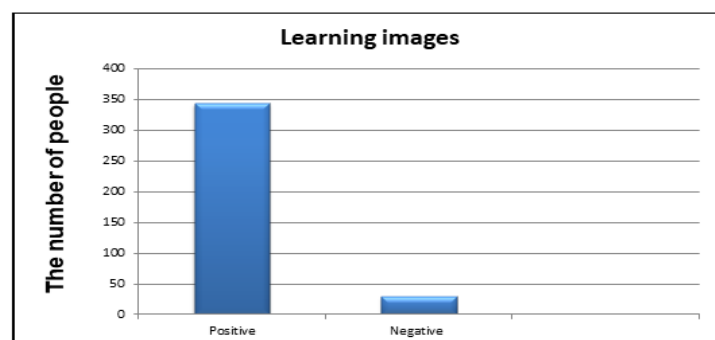


Figure 3.1: Learning images

- Positive: contains 344 people with Covid-19 .
- Negative: contains 29 people who are not infected.

3.2.2 Test images

Database consists of :

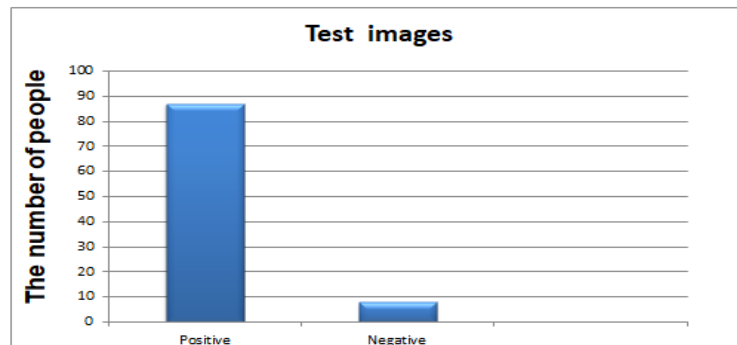


Figure 3.2: Test images

- Positive: contains 87 people with Covid-19.
- Negative: contains 8 people who are not infected.

3.3 Work environment

In this section we will introduce the hardware and software used in our work.

3.3.1 Hardware environment

- Computer: dell Inc.
- Memory (RAM): 8192 MB .
- Processor: Intel(R) core(TM) i5-73DU CPU @ 2.60 GHz (4CPUs), 2.7 GHz .
- Graphic Processing Unit: Intel(R) HD Graphics 620 .
- System type: 64-bit operating system, x64 processor .

3.3.2 Software Environment

The software tool used by our approach is: anaconda python.

3.4 Implementation

This part is reserved for the details of the development environment and the programming language used for the realization of our system.

