REPUBLIQUE ALGERIENNE DEMOCRATIQUE ET POPULAIRE

MINISTERE DE L'ENSEIGNEMENT SUPERIEUR ET DE LA RECHERCHE SCIENTIFIQUE

UNIVERSITE MOHAMED BOUDIAF - M'SILA

Faculty of Mathematics and Computer Science Department of Computer Science

N° :…………………………………………

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FILIERE : COMPUTER SCIENCE

OPTION : ARTIFICIAL INTELLIGENCE

Mémoire présenté pour l'obtention

Du diplôme de Master Académique

Par : -Hichem Laboukhi

-Abdelhakim Benamara

Intitulé

Artificial neural network approach to detect COVID-19 disease from X-ray images

Soutenu devant le jury composé de :

Dr.Kamel Mohamed	Université Mohamed Boudiaf M'sila	Président
Dr. Sayad Lamri	Université Mohamed Boudiaf M'sila	Rapporteur
Dr. Yagoubi Rached	Université Mohamed Boudiaf M'sila	Examinateur
Dr. Amroune Nasereddine	Université Mohamed Boudiaf M'sila	Examinateur

Année universitaire : 2022 /2023

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DEDICACE

أهدي هذا العمل الجميل إلى عائلتي الحبيبة وإلى والديّ الغاليين. أنتم الأشخاص الذين أعطوني الحب والدعم اللا محدودين طوال حياتي. لقد كنتم دائمًا مصدر القوة والتشجيع بالنسبة لي.

لأمي العزيزة، شكرًا لك على حنانك وعنايتك اللامتناهية. كنتِ الشخص الذي رأى فيّ القوة والإمكانيات ودعمتني في كل خطوة أخذتها. أنتِ مصدر إلهام لي بقوتك وإرادتك الصلبة.

ولأبي العزيز، أنت الرجل الذي أحتذي بأثره وأتعلم من حكمته. شكرًا لك على توجيهاتك ونصائحك القيّمة. كنت دائمًا هنا لدعمي وتشجيعي في تحقيق أحلامي. أنت الأب المثالي والأمان الذي أجد فيه الدعم والحب الذي أحتاجه

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List of Abbreviations

AI: Artificial Intelligence

ANNs: Artificial Neural Networks

CNN: Convolutional Neural Network

DL: Deep learning

ML: Machine learning

RNNs: Recurrent Neural Networks

General Introduction

Artificial Intelligence (AI) is a rapidly advancing field of technology that involves computer systems performing tasks that typically require human intelligence. AI achieves this through machine learning, where computer systems learn from data and experience to improve their performance over time. Deep learning is a specialized branch of machine learning that uses neural networks with multiple layers to analyze complex patterns in data. Convolutional Neural Networks (CNNs) are a type of deep learning model commonly used for image recognition, while Recurrent Neural Networks (RNNs) and Artificial Neural Networks (ANNs) are other essential components of deep learning.

The problem studied in this work is the diagnosis of COVID-19 using X-ray images. The rise of the COVID-19 pandemic has created a need for efficient and accurate methods to diagnose the disease. X-ray imaging is a commonly used tool in medical diagnosis, and this study focuses on utilizing X-ray images to detect and diagnose COVID-19.

The solution proposed in this work involves the application of artificial intelligence and deep learning techniques, specifically convolutional neural networks (CNNs), to analyze X-ray images and classify them as COVID-19 positive or negative. The study explores different machine learning algorithms and focuses on the implementation of a CNN model for accurate detection of COVID-19 from X-ray images. The proposed solution aims to provide a reliable and efficient method for diagnosing COVID-19 using X-ray imaging.

In Chapter I, an introduction to COVID-19 and X-ray imaging is provided. It covers the background and history of COVID-19, the symptoms associated with the disease, and the use of X-rays for COVID-19 diagnosis.

Chapter II focuses on artificial intelligence, machine learning, and deep learning. It provides an introduction to these concepts and explains various algorithms and techniques used in the field. It specifically explores the use of CNNs for image analysis and introduces different neural network architectures.

Chapter III describes the work carried out in this study. It discusses the tools and libraries used, such as Anaconda, Python, TensorFlow, Keras, and others. The preprocessing of the dataset and the implementation of the CNN model are explained in detail. The obtained results, evaluation metrics, and accuracy improvement are also discussed.

Chapitre I

COVID-19 and XRAY

I.1. Introduction

Coronavirus is a virus that affects the respiratory system and has spread worldwide since 2020. On January 30, 2020, the World Health Organization declared a global health emergency due to the virus spreading in several countries. Many countries were affected by the virus, and the X-Ray radiography technique was used to detect symptoms associated with the disease

I.2. The Rise Of Covid-19

The year 2020 will forever be remembered as the year of COVID-19, a viral pandemic that swept across the globe, leaving devastation in its wake. It all started in Wuhan, China, in late 2019, when a mysterious illness began to spread among the population. At first, it was thought to be an outbreak of a new strain of flu, but it quickly became clear that this was something far more dangerous.

According to the World Health Organization [1], the first cases of COVID-19 were reported in Wuhan, China, in December 2019 . The virus quickly spread through China and by January 2020, cases had been reported in other countries, including Thailand, Japan, and South Korea [2]

As the virus spread rapidly through China, the world watched in horror as the death toll continued to rise. The Chinese government took drastic measures to contain the outbreak, shutting down entire cities and enforcing strict quarantines. Despite these efforts, the virus continued to spread, and it wasn't long before cases began to appear in other countries.

According to a study published in The Lancet in February 2020, the early measures taken by the Chinese government were effective in slowing the spread of the virus, but more needed to be done to prevent it from spreading further . Unfortunately, by this point, the virus had already spread to other countries, and it was clear that it was no longer just a local issue.

By early 2020, COVID-19 had become a global pandemic. The virus had spread to every corner of the world, infecting millions of people and causing widespread panic and fear. Governments around the world were forced to take drastic measures to try and contain the virus, including closing borders, imposing lockdowns, and mandating mask-wearing.

According to the WHO, as of March 2021, there have been over 120 million confirmed cases of COVID-19 and over 2.6 million deaths worldwide [3]. These staggering numbers highlight the devastating impact that COVID-19 has had on the world.

Despite the heroic efforts of healthcare workers and scientists around the world, the virus continued to spread, and the death toll continued to rise. Vaccines were developed at an unprecedented pace, but it would be many months before they were widely available to the public.

As we look back on the early days of the pandemic, it's clear that the world was caught off guard by the rapid spread of COVID-19. It's a stark reminder of the importance of preparedness and the need for global cooperation in the face of a crisis. The road ahead is still uncertain, but we must remain vigilant and work together to ensure that we are better prepared for whatever the future may bring.

I.3. Brief History Of Covid-19

COVID-19 is a disease caused by the SARS-CoV-2 virus that was first identified in December 2019 in Wuhan, China. The disease quickly spread throughout the world, resulting in a global pandemic.

The first cases of COVID-19 were linked to a seafood market in Wuhan, where live animals were also sold. However, it remains unclear exactly how the virus first jumped from animals to humans.

The virus spread rapidly across China, and on January 23, 2020, the Chinese government placed Wuhan and surrounding cities under lockdown to try to contain the outbreak. By that time, the virus had already spread to other countries.

The World Health Organization [1] declared a global health emergency on January 30, 2020, and by March, the disease had spread to every continent except Antarctica. Many countries have implemented travel restrictions and lockdowns to try to slow the spread of the virus.

As of June 2023, the COVID-19 pandemic has resulted in over 400 million confirmed cases and over 6 million deaths worldwide. Vaccines have been developed and distributed worldwide, but the pandemic continues, with new variants of the virus still emerging. [1]

As we can observe, the shape of the coronavirus can be seen in the following image.

Figure 1.1

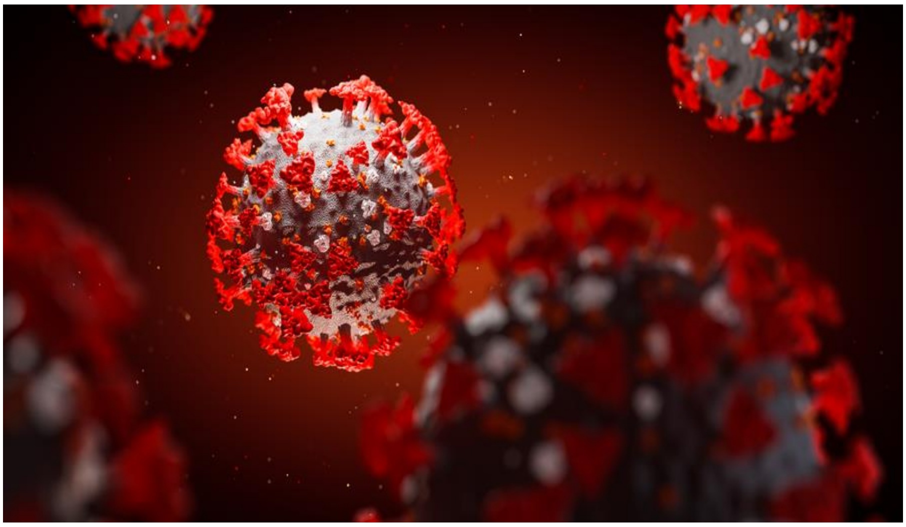


Figure 1.1 : the shape of the coronavirus

I.4. The Propagation Of Covid-19

COVID-19 spreads primarily through respiratory droplets that are released when an infected person talks, coughs, or sneeze. These droplets can be inhaled by people who are nearby, or they can land on surfaces, where they can remain infectious for hours to days. When people touch these surfaces and then touch their mouths, noses, or eyes, they can become infected with the virus.

COVID-19 can also be spread by people who are asymptomatic, meaning they have the virus but do not have any symptoms. This makes it difficult to control the spread of the virus, as people may not realize that they are infected and can unintentionally transmit the virus to others.

The risk of transmission is highest in indoor settings with poor ventilation, where people are in close contact with each other for extended periods of time, such as in crowded public spaces, workplaces, and social gatherings. The risk is lower outdoors, where there is more room for the virus to disperse and where people are less likely to be in close contact with each other.

The best way to prevent the spread of COVID-19 is to follow public health guidelines, such as wearing masks, practicing physical distancing, washing hands frequently, and getting vaccinated. These measures can help reduce the risk of transmission and protect individuals and communities from the virus. [4]

We can also see one of the ways the Corona virus spreads as an example in the following Figure 1.2

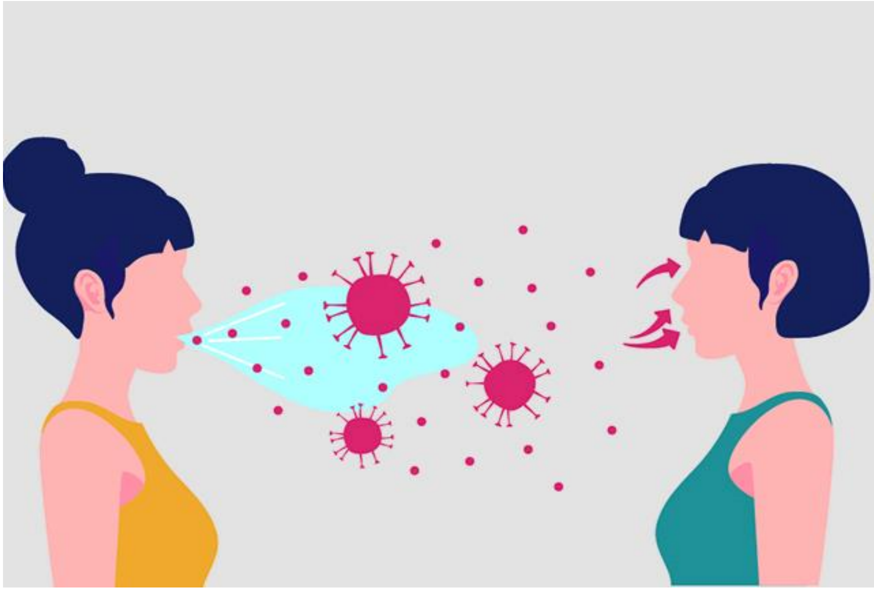


Figure 1.2 : Propagation Of Covid-19

I.5. Symptoms Of Covid-19

Symptoms of COVID-19 can vary from person to person, and some people may not experience any symptoms at all. However [5], common symptoms of COVID-19 include:

- fever or chills;
- cough
- Shortness of breath or difficulty breathing
- exhaustion
- Muscle or body aches
- headache
- New loss of taste or smell
- sore throat
- Congestion or runny nose
- Nausea or vomiting

Symptoms can range from mild to severe, and some people may develop complications such as pneumonia, acute respiratory distress syndrome (ARDS), or multi-organ failure. Older adults and people with underlying medical conditions, such as heart disease, diabetes, or a weakened immune system, may be at greater risk for serious illness and complications.