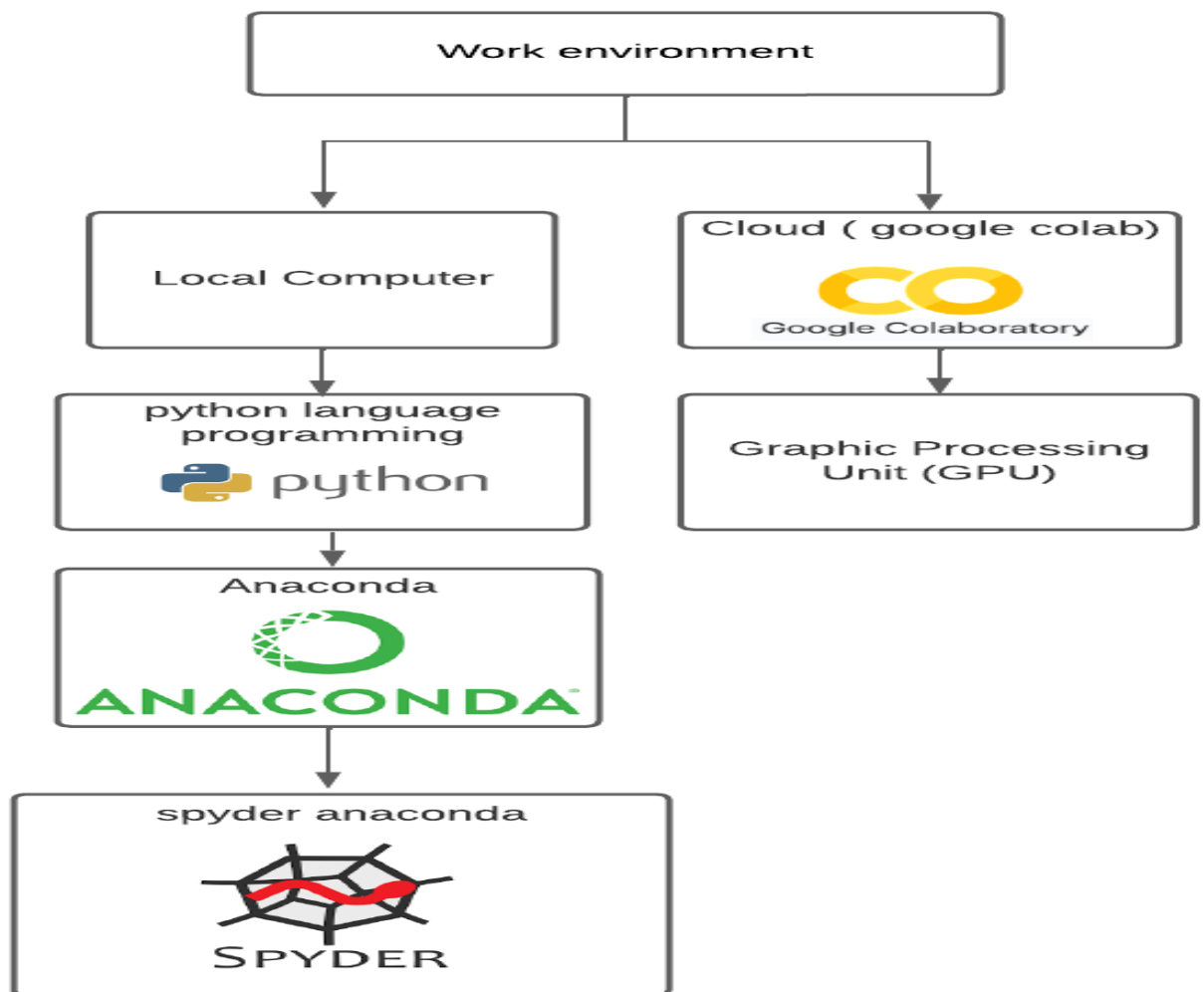


Figure 3.3: work environment

3.4.1 Local Computer

A) Python Language Programming

Python was developed at the Netherlands Institute of Mathematics and Computer Science in Amsterdam by Guido van Rossum in the late 1980s, and was first announced in 1991. The core

of the language is written in the C. Ross language called his language "Python" to express his admiration for a famous British sketch group called Monty Python. [37] Python is a high-level programming language designed to be easy to read and implement. It is open source, which means it is free even for commercial applications. Python can run on Mac, Windows, and Unix systems. [38]



Figure 3.4: Python logo

B) Anaconda

Anaconda is the name of the scientific distribution of Python. gives you the ability to create and execute any Python code through a web browser. Using Jupyter Notebook, a tool for research and training in machine learning that is offered by Anaconda Enterprise. [39]

- **Spyder**

Includes a Python terminal, a variable explorer, a code editor for writing scripts, and numerous more features. It provides robust debugging and code inspection features that enable the user to review code in its entirety or line by line in order to identify and fix errors. [40]

3.4.2 Cloud

A) Google Colab

Google Colab is a cloud Jupyter notebook widespread used to teach machine learning by writing text explanations and Python codes through the browser. [41]

3.4.3 Libraries used

- **TensorFlow:**

We defined the fundamental elements of the CNN-architecture using this library. This library gives a lot of versatility when used to create a neural network, and it is designed for the implementation of automatic and deep learning algorithms. [39]

- **Keras:**

Keras is a compact and easy-to-learn high-level Python library for deep learning . It allows developers to focus on the main concepts of deep learning, such as creating layers for neural networks, while taking care of the nitty-gritty details of tensors, their shapes, and their mathematical details. [42]

- **Numpy:**

This library, designed to handle matrices or multidimensional arrays as well as mathematical functions working on these arrays, was used to change the input types in accordance with the configuration of the models utilized. In the instance of image scanning and window extraction, we employed this library precisely. [39]

- **Matplotlib:**

Is a library of the Python programming language intended to plot and visualize data in the form of graphs, we used this library to visualize our images in the form of graphs. [39]

- **Sklearn:**

Is one of the most useful libraries for machine learning in Python. The sklearn library contains many powerful tools for machine learning and statistical modeling, including classification, regression, clustering, and dimensionality reduction . [43]

- **OpenCV:**

Is a Python library that allows you to perform image processing and computer vision tasks. It provides a wide range of features, including object detection, face recognition, and tracking. In this OpenCV Tutorial in Python, we'll be learning more about the library. [44]

- **Pandas:**

Based on the Python programming language, is a quick open source data manipulation and analysis tool that is strong, flexible, and simple to use. . [39]

- **OS:**

The OS module in Python provides functions for creating and removing a directory (folder), fetching its contents, changing and identifying the current directory, etc. You first need to import the OS module to interact with the underlying operating system. [45]

3.4.4 Submission of the application:

We are now going to present the results obtained thanks to experiments carried out by applying our approach to image classification, we use deep learning and CNN classification method. The goal : is to classify out if a person has Covid-19 or not.

3.5 Hyper-Parameters

To have the best parameters that lead to good results, we relaunched learning multiple times. The main parameters set for learning are:

A) Image size

The default input size for vgg16,vgg19, alexne and google net is 224x224.

B) The batch-size

Is the number of samples used in iteration, the right batch-size provides a sufficiently stable estimate of what the full database gradient would be. For this we have made several experiments in this context. [39]

C) Epoch

Is the total number of learning iterations, it is defined as a stopping criterion whether the results are. For this we have made several experiments in this context. [39]

D) Adam Optimizer

Optimizers are algorithms or methods that are used to change or tune the attributes of a neural network such as layer weights, learning rate, etc. in order to reduce the loss and in turn improve the model. Adam optimization is a stochastic gradient descent method that is based on adaptive estimation of first-order and second-order moments. [46]

3.6 Experimental metrics

- **Accuracy:** we can define accuracy as a measure of the capability of classifying the samples correctly, which is expressed as follows:

$$accuracy(\%) = \frac{TP + TN}{TP + TN + FP + FN} \times 100 \quad (3.1)$$

[33]

- **True Positive (TP):** Is an outcome where the model correctly predicts the positive class. [47]
- **True Negative (TN):** Is an outcome where the model correctly predicts the negative class. [47]
- **False Positive (FP):** Is an outcome where the model incorrectly predicts the positive class. [47]
- **False Negative (FN):** Is an outcome where the model incorrectly predicts the negative class. [47]

- **loss function:** It is used in binary classification problems like two classes. example a person has covid or not . Binary cross entropy compares each of the predicted probabilities to the actual class output which can be either 0 or 1. It then calculates the score that penalizes the probabilities based on the distance from the expected value. That means how close or far from the actual value.
- **Binary Crossentropy function:**

$$\text{Log Loss} = -\frac{1}{N} \sum_{i=1}^N y_i \log \hat{y}_i + (1-y_i) \log(1-\hat{y}_i)$$

Figure 3.5: Binary Crossentropy function

3.6.1 Block diagram

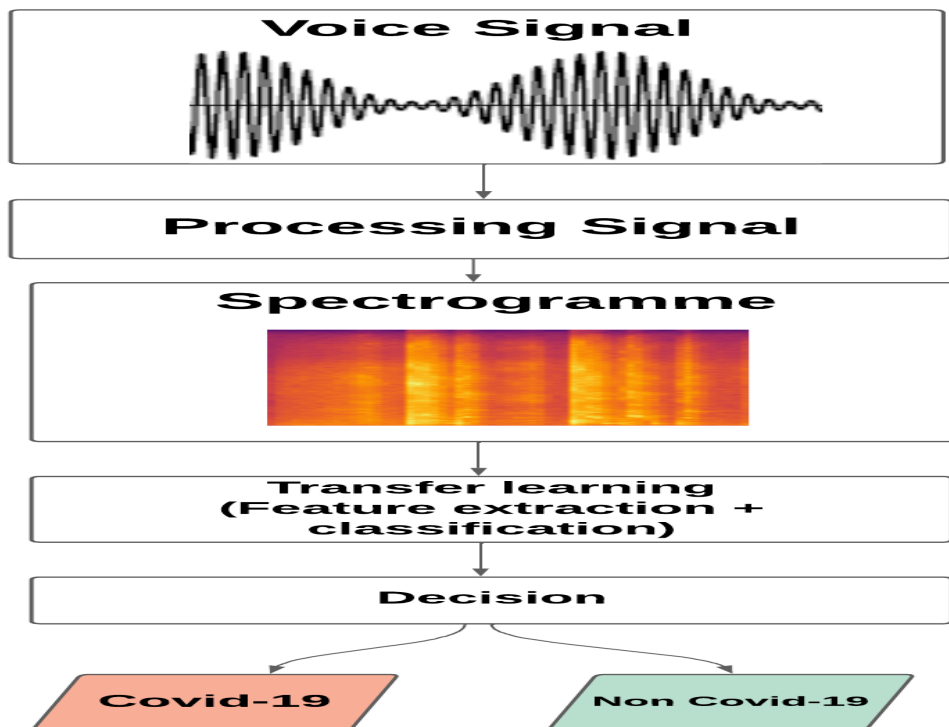


Figure 3.6: Block diagram

3.7 Experimental results

In this part, we simulate pre-trained models (vgg16, vgg19, google net, alex net) With different values of epoch 16, 32, 64, 128 and 256 and different values of batch size 50, 60, 70, 80, 90 and 100. and comparing the models with each other according to the values of accuracy and loss and deducing the best model among them .