It is important to note that some people infected with COVID-19 may experience only mild symptoms or no symptoms at all, but they can still transmit the virus to others who may be at higher risk of severe disease. Therefore, it is important to follow public health guidelines, such as wearing masks, practicing physical distancing, washing hands frequently, and getting vaccinated, to help prevent the spread of the virus. [6].

Through it Figure 1.3, we can know the symptoms of Corona infection

Figure 1.3 : Symptoms of Covid-19

I.6. Diagnosis of COVID-19

The diagnosis of COVID-19 is typically made through laboratory testing. The most common test used to diagnose COVID-19 is the polymerase chain reaction (PCR) test. This test detects the genetic material of the SARS-CoV-2 virus in a sample of respiratory secretions, such as from a nasal or throat swab.

Rapid antigen tests are another type of test that can be used to diagnose COVID-19. These tests detect specific proteins from the virus in respiratory secretions and can provide results in as little as 15 minutes. [7]

Serological tests, which detect the virus in blood samples, can also be used to diagnose COVID-19. However, these tests are typically used to determine if someone has been previously infected with the virus, rather than as a primary diagnostic tool.

It's important to note that a negative test result does not necessarily rule out a COVID-19 infection, especially if the person has been exposed to the virus or is experiencing symptoms. In some cases, a person may need to be retested or evaluated by a healthcare professional to determine if they have COVID-19. [8]

I.7. What are X-rays?

X-rays are a type of electromagnetic radiation that have a higher energy and shorter wavelength than visible light. They were first discovered by German physicist Wilhelm Conrad Roentgen in 1895 and have since become an important tool in medicine, industry, and scientific research.

In medical applications, X-rays are used to produce images of the inside of the body. This is done by passing X-rays through the body and capturing the resulting image on a special film or digital detector. Dense structures, such as bones, absorb more X-rays and appear white or light gray on the image, while less dense structures, such as organs and muscles, absorb fewer X-rays and appear darker.

X-rays are also used in other applications, such as in airport security scanners to detect objects hidden inside luggage, and in industrial settings to inspect materials for defects or to measure the thickness of materials.

However, exposure to X-rays can be harmful in high doses, as the radiation can damage DNA and increase the risk of cancer and other health problems. Therefore, X-rays are used only when necessary and with appropriate safety measures, such as shielding and limiting the amount of radiation exposure.[9]

As shown in the following image, some X-ray images Figure 1.4

Figure 1.4 : X-Ray

I.8. Using X-rays for COVID-19 Diagnosis

While X-rays are not typically used as the primary diagnostic tool for COVID-19, they can be helpful in evaluating patients with suspected or confirmed COVID-19 who are experiencing respiratory symptoms.

Chest X-rays can show the characteristic lung abnormalities associated with COVID-19, such as ground-glass opacities (areas of hazy opacity in the lungs) and consolidation (areas of the lungs that appear more dense). These abnormalities can help healthcare professionals diagnose and monitor the progression of COVID-19 in patients.

However, chest X-rays are not as sensitive as other diagnostic tests, such as the PCR test or rapid antigen test, in detecting the presence of the SARS-CoV-2 virus. Therefore, they are typically used in conjunction with other diagnostic tools and clinical evaluation to diagnose and manage COVID-19.

It's important to note that exposure to X-rays carries a small risk of radiation exposure, which can increase the risk of cancer and other health problems. Therefore, X-rays should be used only when necessary and with appropriate safety measures, such as shielding and limiting the amount of radiation exposure.[10]

As shown in the following Figure 1.5 for some cases

(a) Normal (b) Pneumonia (c) COVD-19

Figure 1.5 : Using X-rays for COVID-19 Diagnosis

I.9. Conclusion:

In this chapter, we learned about the Corona virus, its symptoms, methods of its spread, and how to reduce its risks by sterilization or spacing, and we also learned about the x-ray technology used to detect it.

Chapitre II

Artificial Intelligence, Machine Learning and Deep Learning

Chapitre II.

II.1. Introduction

Today, deep learning (DL) has become a popular method in machine learning (ML) because it offers more advanced pattern recognition and image classification compared to traditional ML methods. Among the commonly used techniques in DL, Convolutional Neural Networks (CNNs) are of particular interest.

When talking about artificial intelligence (AI), it's important to understand what it means. AI refers to the development of computer systems that can perform tasks that typically require human intelligence. Machine learning (ML) is a subset of AI, focusing on algorithms and statistical models that enable computers to learn and make predictions or decisions without being explicitly programmed. Deep learning (DL) is a further subset of ML that uses neural networks with multiple layers to extract high-level features and make complex predictions.

In this chapter, we will discuss the distinctions between AI, ML, and DL, explore different algorithms related to each approach, and examine the diverse areas where they are applied.
As shown in the following figure 2.1

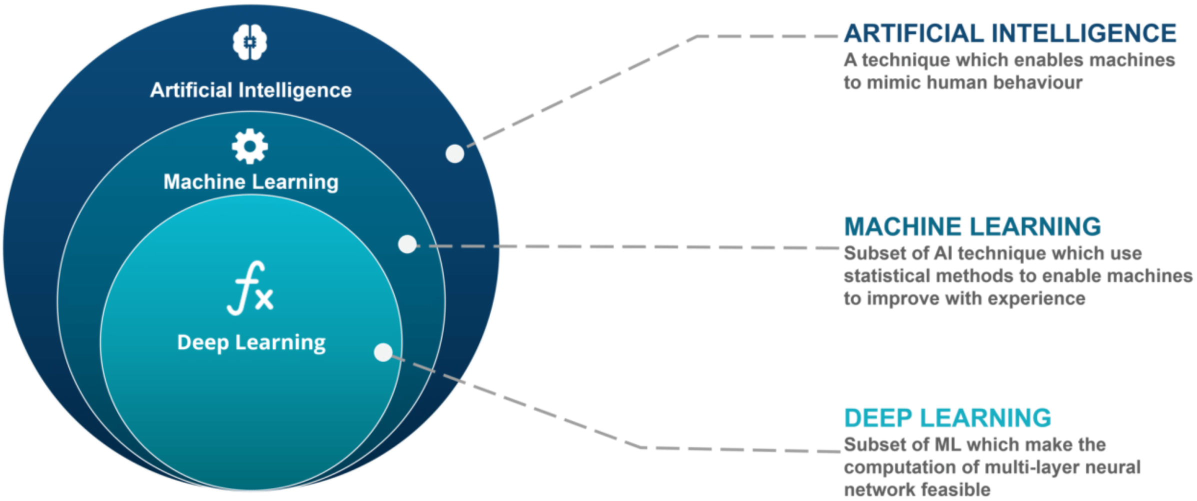


Figure 2.1: AI vs Machine Learning vs Deep Learning

II.2. Artificial intelligence :

Artificial intelligence, commonly known as AI, is defined as "The science and engineering of making intelligent machines, especially intelligent computer programs" [11]. Humans are considered the most intelligent species on planet Earth, and the neocortex is the key component behind their powerful brain [12].

AI can be categorized into three different levels. First, there is Narrow AI, where machines can perform specific tasks better than humans [13]. Second, General AI refers to machines that can perform any intellectual task with the same level of accuracy as a human [13]. Lastly, Active AI represents the level at which machines can surpass humans in many tasks [13].

II.3. Machine Learning :

2.3.1 Definition:

Machine Learning (ML) is a type of computer science that teaches computers to learn from data without explicitly programming them. It's like teaching a child to recognize things by showing them examples and correcting their understanding.

In 1959, Arthur Samuel defined ML as "a field of study that gives computers the ability to learn without being explicitly programmed" [14]. This means that instead of telling computers exactly what to do, we can train them to learn and make predictions based on patterns in data.

In ML, the key idea is training. We provide computers with a lot of data and teach them to make predictions or find patterns. The more data we give them, the better they become at making accurate predictions.

ML is all about teaching computers to learn from data and make predictions. It's an exciting field that has applications in various areas like healthcare, finance, and self-driving cars.

II.4. Types of Machine Learning

There are three types of ML:

As shown in the following figure2.2

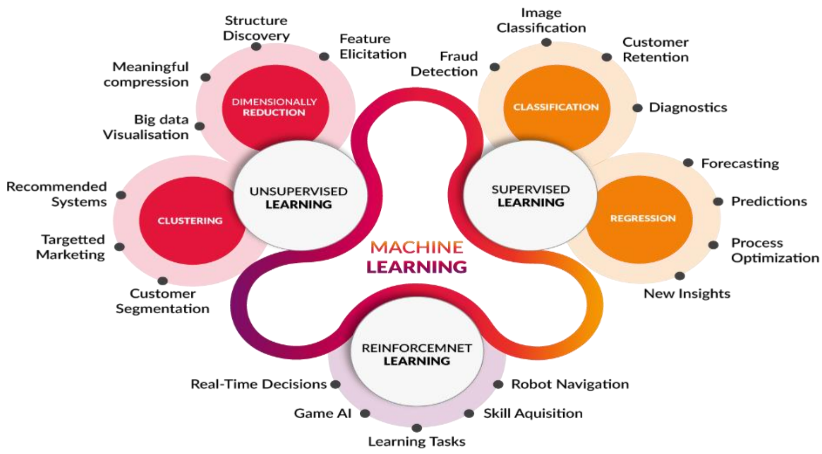


Figure 2.2: Types Of Machine Learning

II.4.1. Supervised Learning

Supervised Learning (SL) is like teaching a computer using examples that have labels. The computer learns from these examples to predict or generate outputs for new data based on what it has learned.

Regression

Regression is a machine learning technique used to predict numerical values. It finds a mathematical relationship between input variables and the output values. The goal is to make accurate predictions for new data by analyzing patterns and relationships in the available data. Regression is widely used in various fields like finance, economics, and medicine to forecast future events and make informed decisions.

Classification

Classification in machine learning is a way to group or categorize data based on their similarities. It's like sorting things into different boxes based on their characteristics. For example, if we have pictures of animals, we can use classification to teach a computer to recognize whether each picture is of a dog or a cat. The computer learns from examples and uses that knowledge to make predictions about new pictures. It's a way for computers to organize and make sense of data by putting them into different categories. [15] .

Applications of supervised machine learning:

- ❖ Email Spam Filtering
- ❖ Image Classification
- ❖ Sentiment Analysis
- ❖ Fraud Detection
- ❖ Credit Scoring
- ❖ Medical Diagnosis

II.4.2. Unsupervised

In unsupervised learning, the computer learns from data without being told the correct answers. It looks for patterns and relationships in the data to make sense of it. There are two main types of unsupervised learning: clustering and association. Clustering groups similar things together, while association finds connections between different things..

Clustering:

Clustering is when we group similar data together based on their common characteristics. For example, we can cluster consumers based on their similar purchasing habits.

Association:

Association is when we find rules that describe relationships between items in the data. These rules can be recommendations for common patterns in the data. For instance, if someone buys item X, they are likely to also buy item Y.