3.7.1 VGG16

Table 3.1: VGG 16 MODEL RESULTS

		Batches			
Epochs	16	32	64	128	256
50	Acc:0.9474 Loss:0.2167	Acc: 0.9263 Loss:0.2381	Acc:0.9474 Loss:0.2403	Acc: 0.9474 Loss:0.3663	Acc: 0.9474 Loss: 0.3706
60	Acc:0.9368 Loss:0.3274	Acc: 0.9368 Loss: 0.2457	Acc:0.9474 Loss:0.3809	Acc: 0.9474 Loss:0.3475	Acc: 0.9474 Loss:0.3609
70	Acc: 0.9263 Loss:0.5870	Acc: 0.9368 Loss: 0.3118	Acc: 0.9474 Loss: 0.3510	Acc: 0.9474 Loss:0.3813	Acc: 0.9474 Loss: 0.3623
80	Acc : 0.9263 Loss: 0.3097	Acc : 0.9368 Loss: 0.2321	Acc:0.9474 Loss : 0.2245	Acc : 0.9368 Loss : 0.2296	Acc: 0.9368 Loss : 0.2264
90	Acc : 0.9474 Loss: 0.2498	Acc:0.9474 Loss: 0.2536	Acc : 0.9474 Loss : 0.2226	Acc : 0.9368 Loss: 0.2312	Acc : 0.9368 Loss: 0.2245
100	Acc: 0.9158 Loss: 0.7187	Acc : 0.9263 Loss :0.2960	Acc :0.9263 Loss:0.2744	Acc : 0.9368 Loss: 0.2274	Acc : 0.9368 Loss: 0.2235

The table show all results of accuracy and loss in the terms of two variables is epoch and batch size , we change it each time , we get all values of accuracy between 0.9158 and 0.9474 ,and loss between 0.2167 and 0.7187 .and we see the best result is on epoch 50 /batch size 16 with accuracy 0.9474 and loss 0.2167.

- VGG16 : (Epoch :50, Batch-size :16)

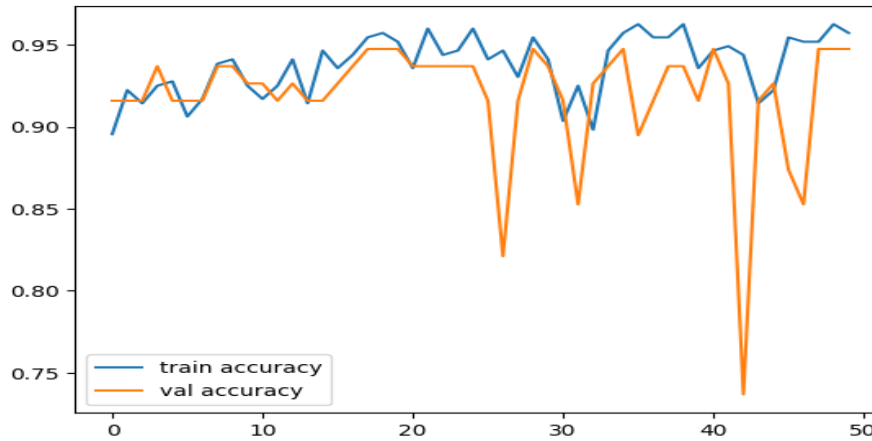


Figure 3.7: VGG16 ACCURACY CURVE

The figure 3.7 shows a graph of the VGG16 model for the validation accuracy and train accuracy of an epochs function, The two curves' value starts from 90%, We notice a convergence between the two curves to the value 20, and a dispersion in the field (25 - 45), then convergence returns again

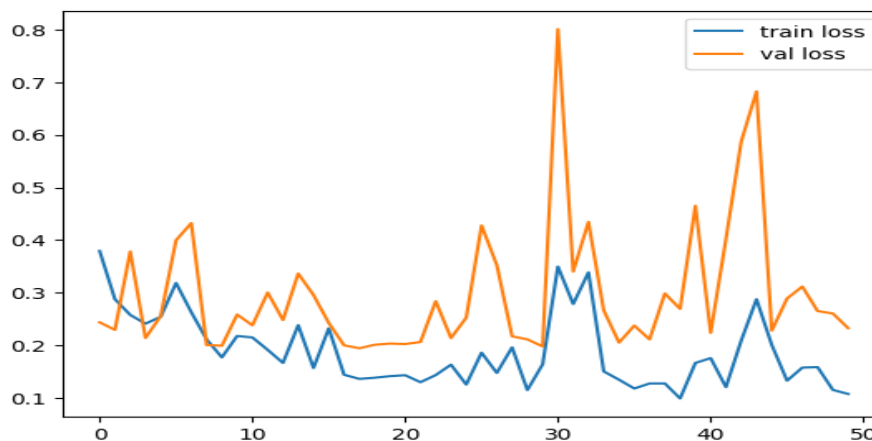


Figure 3.8: VGG16 LOSS CURVE

The figure 3.8 shows a graph of the VGG16 model for the validation loss and train loss of an epochs function, the curve of validation starts from 20% and the curve of train starts from 40%. We notice a convergence between the two curves at several values ,and a dispersion in the field (25 - 45).

3.7.2 VGG 19

Table 3.2: VGG 19 MODEL RESULTS

Batches					
Epochs	16	32	64	128	256
50	Acc: 0.9474	Acc: 0.9263	Acc: 0.9368	Acc: 0.9368	Acc: 0.9158
	Loss: 0.2328	Loss: 0.2694	Loss: 0.2078	Loss:0.2007	Loss:0.2157
60	Acc: 0.8737	Acc:0.9368	Acc:0.9368	Acc: 0.9368	Acc: 0.9368
	Loss:0.2296	Loss0.2133	Loss:0.2267	Loss: 0.1986	Loss: 0.2032
70	Acc: 0.8632	Acc: 0.9158	Acc:0.9368	Acc:0.9474	Acc:0.9368
	Loss: 0.2839	Loss: 0.2010	Loss:0.2088	Loss:0.1956	Loss:0.2005
80	Acc:0.9368	Acc:0.9368	Acc:0.9368	Acc:0.9368	Acc:0.9368
	Loss:0.2480	Loss:0.3809	Loss:0.2051	Loss:0.1984	Loss:0.1984
90	Acc:0.8842	Acc:0.9263	Acc:0.9368	Acc: 0.8842	Acc: 0.9474
	Loss:0.3226	Loss:0.3642	Loss:0.2543	Loss: 0.2274	Loss: 0.2010
100	Acc: 0.8737	Acc: 0.9263	Acc: 0.9368	Acc: 0.9579	Acc:0.9368
	Loss: 0.4140	Loss: 0.3520	Loss: 0.2735	Loss: 0.2029	Loss:0.2017

The table show all results of accuracy and loss in the terms of two variables is epoch and batch size , we change it each time , we get all values of accuracy between 0.8632 and 0.9579,and loss between 0.1956 and 0.4140 .and we see the best result is on epoch 70 /batch size 128 with accuracy 0.9474 and loss 0.1956.

• VGG19 (Epoch :70, Batch-size :128)

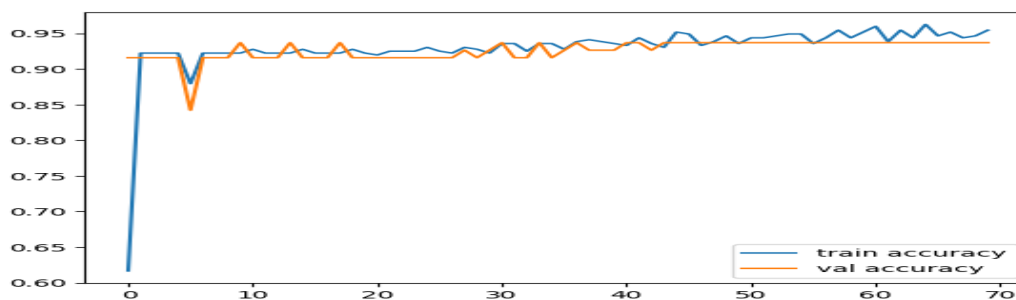


Figure 3.9: VGG19 ACCURACY CURVE

The figure 3.9 shows a graph of the VGG19 model , The curve value of the validation accuracy start almost from 92%, and The curve value of the train accuracy start almost from 62% We notice a dispersion in the value(0),and a convergence in rest of the field