Application of Unsupervised Machine Learning :

- ❖ Market Basket Analysis
- ❖ Document Clustering
- ❖ Dimensionality Reduction for Visualization
- ❖ Pattern Recognition in Speech and Audio Signals

Reinforcement learning

Reinforcement learning is a branch of artificial intelligence that focuses on how intelligent agents make appropriate decisions through interacting with the environment and receiving rewards or punishments. The goal of reinforcement learning is to develop an optimal policy or strategy that allows the agent to maximize rewards over time .

II.5. Machine Learning Algorithmes:

II.5.1. Logistic Regression (LR):

Logistic Regression is a statistical method used to predict binary outcomes based on a given dataset. It estimates the probability of an event occurring based on a set of independent variables. For example, we can use Logistic Regression to predict whether a high school student will be accepted or rejected by a particular college based on their academic performance and other factors. Here are some key points

- Logistic Regression is a supervised learning algorithm that uses logistic functions to predict the probability of a binary outcome.
- It models the relationship between predictor variables and a categorical response variable.
- The output of Logistic Regression is a probability score between 0 and 1.
- Logistic Regression can be used to predict binary outcomes such as passing or failing a test, responding yes or no on a survey, and having high or low blood pressure.
- Logistic Regression is widely used in various fields such as marketing, healthcare, and data science.

In summary, Logistic Regression is a useful tool for predicting binary outcomes based on a given dataset. It is widely used in many fields and can help businesses and organizations make informed decisions. [16]

II.5.2. Support Victor Machine (SVM) :

Support Vector Machines (SVM) is a well-known machine learning technique used for classification tasks. It creates separating lines in a multi-dimensional space to distinguish data points belonging to different categories. The goal of SVM is to find the optimal line that maximizes the margin between the different categories. It is commonly used for solving classification and prediction problems.As shown in the following figure2.3

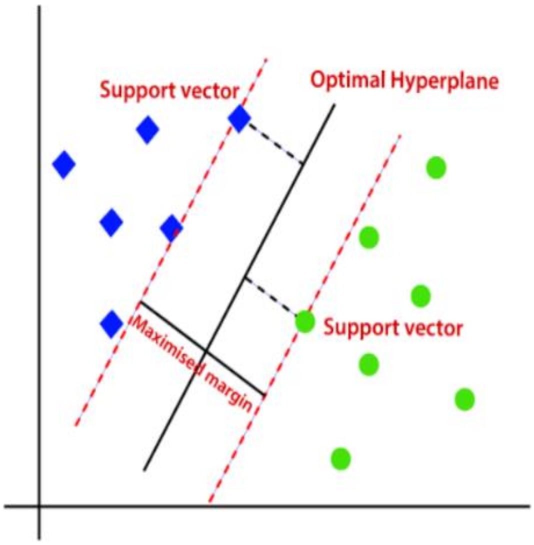


Figure 2.3: Support Vector Machines

II.5.3. Naïve Bayes (Nb) :

Naive Bayes is a machine learning algorithm used for classification tasks. It is based on Bayes' theorem with the assumption of independence between features. Naive Bayes algorithm predicts the class of new data points by calculating the probability of belonging to a certain class based on the probability of the features associated with that class. The algorithm assumes that the features are independent of each other, hence the name "naive". Here is a simple example to explain how Naive Bayes algorithm works in fruit classification:

- Let's assume we have a set of fruits that includes apples and oranges.
- We have three features for fruit classification: color (red or orange), shape (round or oval), and taste (sweet or sour).
- We have training data that contains several examples of fruits with their correct classification.
- The Naive Bayes algorithm is trained using this training data.
- When new data comes in for classification, the algorithm uses the calculated probabilities to determine the most likely class.
- For example, if a fruit is red, round, and sweet, the algorithm will classify it as an apple.

Using Naive Bayes algorithm, we can classify many things based on the available features. It is used in text classification, sentiment analysis, spam filtering, article classification, and many other applications. Naive Bayes classification is one of the simplest and most effective classification algorithms that help build fast machine learning models that can make quick predictions. It is a probabilistic classifier, which means it predicts based on the probability of an object's existence.[17]

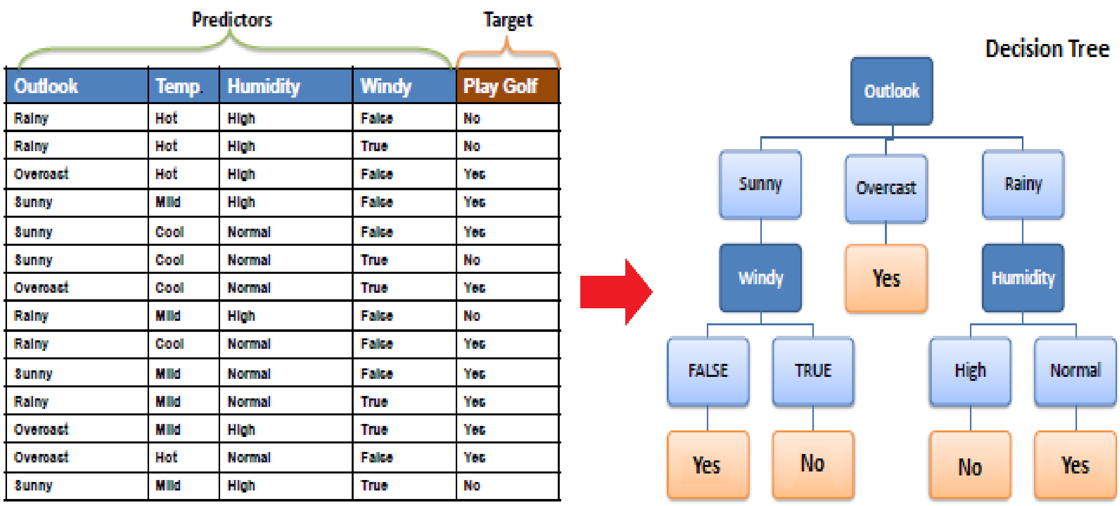
II.5.4. Dession Tree:

A decision tree is a flowchart-like structure used for both classification and regression tasks. It is a non-parametric supervised learning algorithm that recursively partitions data based on different conditions. Each internal node represents a feature or attribute, the branch represents a decision rule, and each leaf node represents the outcome. The decision tree splits the nodes on all available variables and then selects the split that results in the most homogeneous sub-nodes. Here is a simple example of how a decision tree works:

Let's assume we have a set of data that includes information about weather conditions.

- ❖ We have several features for weather classification, such as temperature, humidity, and wind speed.
- ❖ We have training data that contains several examples of weather conditions with their correct classification.
- ❖ The decision tree algorithm is trained using this training data.
- ❖ When new data comes in for classification, the algorithm uses the decision tree to determine the most likely class.
- ❖ For example, if the weather is overcast with a temperature of 70 degrees and a humidity of 80%, the algorithm will classify it as a "no" for playing tennis.

Decision tree algorithm is widely used in various fields, including finance, healthcare, and marketing. It is a powerful tool for decision-making and can help in identifying the most important features for classification tasks.[18] . As shown in the following figure2.4



Outlook	Temp.	Humidity	Windy	Play Golf
Rainy	Hot	High	False	No
Rainy	Hot	High	True	No
Overcast	Hot	High	False	Yes
Sunny	Mild	High	False	Yes
Sunny	Cool	Normal	False	Yes
Sunny	Cool	Normal	True	No
Overcast	Cool	Normal	True	Yes
Rainy	Mild	High	False	No
Rainy	Cool	Normal	False	Yes
Sunny	Mild	Normal	False	Yes
Rainy	Mild	Normal	True	Yes
Overcast	Mild	High	True	Yes
Overcast	Hot	Normal	False	Yes
Sunny	Mild	High	True	No

Figure 2.4: Dession Tree.

II.5.5. Neural Networks:

A neural network is a mathematical model that imitates the learning process of the human brain. It consists of small units called artificial neurons that work together to process information. The neural network receives input signals, which are passed through multiple layers where the data is gradually analyzed and processed. Finally, the output is generated from the output layer.

Neural networks are a tool used in the field of artificial intelligence. They can learn from data and acquire knowledge based on previous experiences. Neural networks are used in various applications such as speech and image recognition, sales forecasting, data analysis, and machine translation.

In simple terms, we can think of a neural network as a mathematical model that mimics the brain's functioning. It can learn and acquire knowledge from data to solve a wide range of complex problems. As shown in the following figure2.5

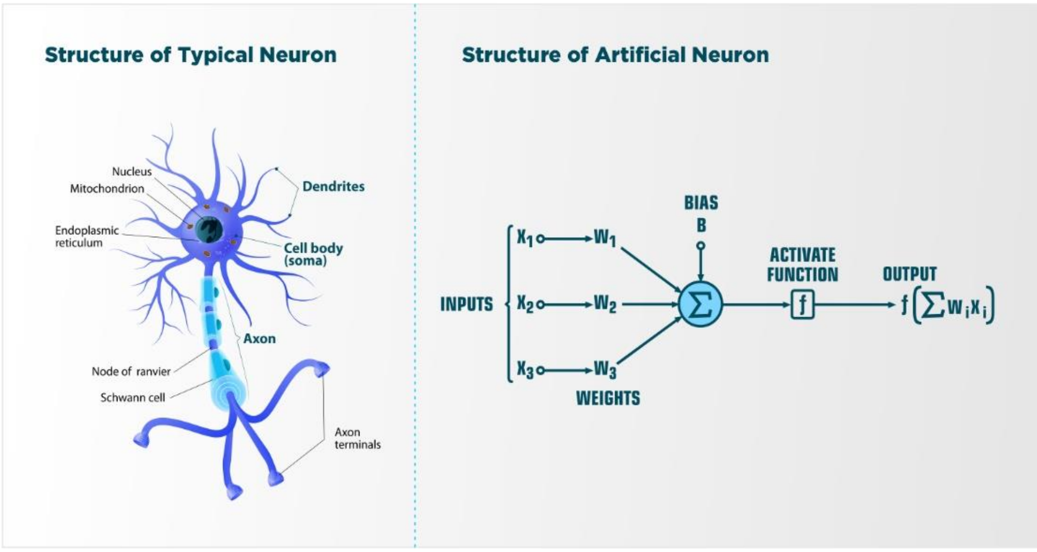


Figure 2.5: Neural Networks.

II.6. Deep learning

II.6.1. Definition :

Deep learning is a part of artificial intelligence (AI) that uses artificial neural networks to solve complex problems . These networks are inspired by the human brain and can learn from raw data like images, text, or audio. Deep learning is used in tasks such as image recognition and language processing. Popular deep learning frameworks include TensorFlow and PyTorch . The field is constantly evolving, and its advancements are expected to play a crucial role in the future of AI.

II.6.2. Deep Learning Tricks:

Dropout: is used for a technique, which drops out some nodes of the network. This technique is applied in the training phase to reduce overfitting effects. [19]

Max-Pooling : We start by defining the filter, and then we use the maximum assembly to minimize the size. By employing the maximum assembly, the dimensions can be minimized. [20]

- Batch Normalization: It stabilizes and accelerates the deep neural network, by normalizing the output from layer. [21]

II.6.3. Some examples of the uses of deep learning :

- Gaming: Deep learning is used in gaming applications such as game AI, character animation, and game physics.
- Finance: Deep learning is used in finance applications such as fraud detection, risk assessment, and algorithmic trading.