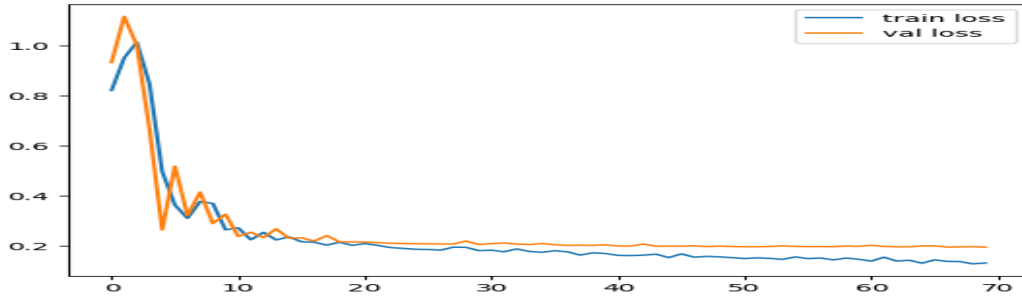


Figure 3.10: VGG19 LOSS CURVE

The figure 3.10 shows a graph of the VGG19 model , The curve value of the validation loss start almost from 90%, and the curve value of the train loss start almost from 81% We notice a convergence in all the field

3.7.3 Google net

Table 3.3: GOOGLNET MODEL RESULTS

Batches					
Epochs	16	32	64	128	256
50	Acc: 0.9158 Loss: 0.2903	Acc: 0.8737 Loss: 0.2996	Acc: 0.9053 Loss: 0.2695	Acc: 0.9158 Loss:0.3907	Acc: 0.9158 Loss:0.5244
60	Acc: 0.5244 Loss:0.2895	Acc:0.9053 Loss:0.3048	Acc:0.9053 Loss:0.3111	Acc: 0.8526 Loss: 0.4530	Acc: 0.6526 Loss: 0.6747
70	Acc: 0.9158 Loss: 0.2903	Acc: 0.9158 Loss: 0.2893	Acc:0.9158 Loss:0.2893	Acc:0.9474 Loss:0.8520	Acc:0.9368 Loss:1.5371
80	Acc:0.9158 Loss:0.2899	Acc:0.9158 Loss:0.2892	Acc:0.9158 Loss:0.2869	Acc:0.9158 Loss:0.6296	Acc:0.9263 Loss:1.1001
90	Acc:0.9158 Loss:0.2893	Acc:0.9158 Loss:0.2894	Acc:0.9158 Loss:0.2869	Acc: 0.9158 Loss: 0.3535	Acc: 0.9263 Loss: 1.1384
100	Acc: 0.9158 Loss: 0.2892	Acc: 0.9474 Loss: 0.4463	Acc: 0.9158 Loss: 0.4682	Acc: 0.7789 Loss: 0.8256	Acc:0.9158 Loss:0.9962

The table show all results of accuracy and loss in the terms of two variables is epoch and batch size , we change it each time , we get all values of accuracy between 0.5244 and 0.9474,and loss between 0.2695 and 1.5371 .and we see the best result is on epoch 50 /batch size 64 with accuracy 0.9053 and loss 0.2695.

• **GOOGLENET (Epoch :50, Batch-size :64)**

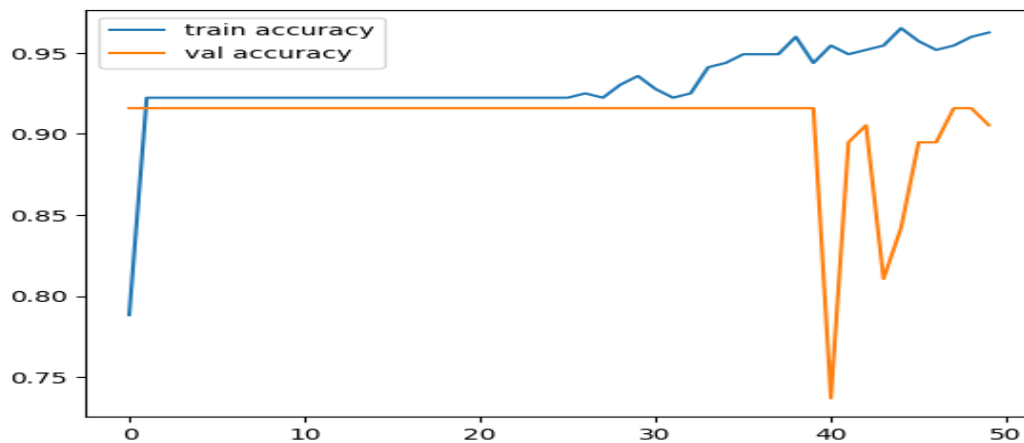


Figure 3.11: GOOGLENET ACCURACY CURVE

The figure 3.11 shows a graph of the GOOGLENET model for the validation accuracy and train accuracy of an epochs function, The curve value of the validation accuracy start almost from 92%, and the curve value of the train accuracy start almost from 78% ,We notice a dispersion in the value(0) and the field (32 - 50),and converge at the rest of the values.