II.7. Deep Neural Network:

II.7.1. Artificial Neural Network :

An Artificial Neural Network (ANN) is a computer model that is inspired by the human brain. It is made up of small parts called neurons that work together to solve complex problems. ANNs are used in machine learning and deep learning to help computers learn and make decisions. They are particularly good at recognizing patterns and categorizing data. ANNs are used in many applications, such as image and speech recognition, natural language processing, and predictive analytics. [22] As shown in the following figure2.6

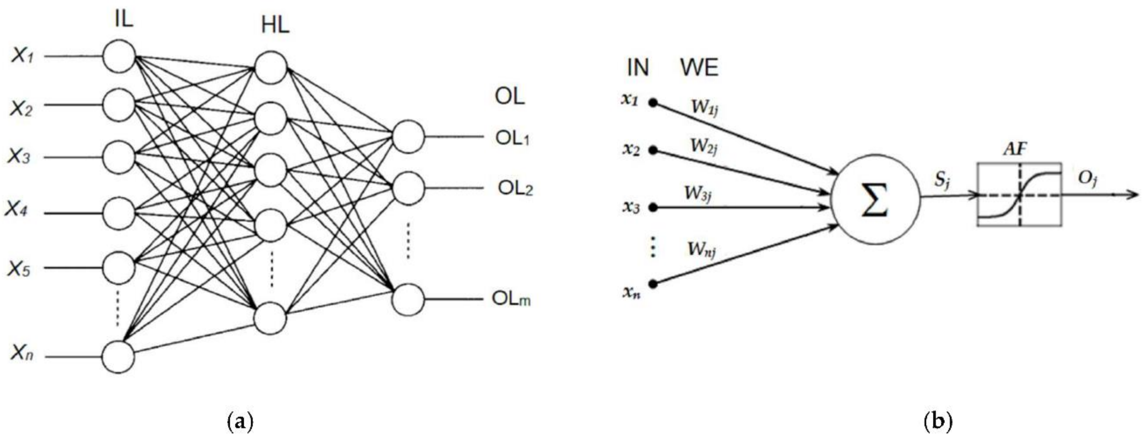


Figure 2.6: Schematic of an artificial neural network.

II.7.2. Recurrent Neural Network (RNN) :

RNN is a type of neural network that finds patterns in sequences of data. It has loops that pass information from one step to the next, making it great for tasks like speech recognition, language translation, and predicting time-based patterns. RNNs are ideal for tasks involving language processing and speech recognition, and they're used in applications like handwriting recognition, image descriptions, and music creation. [23] As shown in the following figure2.7

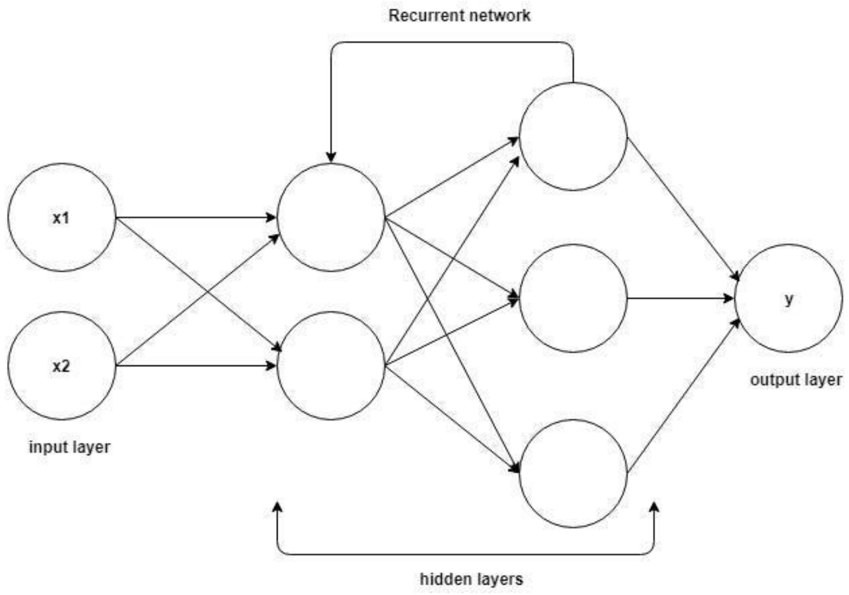


Figure 2.7: Schematic of a Recurrent neural network.

II.7.3. Deep Neural Networks (DNNs) :

Deep Neural Networks (DNNs) are networks that process data from input to output without going backward. While they have been effective in many applications, the training process can be lengthy and tiring. DNNs were inspired by how the brain processes inputs at different levels, but they lack memory, so they need to start anew each time. They don't function in the same way as the human brain. As shown in the following figure2.8

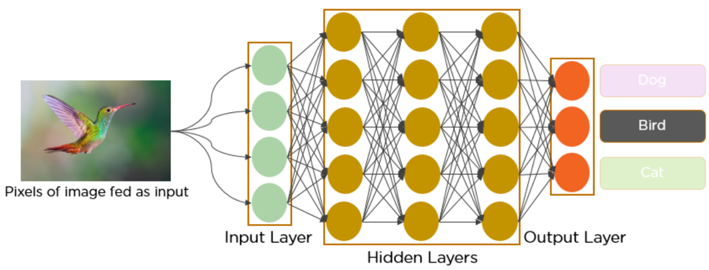


Figure 2.8 : Deep Neural Networks

II.8. Convolution Neural Network (CNN) :

II.8.1. Definition:

A Convolutional Neural Network (CNN) is a type of advanced computer algorithm commonly used for understanding and processing images. It draws inspiration from how our brains process visual information, especially in the visual cortex.

A CNN is specifically designed to analyze visual data, like images, by learning and extracting important features directly from the input. It consists of different layers, including convolutional layers, pooling layers, and fully connected layers. Each layer plays a crucial role in helping the network understand and classify visual information.

The main part of a CNN is the convolutional layer. In this layer, there are filters or feature detectors that learn to detect important visual elements, such as edges, textures, and shapes. These filters move across the input data and perform calculations to create a feature map, which shows where these elements are present in the input. The convolutional layer can capture different levels of features, starting from basic ones like lines and edges to more complex patterns like shapes and objects.

Pooling layers are often used after the convolutional layers to reduce the size of the feature maps. They do this by summarizing nearby values, like taking the maximum value in a certain area. This helps in simplifying the calculations and capturing the most important features while reducing the computational load.

Finally, the fully connected layers in a CNN take the high-level features extracted by the convolutional and pooling layers and use them for tasks like classifying or predicting. These layers connect each neuron from the previous layer to the next layer, allowing the network to learn complex relationships and make predictions based on the learned features. In essence, these fully connected layers help the CNN understand what the extracted features mean and how they relate to different classes or categories.

CNNs have had a significant impact on computer vision tasks, including image classification (identifying what objects are present in an image), object detection (locating and identifying multiple objects in an image), face recognition (recognizing and verifying faces), and image segmentation (dividing an image into meaningful regions). Their ability to automatically learn and extract important features from images makes them highly effective in analyzing and understanding complex visual data. [24] [25] [26] [27] As shown in the following figure2.9

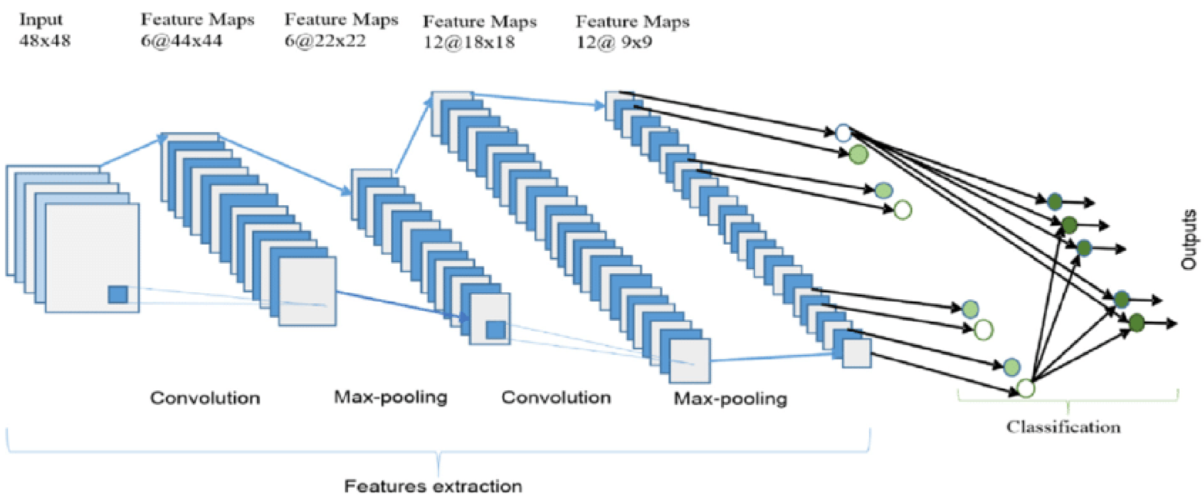


Figure 2.9 :The overall architecture of the Convolutional Neural Network CNN

II.8.2. Examples of Uses of Convolutional Neural Networks:

Convolutional neural networks are a broad area of research and a recent focus of researchers:

- ❖ Autonomous Vehicles: CNNs are used in self-driving cars to detect and classify objects on the road, such as other vehicles, pedestrians, and traffic signs.
- ❖ Video Analysis: CNNs can be used for video analysis tasks, such as action recognition, object tracking, and video summarization.

II.9. Activation function:

II.9.1. Definition:

Activation Functions are specially used in artificial neural networks to transform an input signal into an output signal which in turn is fed as input to the next layer in the stack. In an artificial neural network, we calculate the sum of products of inputs and their corresponding weights and finally apply an activation function to it to get the output of that particular layer and supply it as the input to the next layer. [28]

II.9.2. Types Of Activation Functions:

- ❖ ReLU.
- ❖ SoftMax.
- ❖ Logistic.
- ❖ Tanh.
- ❖ Leaky ReLU.

II.9.3. RelU:

Relu stands for rectified liner unit and is a non-linear activation function which is widely used in neural network. The upper hand of using Relu function is that all the neurons are not activated at the same time. This implies that a neuron will be deactivated only when the output of linear transformation is zero. [29]

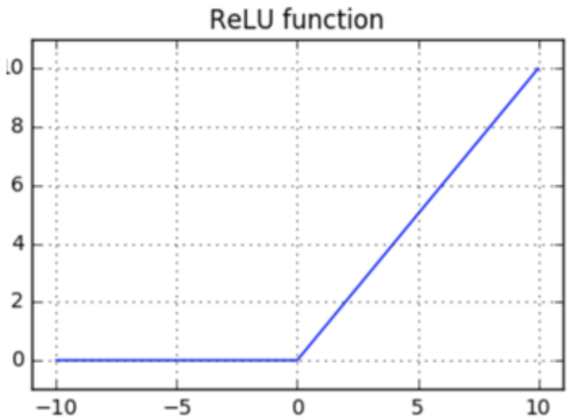


Figure 2.10 : ReLU Activation Function plot

II.9.4. B. Softmax:

The Softmax function is a sigmoid function that has been combined with other sigmoid functions. Because a sigmoid function gives numbers in the range of 0 to 1, we may regard these as data points of a specific class's probability. [28]

II.9.5. Choosing The Right Activation Function:

For better performance and less erroneous results, a lot of things have to be considered like the number of hidden layers in a network, training methods, hyperparameter tuning etc, and activation function is one of the most important parameters to consider. Choosing the right activation function for any particular task may be a te For classification problems, a combination of sigmoid functions gives better results.If there are dead neurons in our network, then we can use the leaky Relu function. Relu function has to be used only in the hidden layers and not in the outer layer.[30]

II.10. How Does Convolutional Neural Network Work?

Convolutional Neural Network architecture consists of four layers:

- Convolutional layer :where the action starts. The convolutional layer is designed to identify the features of an image. Usually, it goes from the general (i.e., shapes) to specific (i.e., identifying elements of an object, the face of a certain man, etc.).
- Rectified Linear Unit layer (aka Relu) : This layer is an extension of a convolutional layer. The purpose of Relu is to increase the non-linearity of the image. It is the process of stripping an image of excessive fat to provide a better feature extraction.
- The pooling layer: is designed to reduce the number of parameters of the input i.e., perform regression.
- The connected layer : It is a final straight line before the finish line where all the things are already evident. And it is only a matter of time when the results are confirmed.

II.10.1. CNN-Based Approach for COVID-19 Detection from X-ray Images

Convolutional Neural Networks (CNNs) are commonly used to detect COVID-19 from X-ray images. The process involves these steps:

Data Collection: Gather a dataset of X-ray images that includes COVID-19 positive cases and negative cases (normal or other lung diseases). The images should be properly labeled.

Preprocessing: Prepare the X-ray images by enhancing relevant features and reducing noise. Common techniques include resizing the images to a consistent size, normalizing them, and removing artifacts or background noise.

Model Architecture: Design a CNN model specifically for COVID-19 detection. It typically consists of convolutional layers followed by pooling layers to extract image features. Additional layers like batch normalization and dropout can improve performance and prevent overfitting. The final layers are fully connected for classification.

Training: Train the CNN model using the preprocessed X-ray images. Split the dataset into training and validation sets. The model adjusts its internal parameters (weights and biases) using optimization algorithms, such as stochastic gradient descent, to minimize prediction errors. This process repeats for multiple epochs until the model accurately classifies COVID-19 cases.

Evaluation: Assess the trained CNN model using a separate test dataset that it hasn't seen before. Calculate evaluation metrics like accuracy, precision, recall, and F1-score to measure its performance in COVID-19 detection from X-ray images.

It's important to have a high-quality and diverse dataset for training to improve the CNN model's performance. The larger and more representative the dataset, the better the model's ability to generalize to new X-ray images.

II.11. Model evaluation concepts:

II.11.1. The convolution layer (CONV):

In the context of artificial intelligence, convolution is a systematic process that combines two pieces of information; it's a function that transforms another function. Convolutions have been utilized extensively, especially in image processing, to make images appear smoother or more defined and for various other tasks such as highlighting edges and creating a raised effect. (For instance, enhancing edges and creating a raised appearance) Convolutional Neural Networks (CNNs) establish a close relationship between neighboring neurons in consecutive layers.

In the artificial intelligence, the most commonly used convolution is the 2D convolution layer, often denoted as conv2D. This layer works by sliding a filter or kernel over 2D input data, multiplying corresponding elements, and adding them up to produce a single output pixel. This process repeats for every location the kernel moves across, effectively transforming a 2D matrix of features into a different 2D feature matri [31]

II.11.2. Pooling layers :

Pooling layers are like the building blocks of convolutional neural networks (CNNs). While convolutional layers search for features in images, pooling layers aggregate and simplify these features. They do this to make the representation smaller, which makes the network simpler by reducing the number of things it has to remember and calculate.[32] As shown in the following figure2.11

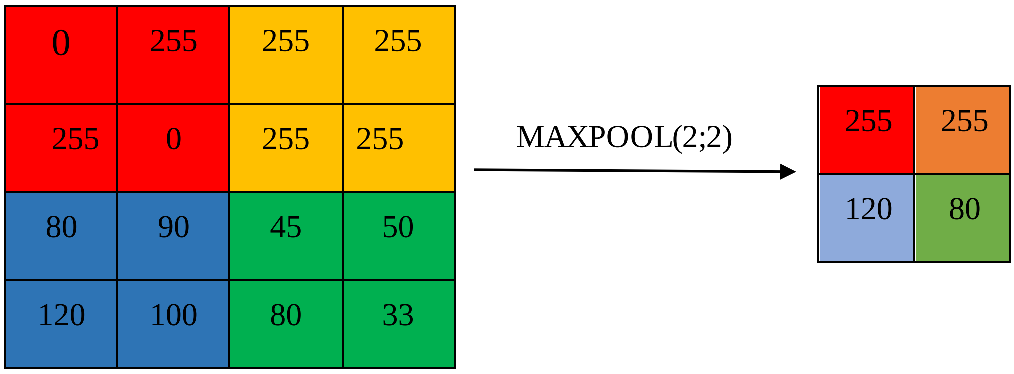
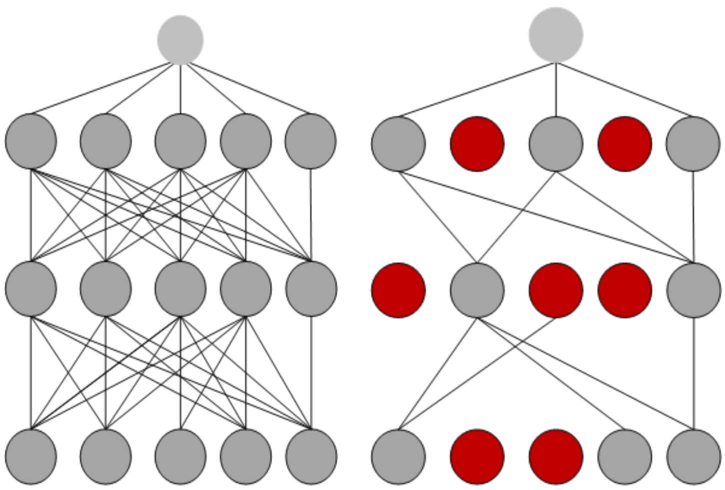


Figure 2.11 : Max pool work

II.11.3. Droupout :

Dropout in neural networks means that some neurons are randomly excluded during training. Simply put, it involves ignoring some neurons in the network during forward and backward passes.

Technically, in each training phase, individual nodes are removed from the network with probability (1-p) or retained with probability p. This results in a smaller network, while also removing connections to and from disconnected nodes.[33] As shown in the following figure2.12



(a)Standard Neural (b) after applying dropout

Figure 2.12 : Dropout work

II.11.4. Flattening:

The flattening step in building a convolutional neural network (CNN) is where we take the pooled feature map (created in the pooling step) and convert it into a one-dimensional vector. This means we're essentially taking a grid of values and arranging them in a single line, making it easier for the neural network to process.[34]

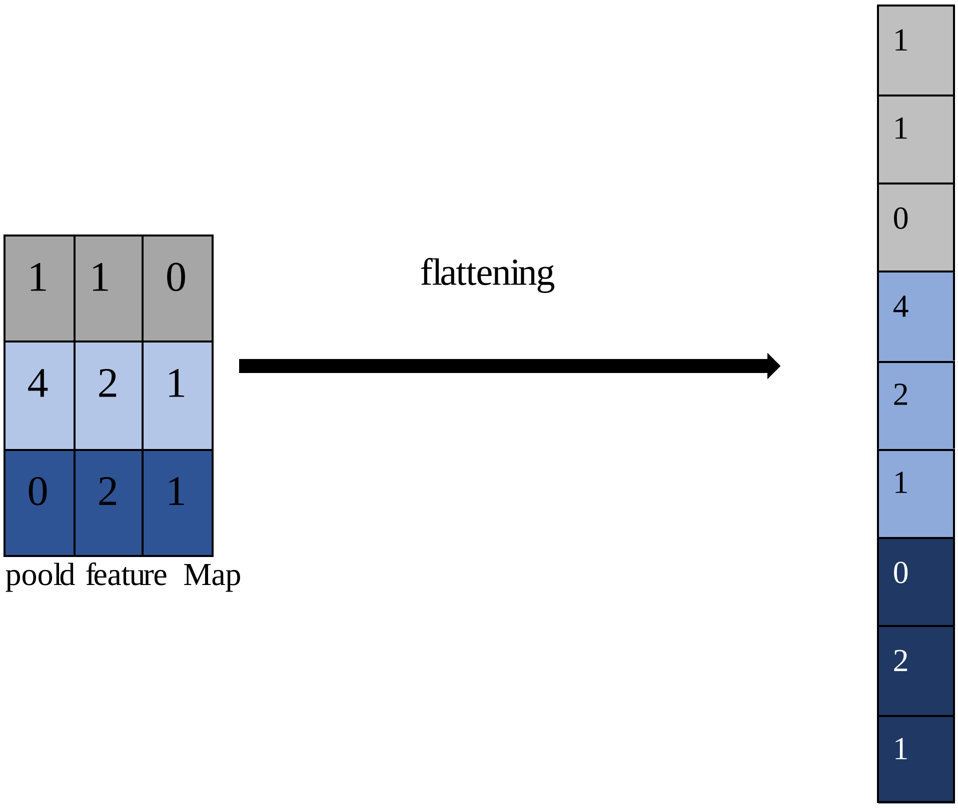


Figure 2.13 : lattening work

II.11.5. Accuracy:

is a commonly used metric in multi-class classification that is calculated directly from the confusion matrix. [35]

Machine learning classification accuracy is like a scorecard that shows how good our algorithm is at getting things right. It tells us how often the algorithm makes the correct predictions, in simpler terms, it's a measure of our model's accuracy.[36]

$$Accuracy = \frac{\text{Number of correct prediction}}{\text{Total number of prediction}}$$

II.11.6. Loss:

Loss is a numerical value that indicates the degree of error in a model's prediction for a single instance. If the model's prediction is perfect, the loss will be zero; otherwise, it will be higher. The objective of model training is to discover a combination of weights and biases that result in low average loss across all instances. [37]

II.12. Batch size and Epochs:

II.12.1. Batch size:

The batch size is a hyper parameter that defines the number of samples to work through before updating the internal model parameters.[38]

II.12.2. Epochs:

The number of epochs is a hyperparameter that specifies how many times the learning algorithm will iterate over the entire training dataset.[39]

II.13. Methods of evaluation:

II.13.1. Confusion matrix:

A confusion matrix, also known as an error matrix, is a specific chart used to find out how well a classification is performing in a simple visual way.[40]

Predicted class

Actual values		***Positive***	***Negative***
	Positive	***True Positive TP***	***False Negative FP***
	Negative	**False Positive FP**	***True Negative TN***

Figure. 2.14 Confusion matrix work For 2 classes

II.13.2. Precision:

Precision is a measure that tells us how accurately a model identifies positive samples. It's calculated by taking the number of true positive samples and dividing it by the total number of samples labeled as positive, whether they were labeled correctly or not. [41]

$$Precision = \frac{True\ Positive}{\text{True } Positive + False\ Positive}$$

II.13.3. Recall :

sometimes called "true positive rate," is calculated by dividing the number of correctly identified positive samples by the total number of actual positive samples. It measures how well the model can find positive samples, and a higher recall means more positive samples are being correctly identified. [41]

$$Recall = \frac{\text{True Positive}}{\text{True Positive+False Negative}}$$

II.13.4. F1 score :

The F1 score is an evaluation metric used to assess machine learning model performance. It combines both precision and recall, making it especially useful for unbalanced datasets.[42]

II.14. Conclusion:

In this chapter, we talked about deep learning DL, which is a part of machine learning ML, which is contained in artificial intelligence AI, their respective techniques, their types, and concepts related to each one. Where we dealt with the most important algorithms and the various types of machine learning, and we have known the CNN

Chapitre III

Implementation and Results

Chapitre III.

III.1. Introduction:

In this chapter, we will talk about the Python language, which is widely used and important in many areas, especially in artificial intelligence. Python is popular for creating machine learning and AI projects, and it is also used in web development and game programming. We will explore important libraries and functions that help us learn and apply machine learning, such as Keras and Tensorflow.

III.2. Anaconda Environment:

III.2.1. Definition:

Anaconda is an open-source software environment for the Python programming language. It provides a comprehensive set of tools and packages used in fields like science, data analysis, and analytics. This includes packages such as NumPy, Pandas, SciPy, and others, which help with processing and analyzing data, as well as applying machine learning techniques. Anaconda is known for its easy management of packages and the ability to create separate environments for different projects. It can be used on different operating systems and is freely available for use. [43]

Anaconda includes a fantastic integrated development environment (IDE), Spyder (Scientific Python Development Environment), as well as other useful tools like jupyter notebooks, the python console, and the excellent package management tool, conda, which allows us to install, remove, or upgrade any Anaconda package with a single command in Anaconda Prompt. Anaconda 5.2.0, which is compatible with Python 3.6, is used in our research. [44]

III.3. Python language:

III.3.1. Definition:

The Python language is an easy, simple and easy-to-learn programming language that is used in several different fields and is gaining wide popularity in both academic and industrial circles. [45]

Python for ML and DL Applications is a set of libraries that allow developers to quickly extract and convert data, execute data wrangling operations, apply existing robust ML algorithms, and create bespoke algorithms. These are the libraries that are available. Numpy, scipy, Pandas, Scikit-Learn, tensorflow, Keras, and more Python libraries. [46]

III.4. Google Colab

Google Colab is a free cloud-based platform that allows you to run Python code in a Jupyter Notebook environment. It provides access to powerful computing resources, such as GPUs and TPUs, making it a popular choice for data science and machine learning projects.
With Google Colab, you can collaborate with others, import and export notebooks, and access a wide range of libraries and tools.