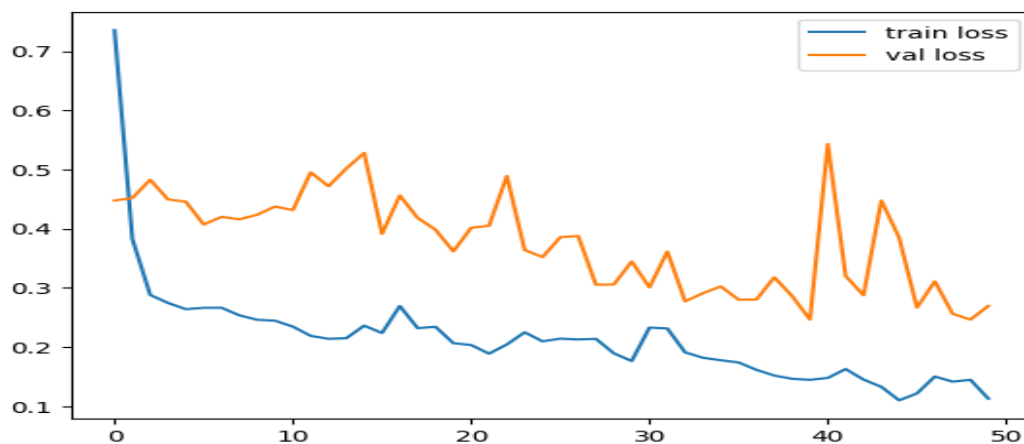


Figure 3.12: GOOGLENET LOSS CURVE

The figure 3.12 shows a graph of the GOOGLNET model for the validation loss and train loss of an epochs function, The curve value of the validation accuracy start almost from 45%, and the curve value of the train accuracy start almost from 72% ,We notice a intersection in the value(2),and a dispersion rest of the field.

3.7.4 Alex net

Table 3.4: ALEXNET MODEL RESULTS

Batches					
Epochs	16	32	64	128	256
50	Acc: 0.9368 Loss: 0.2470	Acc: 0.8947 Loss: 0.5659	Acc: 0.9474 Loss: 0.8612	Acc: 0.9474 Loss:1.2469	Acc: 0.9474 Loss:1.1904
60	Acc: 0.8947 Loss:0.3549	Acc:0.9368 Loss0.4289	Acc:0.9474 Loss:1.0541	Acc: 0.9474 Loss: 1.1571	Acc: 0.9474 Loss: 1.2034
70	Acc: 0.9263 Loss: 0.3819	Acc: 0.9263 Loss: 0.2658	Acc:0.5895 Loss:1.5774	Acc:0.9158 Loss:0.4874	Acc:0.9158 Loss:4.9212
80	Acc:0.4526 Loss:1.1385	Acc:0.6737 Loss:1.2756	Acc:0.2947 Loss:2.0137	Acc:0.9158 Loss:3.8173	Acc:0.9158 Loss:2.0229
90	Acc:0.4947 Loss:0.7299	Acc:0.9474 Loss:0.3679	Acc:0.8316 Loss:0.7379	Acc: 0.4105 Loss: 2.7733	Acc: 0.9158 Loss: 1.1630
100	Acc: 0.9263 Loss: 0.2911	Acc: 0.9368 Loss: 0.5771	Acc: 0.9579 Loss: 0.8207	Acc: 0.9474 Loss: 1.1416	Acc:0.7684 Loss:1.2334

The table show all results of accuracy and loss in the terms of two variables is epoch and batch size , we change it each time , we get all values of accuracy between 0.2947 and 0.9579,and loss between 0.2470 and 4.9212 .and we see the best result is on epoch 50 /batch size 16 with accuracy 0.9368 and loss 0.2470.