III.5. Spyder

Spyder is a powerful scientific environment written in Python, for Python, and designed by and for scientists, engineers and data analysts. It features a unique combination of the advanced editing, analysis, debugging, and profiling functionality of a comprehensive development tool with the data exploration, interactive execution, deep inspection, and beautiful visualization capabilities of a scientific package.

III.6. Python Libraries:

III.6.1. NumPy:

NumPy is the fundamental package for scientific computing in Python. It is a Python library that provides a multidimensional array object, various derived objects (such as masked arrays and matrices), [47]

III.6.2. TensorFlow:

TensorFlow is an amazing information stream in machine learning library made by the Brain Team of Google and made open source in 2015. [48]

III.6.3. Keras:

Keras is a Python-based deep learning API that runs on top of the TensorFlow machine learning platform. [49]

III.6.4. Pandas:

Pandas is a well-known Python-based data analysis package that offers a wide range of functions, from parsing numerous file formats to transforming an entire data table into a numpy matrix array.[50]

III.6.5. Matplotlib:

Matplotlib is a comprehensive library for creating static, animated, and interactive visualizations in Python.[51]

III.7. Datasets Descreption :

When learning about machine learning, it is required to use real-world data, rather then synthetic datasets. Fortunately, there are many open datasets available in different fields. Here are some places to find data.[52]

- ❖ UC Irvine Machine Learning Repository. [53]
- ❖ Kaggle datasets. [54]
- ❖ Amazon's AWS datasets. [55]

III.7.1. Data used:

The dataset is structured into two main folders, "train" and "test." Within both the "train" and "test" folders, there are three subfolders: "COVID19," "PNEUMONIA," and "NORMAL." Intotal, the dataset comprises 6,432 X-ray images. The test data portion consists of 20% of the total images . [55]

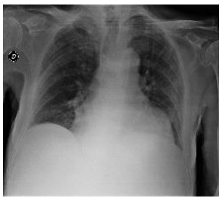
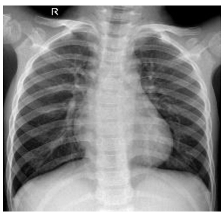
COVID-19				
PNEUMONIA:				
NORMAL:				

Figure 3.1 : Datasets Descreption

III.7.2. Preprocessing of the used dataset:

We split the dataset into training and test sets, and used the spider's language to specify the ratio for both the training and test data. We chose a ratio of 80% for training and 20% testing, with a 0% ratio for validation. [56]

Why 0% for validation :

- Avoid complicating the partitioning process as simplicity will be more effective for my particular project
- In simple projects like basic classification or training a straightforward model, you may not require a large portion of your data for a validation set. Instead, you can just split your data into a training set and a test set.

```
import splitfolders
data = ('C:/Users/hicham/Desktop/Data/')
new_data = ('C:/Users/hicham/Desktop/new pro/')
splitfolders.ratio(data, new_data, seed = 1337 , ratio = (0.8,0.0,0.2) )
```

III.8. Realized :

In this part , I will explain the topic of my project, talk about the CNN model that I built to get really accurate results, and mention the user-friendly graphical interface that I built to facilitate experiments in deep learning

III.8.1. Preprocessing of the used dataset:

Import the required layers and modules to create our convolution neural net architecture

- Importing librar.
- Create path.
- resize images.
- define input image.
- create the Network.
- Generate the model.

```
model = Model(inputs = img_imput, outputs = x , name = 'CNN_COVID_19')
```

- Print network structure.
- Compiling the model.
- hist (the training and testing operation):

batch_size = 30

hist = model.fit(traindata, steps_per_epoch = traindata.samples//batch_size,

validation_data = testdata,validation_steps = testdata.samples//batch_size,

= epochs50(

- ❖ Save the model:

model.save("C:/Users/hicham/Desktop/DATA SET/DATA2/save.h5")

III.9. Convolutional Neural Network Model:

III.9.1. The Proposed Model:

In this work, we created an artificial neural network model to detect Covid-19 disease from X-ray images, using recurrent neural layers (CNN) and several tools and functions such as (Max-pooling), as will be explained in this part of the chapter..

III.9.2. CNN architectures concept:

In typical CNN architectures, there is a repeated pattern: convolutional layers followed by ReLU layers, then pooling layers. This makes the network both smaller and deeper as it processes the data. Towards the end, a regular feedforward neural network is used, composed of fully connected layers with ReLU activation, and the final layer produces predictions. [57]

III.9.3. outline of the proposed CNN model:

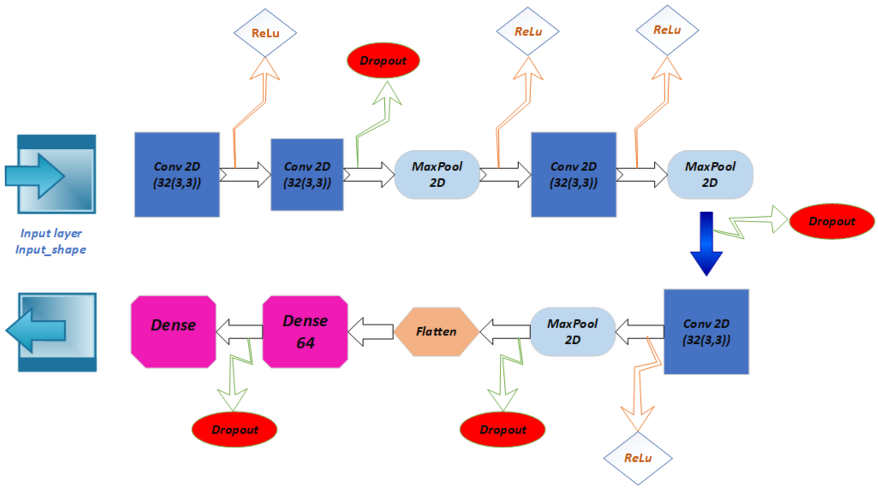


Figure 3.2: The stages of the convolutional neural network model

Our project's main goal was to create a CNN (Convolutional Neural Network) that achieves the highest accuracy while being as fast as possible. This model is structured with several layers, as shown in (Fig 3.2):

- create the Network:
  - .A first layer : convolutional layer Conv2D constituted of 32 filters of size (3x3) and
  - (padding = 'same' ,activation='relu')
  - .A second layer : convolutional layer Conv2D constituted of 64 filters of size (3x3) and (padding='same' , activation='relu')
  - . A third layer: MaxPooling MaxPool of size (2x2) and strides(2,2)
  - Dropout(0.25)
  - .A Forth layer: convolutional layer Conv2D constituted of 64 filters of size (3x3) and (padding = 'same' ,ctivation='relu')
  - . A Fifth layer: : MaxPooling MaxPool of size (2x2) and strides(2,2)
  - Dropout(0.25)
  - .Sixth layer: : convolutional layer Conv2D constituted of 128 filters of size (3x3) and (padding = 'same' , activation='relu')
  - .A Seventh layer: MaxPooling MaxPool of size (2x2) and strides(2,2)
  - Dropout(0.25)
  - Flatten
  - . Eighth layer : Dense(64)
  - Dropout(0.5)
  - . Dense(4) and activation ='softmax

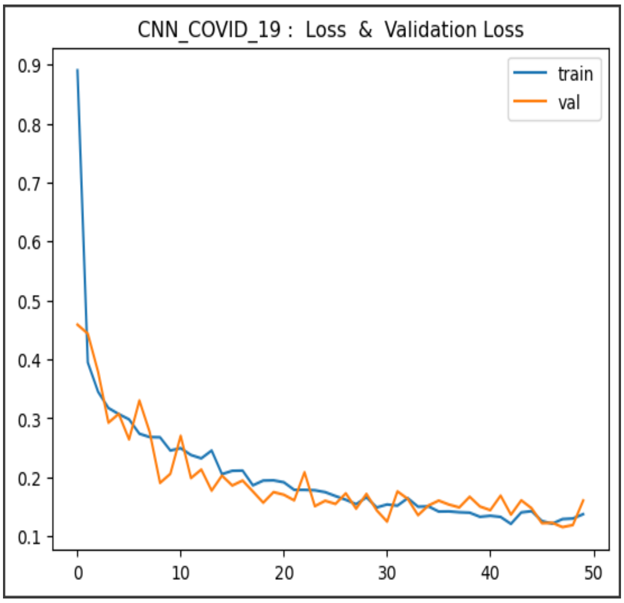
III.9.4. The convolution layer (CONV):

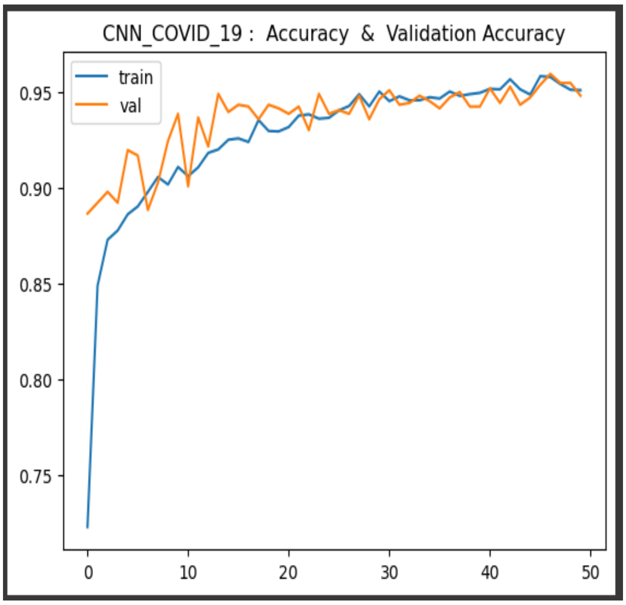
In the context of artificial intelligence, convolution is a systematic process that combines two pieces of information; it's a function that transforms another function. Convolutions have been utilized extensively, especially in image processing, to make images appear smoother or more defined and for various other tasks such as highlighting edges and creating a raised effect. (For instance, enhancing edges and creating a raised appearance) Convolutional Neural Networks (CNNs) establish a close relationship between neighboring neurons in consecutive layers.

In the artificial intelligence, the most commonly used convolution is the 2D convolution layer, often denoted as conv2D. This layer works by sliding a filter or kernel over 2D input data, multiplying corresponding elements, and adding them up to produce a single output pixel. This process repeats for every location the kernel moves across, effectively transforming a 2D matrix of features into a different 2D feature matri. [58]

III.10. Obtained results:

III.10.1. Diagram





A)Diagram representing loos and val loos B) Diagram representing Accracy and val Accuracy

Figure 3.3: Explanatory charts

A) The following curve is for the Loss and Validation Loss values over loops (Epochs) while training the CNN (Convolutional Neural Network) model. The goal of this graph is to evaluate training performance and to see if the model is learning well or not. Let's analyze the curve

III.10.2. Train Loss:

- This line represents the loss values on the training dataset as the loops progress (Epochs).
- The loss on the training data seems to decrease gradually as the loops progress, indicating that the model learns well from the training data.

III.10.3. Validation Loss:

- This line represents the loss values on the validation data set as the loops progress.

- Note that Validation Loss also decreases gradually as the episodes progress. This means that the model also performs well on validated data and there is no obvious overfitting where Validation Loss is greater than Train Loss.

III.10.4. Convergence:

It is observed that the loss reaches a relatively low value of around 0.1 after a number of loops. This indicates that the model has learned well from the data and is able to predict the data accurately.

III.10.5. Loss Convergence:

When the loss values for training and validation are close to each other and exceed a certain point without increasing significantly, it is a good indication that the model is stable and that there is no significant overfitting.