- **ALEXNET (Epoch :50, Batch-size :16)**

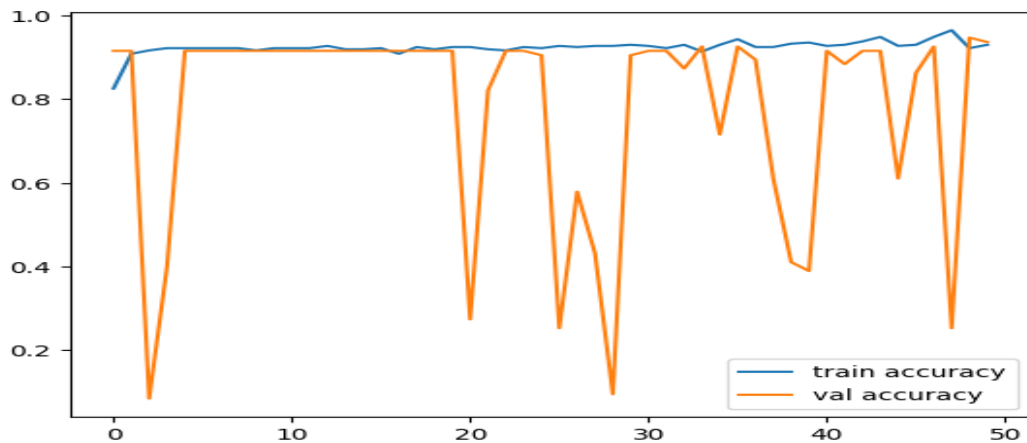


Figure 3.13: ALEXNET ACCURACY CURVE

The figure 3.13 shows a graph of the ALEXNET model for the validation accuracy and train accuracy of an epochs function. The curve of the validation starts from 90% and the curve of train starts from 80%. We notice convergence in the field (5-20) and other values, and divergent in the rest of the values.

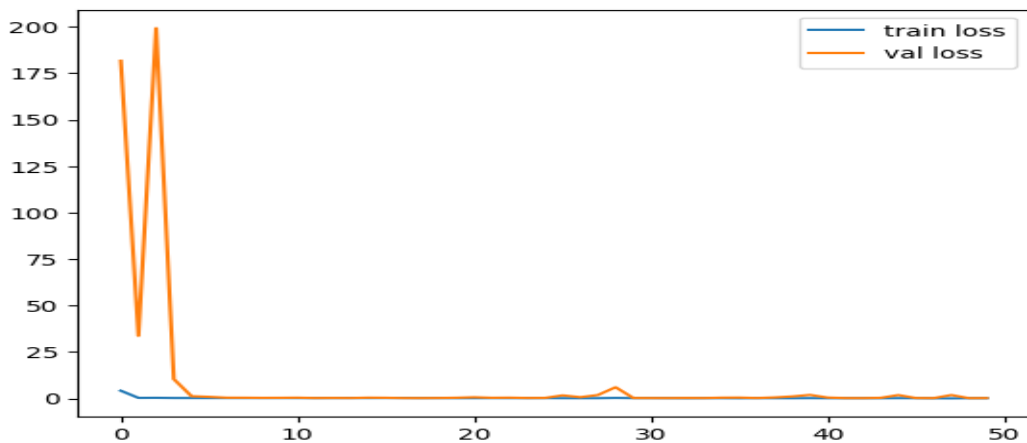


Figure 3.14: ALEXNET LOSS CURVE

The figure 3.14 shows a graph of the ALEXNET model for the validation loss and train loss of an epochs function. The curve of the validation starts from 180 and the curve of train starts from 0. We notice a dispersion in the field (0-5) and converge at the rest of the values.

Table 3.5: The selected values

The Model	Vgg16	Vgg19	Google-net	Alex-net
Batch size	16	128	64	16
Epochs	50	70	50	50
Result	Acc:0.9474	Acc:0.9474	Acc:0.9053	Acc:0.9368
	Loss:0.2167	Loss:0.1956	Loss:0.2695	Loss:0.2470

The Table show the best result in every model , we get all values of accuracy between 0.9053 and 0.9474,and loss between 0.1956 and 0.2695.and we see the best result is result of the vgg 19 model

3.8 Conclusion

In this chapter, we applied a deep learning approach based on pre-trained CNN model networks (VGG16, VGG19, GoogleNET, AlexNET). The database used in this study is the coswara dataset, which is divided into two parts: infected persons (positive) and uninfected persons(negative) . In our experiments, we found that the results differ from one model to another, As can be seen, the best model is VGG19 because it has high accuracy and lower loss rate.

General Conclusion

Image classification is an important task in computer vision. Computer, object recognition and machine learning. Despite the possibilities of activities in the field of image Ranking is often not considered any method 100% weak, but new growing companies are trying Improve their score to get better results. It is in this context that our aiming work is done to classify infected people and not infected with COVID-19 through Database of sounds converted to spectrogram.

To do our classification work, we used deep learning, which has shown its performance in recent years, and we chose the method of CNNs with pre-trained models as the classification method, this choice is justified by the simplicity and effectiveness of the method. The result obtained during the testing phase confirms the effectiveness of our approach, as the results of all the models we tested (VGG16,VGG19,GOOGLNET,ALEXNET) were relatively good, and after comparing them we found that VGG19 is the best model with accuracy = 0.9474 and loss = 0.1956 (epoch 70 and batch size 128).

Our future work is to realize this AI-based system for early detection of COVID-19-negative and healthy coughs recorded on a smartphone, This type of screening is non-contact, easy to apply, and can reduce the workload in testing centres as well as limit transmission by recommending early self-isolation to those who have a cough suggestive of COVID-19.

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