B) The following curve shows the accuracy values on the training dataset and the accuracy values on the validation dataset with respect to the number of episodes (Epochs) while training the CNN model. This curve helps evaluate how the model's performance improves as training progresses. Let's analyze the curve:

III.10.6. Train Accuracy :

- This line represents the accuracy values on the training dataset as the loops progress.
- It is shown that the accuracy of the model on the training data increases progressively as the episodes progress. This means that the model learns well from the training data and becomes more accurate.

III.10.7. Validation Accuracy:

- This line represents the accuracy values on the validation data set as the loops progress.
- It is observed that the verification accuracy also increases gradually as the episodes progress. This indicates that the model performs equally well on validated data and that there is no significant overfitting.

III.10.8. Accuracy Improvement:

- It is noted that the accuracy on the verified data increases gradually and reaches a high value close to 0.95 (95%) with the passage of the loops.

- This indicates that the model improves continuously with additional training and is able to predict the data with high accuracy.

III.11. The evaluation metrics for a convolutional neural network (CNN) :

Now we will explain the results of the evaluation metrics of the convolutional neural network (CNN) model that was trained on grayscale medical images of chest X-rays with three categories: Covid, normal, and pneumonia. Let us analyze these results in detail.

III.11.1. Confusion Matrix:

Confusion matrix is a table used to evaluate the performance of a classification model. Shows the number of true positive (TP), true negative (TN), false positive (FP), and false negative (FN) predictions for each category. Refer to chapter 2 for more information about confusion matrix.

```
[[ 10  24  62]
 [ 21  64 149]
 [ 61 194 475]]
```

➢ In this matrix:

- The first row represents the COVID class.
- The second row represents the NORMAL class.
- The third row represents the PNEUMONIA class.
- The first column represents the model's predictions for COVID.
- The second column represents the model's predictions for NORMAL.
- The third column represents the model's predictions for PNEUMONIA.
- For example, in the first row, the model correctly predicted 10 instances of COVID, but it incorrectly predicted 24 instances as NORMAL and 62 instances as PNEUMONIA.

III.11.2. Classification Report:

The classification report provides various metrics for each class, including precision, recall, and F1-score.

Classification Report

	precision	recall	f1-score	support
COVID	0.11	0.10	0.11	96
NORMAL	0.23	0.27	0.25	234
PNEUMONIA	0.69	0.65	0.67	730
accuracy			0.52	1060

- Precision: Precision measures how many of the positive predictions were actually correct. It's calculated as TP / (TP + FP).
- Recall: Recall (also called sensitivity) measures how many of the actual positives were correctly predicted. It's calculated as TP / (TP + FN).
- F1-score: The F1-score is the harmonic mean of precision and recall and provides a balance between the two metrics.
- Support: The number of instances in each class.

III.12. Accuracy:

The overall accuracy of the model is 52%. This means that, on average, the model made correct predictions for 52% of the total instances in the evaluation dataset.

4/Macro Avg and Weighted Avg:

- These rows in the classification report provide average metrics across all classes.
- Macro Avg calculates the metrics independently for each class and then takes the unweighted mean of those metrics. It doesn't consider class imbalances.
- Weighted Avg calculates the metrics for each class and then takes a weighted mean, considering the support (number of instances) for each class. It gives more weight to classes with more instances.

III.13. Comparing the results :

We compared our results with several developers who worked with the same data, such as developer by DenseNet121, who obtained a training accuracy score of 94% while using a more complex architecture based on DenseNet121, a well-known architectural model.

The model has 121 layers and also uses 3 RGP color channels. [59]

	Accuracy	Val accuracy	Loss	Val Loss
Our model	0.9510	0.9545	0.1298	0.1188
TARA PRASAD PANDEY	0.9434	0.9562	0.1427	0.1426

Figure 3.4: Comparing the results

Overall, the model seems to learn well and is trending toward improvement in performance Overall, the curve shows a continuous improvement in the model's performance over the loops and the accuracy approaches 0.95, which is a good indication that the model has learned well and can handle the data with high accuracy.

III.14. Application interface:

- Home Page: This application contains five buttons, each of them has a separate page:

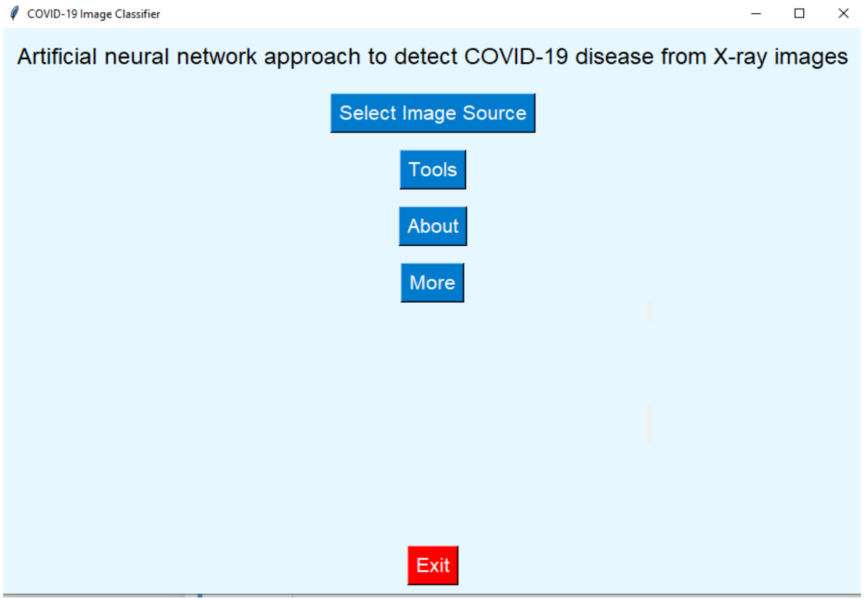


Figure 3.5: Home Page of application

After selecting the image to be classified, the results are displayed as shown in (Figure 3.4)

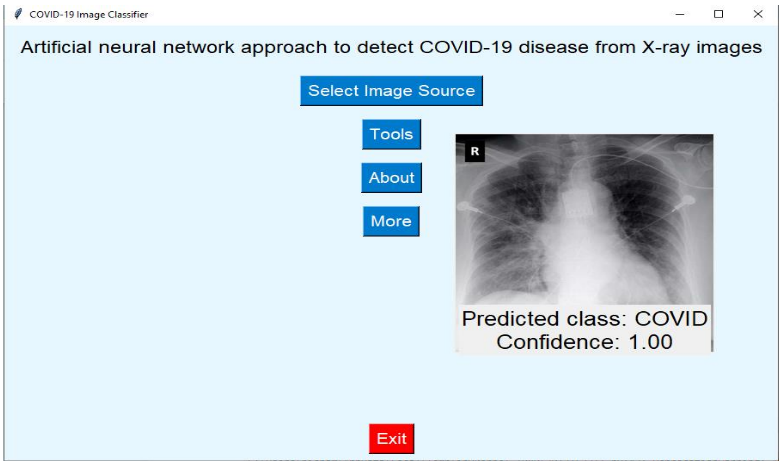


Figure **3.6: Select image Source of application**

Tools Page: Here are some tools to help you learn more about the field of deep learning, including the environment used to create this application

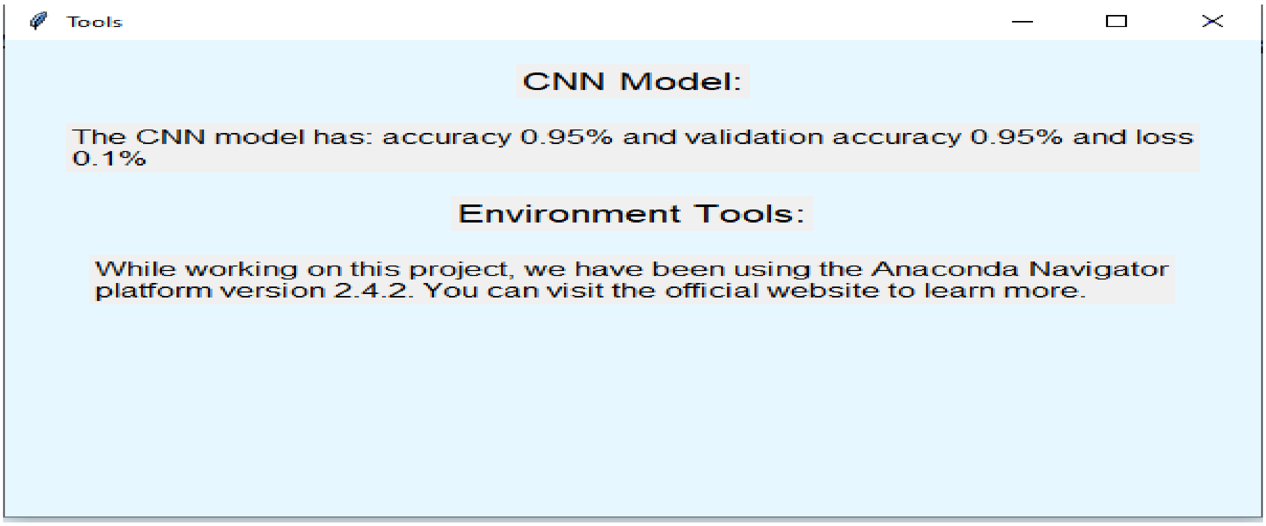


Figure **3.7:Tools page of application**

About Page: This page contains some explanations regarding the application.

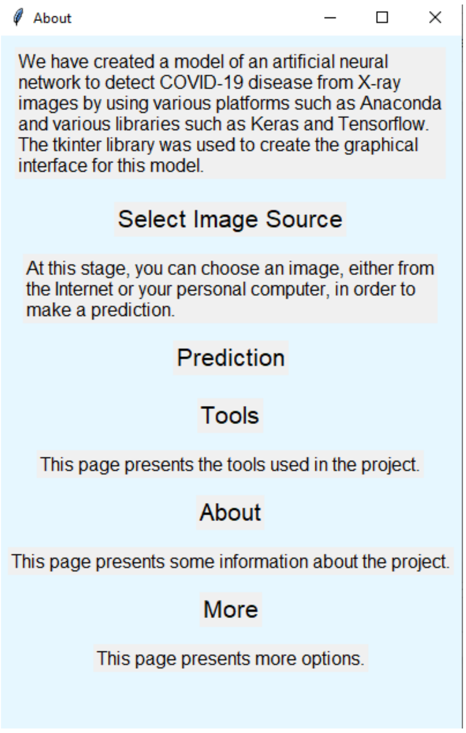


Figure **3.8: About Page of application**

- More Page:The More page contains more explanations and contains some links in order to learn more about our project.

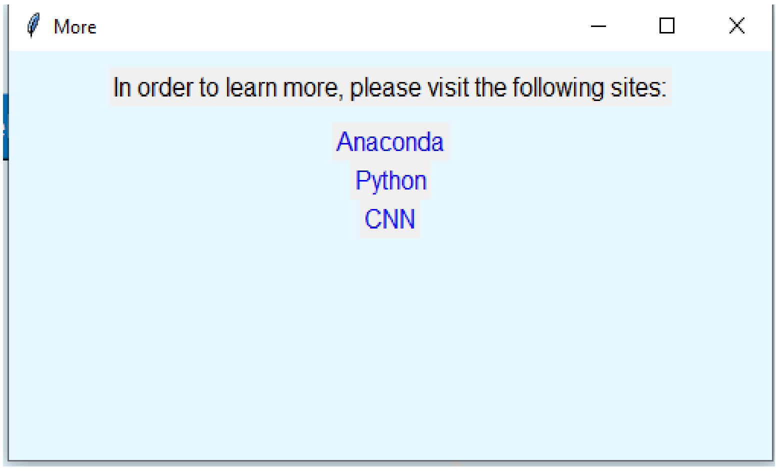


Figure **3.9: More Page of application**

III.15. Conclusion:

The general idea of this chapter depends on how the data is processed and prepared for action. In our deep learning project, we relied on the use of convolutional layers in two parts: building and developing the model, improving its accuracy, and working on developing interface schemes that are compatible with this proposal and that help in understanding and ease of use, and this is what was done. we have presented our project development environment and the most important libraries that we used. We chose them for the strength and accuracy of their results.

CONCLUSION

Chapitre IV. General Conclusion

This research utilized artificial neural networks, specifically deep learning techniques, to detect COVID-19 from chest X-ray images. The developed neural network model, incorporating multi-layer deep neural networks and convolutional neural networks, was evaluated using a dataset containing both infected and non-infected individuals' medical images. The study demonstrated the model's ability to effectively differentiate between COVID-19 positive and negative cases, highlighting the potential of artificial neural networks as a valuable tool in diagnosing COVID-19. The research signifies a significant advancement in creating intelligent and precise diagnostic tools for early detection and treatment of COVID-19, with the potential to enhance patient care and curb the global spread of the virus. However, further research and development, including enlarging the dataset and refining neural network models, are essential to enhance accuracy and reliability. Continued innovations in this field may lead to the creation of more advanced and effective diagnostic tools to combat the spread of COVID-19 and similar diseases in the future.

The problem studied in this work is the detection of COVID-19 disease from X-ray images using an artificial neural network approach. With the outbreak of the COVID-19 pandemic, there has been a need for efficient and accurate diagnostic methods. X-ray imaging has shown potential in detecting COVID-19-related lung abnormalities. However, the interpretation of X-ray images can be subjective and time-consuming for radiologists. Therefore, the researchers aimed to develop an automated system that can accurately detect COVID-19 from X-ray images, providing a faster and more consistent diagnosis.

The solution proposed in this work is the utilization of artificial neural networks, specifically deep learning techniques, for the detection of COVID-19 from X-ray images. Artificial neural networks are computational models inspired by the structure and function of the human brain. They can learn patterns and features from large datasets and make predictions based on the learned information. In this study, the researchers trained an artificial neural network using a dataset of COVID-19 and non-COVID-19 X-ray images. The network was designed to analyze the images and classify them as either COVID-19 positive or negative.

The findings of this work demonstrated the effectiveness of the proposed artificial neural network approach in detecting COVID-19 from X-ray images. The trained network achieved high accuracy in differentiating between COVID-19 and non-COVID-19 cases. This suggests that artificial neural networks have the potential to serve as reliable tools for COVID-19 diagnosis, providing a rapid and automated solution. The use of deep learning techniques allows for the extraction of intricate patterns and features from X-ray images, enabling accurate detection of

COVID-19-related abnormalities. These findings contribute to the ongoing efforts in developing advanced diagnostic systems for the timely identification and management of COVID-19 case

REFERENCES

Chapitre V. Références

[1] World Health Organization. (2020, December 31). WHO Director-General's opening remarks at the media briefing on COVID-19. https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---21-december-2020

[2] Wu, J. T., Leung, K., & Leung, G. M. (2020). Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. The Lancet, 395(10225), 689-697. https://doi.org/10.1016/S0140-6736(20)30260-9

[3] World Health Organization. (2021, September 22). Coronavirus disease (COVID-19) Weekly Epidemiological Update and Weekly Operational Update.https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports

[4] Coronavirus disease (COVID-19): How is it transmitted

https://www.who.int/news-room/questions-and-answers/item/coronavirus-disease-covid-19-how-is-it-transmitted

[5] Symptoms of COVID-19 https://www.health.state.mn.us/diseases/coronavirus/basics.html

[6] COVID-19 symptoms

https://health.ucdavis.edu/coronavirus/covid-19-information/coronavirus-symptoms

[7] CDC - Diagnosis | Clinical Care Considerations

https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-care/clinical-considerations-diagnosis.html

[8] PMC - COVID-19 diagnosis and management: a comprehensive review

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7267177

[9] Stanford Health Care - X-ray, Electromagnetic Radiation - Medical Test

https://stanfordhealthcare.org/medical-tests/x/xray.html

[10] NCBI - Chest X-ray in new Coronavirus Disease 2019 (COVID-19) infection: findings and correlation with clinical outcome

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7282464/

[11] Russell, S., Norvig, P. Artificial Intelligence: A Modern Approach. Pearson, 2016. (Link: https://www.amazon.com/Artificial-Intelligence-Modern-Approach-3rd/dp/0136042597)

[12] Nilsson, N. J. Artificial Intelligence: A New Synthesis. Morgan Kaufmann, 1998. (Link: https://www.amazon.com/Artificial-Intelligence-New-Synthesis/dp/1558604677)

[13] Bostrom, N. Superintelligence: Paths, Dangers, Strategies. Oxford University Press, 2014. (Link: https://www.amazon.com/Superintelligence-Dangers-Strategies-Nick-Bostrom/dp/0198739834)

[14] Samuel, A. (1959). Field of study in machine learning. IBM Journal of Research and Development, 3(2), 210–229. (Link: https://ieeexplore.ieee.org/document/5392564)

[15] Machine Learning Mastery: "Classification as Supervised Learning" (https://machinelearningmastery.com/classification-as-supervised-learning/)

[16] Logistic Regression https://online.stat.psu.edu/stat462/node/207/

[17] https://towardsdatascience.com/https-medium-com-pupalerushikesh-svm-f4b42800e989

[18] https://www.javatpoint.com/machine-learning-decision-tree-classification-algorithm

[19] Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.

[20] TensorFlow: https://www.tensorflow.org/

[21] PyTorch: https://pytorch/

[22] Python Machine Learning Tutorial, Next Chapter: Neural Networks With Scikit URL :

https://www.pythoncourse.eu/neural_networks_with_dropout.php

[23] Rabah Hammouche; Abdelouahab Attia; Samir Akhrouf, 2020 4th International Symposium on Informatics and its Applications (ISIA)

[24] Mathew,A., P.Amudha, S.Sivakumari,Deep Learning Techniques: An Overview,(2020)Amitha Mathew Et Al.

[25] Jake Frankenfield ,Eric Estevez, Aug 28, 2020,Artificial Neural Network (ANN),Investopedia URL https://www.investopedia.com/terms/a/artificial-neural-networks-ann.asp

[26] D. H. Hubel و T. N. Wiesel ،"Receptive Fields and Functional Architecture of Monkey Striate Cortex" ،The Journal of Physiology1968 ،.

[27] Yanming Guo ،Yu Liu ،Ard Oerlemans ،Songyang Lao ،Song Wu ،Michael S. Lew ،"Deep Learning for Visual Understanding: A Review" ،Neurocomputing187 ، (2016) ،pp 48-27 .

[28] https://towardsdatascience.com/everything-you-need-to-know-about-activation-functions-in-deep-learning-models-84ba9f82c253

[29] R. Girshick ،"Fast R-CNN" ،Proceedings of the 2015 IEEE International Conference on Computer Vision ،pp1448-1440 . doi: 10.1109/ICCV.2015.169

[30] Sarkar, D., Bali, R. And Sharma, T., N.D. Practical Machine Learning With Python, P69.

[31][https://www.databricks.com/glossary/convolutionallayer#:~:text=The%20most%20common%20type%20of,into%20a%20single%20output%20pixel

[32] [https://towardsai.net/p/l/introduction-to-pooling-layers-in-cnn]

[33][https://medium.com/@amarbudhiraja/https-medium-com-amarbudhiraja-learning-less-to-learn-better-dropout-in-deep-machine-learning-74334da4bfc5]

[34][https://www.nickmccullum.com/python-deep-learning/flattening-full-connection/]

[35] https://www.arxiv-vanity.com/papers/2008.05756/

[36] *https://developers.google.com/machine-learning/crash-course/classification/accuracy*

[37] https://developers.google.com/machine-learning/crash-course/descending-into-ml/training-and-loss]

[38] https://stackoverflow.com/questions/42998989/batch-size-in-tensorflow-understanding-the-concept

[39] https://machinelearningmastery.com/difference-between-a-batch-and-an-epoch/

[40] *https://www.analyticsvidhya.com/blog/2021/06/confusion-matrix-for-multi-class-classification/*

[41][https://blog.paperspace.com/deep-learning-metrics-precision-recall-accuracy/]

[42][https://arize.com/blog-course/f1-score/]

[43] https://docs.anaconda.com/free/navigator/tutorials/manage-environments/

[44] https://docs.anaconda.com/free/anaconda/reference/packages/old-pkg-lists/5.2.0/py3.6_osx-64

[45] What is Python? Executive Summary,python organization URL :https://python.sdv.univ-paris-diderot.fr/.

[46] Raschka, S. And Mirjalili, V., N.D. Python Machine Learning. 2nd Ed. P.58.

[47] Numpy.Org URL:https://numpy.org/doc/stable/user/whatisnumpy.html

[48] Tensorflow https://ijisrt.com/wp-content/uploads/2019/06/IJISRT19JU358.pdf

[49] About Keras. URL: Https://Keras.Io/About/.

[50] What-Is-Pandas-In-Python. URL: Https://Www.Educative.Io/Edpresso/What-Ispandas-In-Python

[51] https://matplotlib.org/

[52] [https://archive.ics.uci.edu/]

[53] [Find Open Datasets and Machine Learning Projects | Kaggle]

[54] [https://registry.opendata.aws/]

[55] https://www.kaggle.com/datasets/prashant268/chest-xray-covid19-pneumonia

[56] [https://pypi.org/project/split-folders/]

[57] [https://www.oreilly.com/library/view/hands-on-machine-learning/9781492032632/]

[58]https://www.databricks.com/glossary/convolutional-layer#:~:text=The%20most%20common%20type%20of,into%20a%20single%20output%20pixel.

[59] https://www.kaggle.com/code/scodepy/covid-detection

Chapitre VI. Abstract

This research employs artificial neural networks, specifically deep learning techniques, to detect COVID-19 from chest X-ray images. The study created and assessed a neural network model using a dataset of medical images from both COVID-19 infected and non-infected individuals. The results demonstrated the model's effectiveness in accurately distinguishing between infected and non-infected cases, showcasing its potential as a valuable diagnostic tool for COVID-19. The study emphasizes the necessity for ongoing research, expanding datasets, and refining neural network models to enhance accuracy. It underscores the significant potential of artificial intelligence and deep learning in disease diagnosis, promoting continuous collaboration between researchers and healthcare institutions to address global health challenges.

Keywords: artificial neural networks, COVID-19 detection, chest X-ray images, deep learning techniques, intelligent diagnostic tools, dataset, infected cases, non-infected cases, accuracy, reliability, innovations, patient care, infectious diseases, artificial intelligence, global health challenges.

الملخص

تستخدم هذه الدراسة الشبكات العصبية الاصطناعية، وبالتحديد تقنيات التعلم العميق، لاكتشاف فيروس COVID-19 من صور الأشعة السينية للصدر. قامت الدراسة بإنشاء وتقييم نموذج لشبكة عصبية باستخدام مجموعة بيانات تتضمن صورًا طبية لأشخاص مصابين وغير مصابين بفيروس .COVID-19 أظهرت النتائج فعالية النموذج في التمييز الدقيق بين الحالات المصابة وغير المصابة، مما يبرز إمكانيته كأداة تشخيص قيمة لفيروس .COVID-19 تشدد الدراسة على ضرورة استمرار البحث وتوسيع مجموعات البيانات وتحسين نماذج الشبكات العصبية لزيادة الدقة. وتسلط الدراسة الضوء على الإمكانيات الكبيرة للذكاء الاصطناعي وتقنيات التعلم العميق في تشخيص الأمراض، مشجعة على التعاون المستمر بين الباحثين والمؤسسات الصحية لمواجهة التحديات الصحية العالمية.

الكلمات الرئيسية: الشبكات العصبية الاصطناعية، كشفCOVID-19 ، صور الأشعة السينية للصدر، تقنيات التعلم العميق، أدوات التشخيص الذكية، مجموعة البيانات، الحالات المصابة، الحالات غير المصابة، الدقة، الموثوقية، الابتكارات، رعاية المرضى، الأمراض المعدية، الذكاء الاصطناعي، التحديات الصحية العالمية.