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Mohamed El Bachir El Ibrahimi University of Bordj Bou Arreridj
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Master in Computer Science
Specialty: Business Intelligence Engineering

THEME
Autism Spectrum Disorder Detection Using Deeplearning Techniques

Presented by:

Benyzid Slimane

Fareh Samir

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In front of the jury composed of:

President: Pr.Attia Abdelouahab

Examiner: Dr. Benabid Sonia

Supervisor: Dr. Maza Sofiane

Guest: Dr. Louriachi Imen

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Dedication

I dedicate my work:

To my dear parents, who have always encouraged me and never left my side.

To my family members, who were there for me when I needed them.

To my supervisor, Dr. Maza Sofiane, for sharing his knowledge and advice with me.

To my friends, thank you for your love and support.

To everyone who helped me, I genuinely appreciate your help.

Acknowledgments

First, I thank God for giving me the patience and determination to complete this work.

I am grateful to my supervisor, Dr. Maza Sofiane, for his help during this project.

I would also like to thank the jury members for their time and expertise in evaluating my work.

I am grateful to all the professors in the Computer Science department for sharing their knowledge with all the students, myself included.

Finally, I thank all the people who have supported me during this project.

Abstract

This project aims to develop an intelligent system for detecting autism spectrum disorder (ASD) using deep learning techniques. Autism is a complex condition that affects communication and behavior, and early diagnosis is critical for effective, appropriate, and prompt intervention. The system uses convolutional neural networks (CNNs), such as MobileNet and VGG19, to classify individuals as having or not having autism based on face images and eye-tracking data.

A publicly available Kaggle dataset containing images representing typical visual behavior of individuals with ASD was used. The data was preprocessed through resizing, normalization, and augmentation to improve model performance. The model was evaluated using precision, accuracy, recall, F1 score, and ROC-AUC.

The results demonstrated high performance and outperformed traditional methods, demonstrating the model's effectiveness in detecting autism. This project highlights the role of artificial intelligence in advancing healthcare by enabling faster and more accurate diagnosis of complex conditions.

Resumé

Ce projet vise à développer un système intelligent de détection des troubles du spectre autistique (TSA) à l'aide de techniques d'apprentissage profond. L'autisme est une maladie complexe qui affecte la communication et le comportement, et un diagnostic précoce est essentiel pour une intervention efficace, appropriée et rapide. Le système utilise des réseaux neuronaux convolutifs (CNN), tels que MobileNet et VGG19, pour classer les individus comme étant ou non autistes en fonction des images du visage et des données de suivi oculaire.

Un ensemble de données accessible au public provenant de Kaggle a été utilisé, contenant des images représentant le comportement visuel typique des personnes atteintes de troubles du spectre autistique. Les données ont été prétraitées par redimensionnement, normalisation et augmentation pour améliorer les performances du modèle. Le modèle a été évalué à l'aide de l'exactitude, de la précision, du rappel, du score F1 et du ROC-AUC.

Les résultats ont montré des performances élevées et ont surpassé les méthodes traditionnelles, démontrant l'efficacité du modèle dans la détection de l'autisme. Ce projet met en évidence le rôle de l'intelligence artificielle dans l'avancement des soins de santé en permettant un diagnostic plus rapide et plus précis de maladies complexes.

ملخص

يهدف هذا المشروع إلى تطوير نظام ذكي للكشف عن اضطراب طيف التوحد (ASD) باستخدام تقنيات التعلم العميق. يُعد التوحد حالةً معقدةً تؤثر على التواصل والسلوك، ويُعد التشخيص المبكر أمرًا مهما جدا للتدخل الفعال و المناسب و الفوري . يستخدم النظام الشبكات العصبية التلافيفية (CNNs)، مثل (Mobilenet) و(VGG19)، لتصنيف الأفراد إلى مصابين بالتوحد أو غير مصابين به بناءً على صور الوجوه وبيانات تتبع العين.

استُخدمت مجموعة بيانات متاحة للجمهور من (Kaggle)، تحتوي على صور تمثل السلوك البصري النموذجي للأفراد المصابين بطيف التوحد. خضعت البيانات لمعالجة مسبقة من خلال تغيير الحجم والتطبيع والزيادة لتحسين أداء النموذج. تم تقييم النموذج باستخدام الدقة والإحكام والتذكر ودرجة (F1)و(ROC-AUC).

بينت النتائج أداءً عاليًا وتفوقت على الطرق التقليدية، مما يدل على فعالية النموذج في الكشف عن التوحد. يُسلط هذا المشروع الضوء على دور الذكاء الاصطناعي في تطوير الرعاية الصحية من خلال تمكين تشخيص أسرع وأكثر دقة للحالات المعقدة.

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General Introduction

Artificial intelligence (AI) become an integral part of our daily lives, from simple voice assistants to autonomous driving.[1] This project aims to explore the foundations of AI and apply this knowledge to develop and improve a simple yet practical application. We will cover fundamental concepts in machine learning,[2] such as supervised and unsupervised learning, and apply these techniques to solve one or more specific problems.

AI has made significant progress in recent years, particularly with the emergence of deep learning. This branch of AI aims to leverage the human brain to enable machines to learn autonomously from massive amounts of data. In this project, we will explore the fundamentals of deep learning [3] and apply an artificial neural network to solve a specific problem, such as image recognition [4] and analysis or text generation.

Autism is a complex neurodevelopmental disorder with challenges in early diagnosis. Deep learning, a branch of AI, offers new prospects for improving autism detection.[5] The main goal of this thesis is to detect ASD (Autism Spectrum Disorder) based on deep learning techniques, utilizing the 'image-autism' dataset from Kaggle and the 'eye-tracking' dataset imported from Google Drive. In this project, we will explore how artificial neural networks can identify specific patterns in data, such as facial images and eye movement analysis, to help diagnose autism more accurately and quickly.

To accomplish this, the thesis is organized into three chapters:

Chapter one: In this chapter, we explained that it is essential to understand that autism is a complex neurodevelopmental disorder, not just a "simple disease." Using accurate terminology and understanding the nature of autism is essential to having respectful and informed discussions.

Chapter two: In this chapter, we show how deep learning has transformed the field of artificial intelligence by enabling machines to understand complex patterns using multi-layered neural networks. We highlight how this progress has led to breakthroughs in fields such as image and speech recognition, and language processing. Despite its resource-intensive nature and the sometimes difficult interpretation of its results, deep learning continues to offer promising advances in artificial intelligence.

Chapter three: In this chapter, we explain the implementation steps of the detection process and the results of the trained autism detection using deep learning that we use in our project, which contains two CNN models working on two datasets: Image Autism and Eye Tracking Autism.

In the end, this thesis concludes with a general conclusion.

Chapter 1

Autisme spectrum disease

1.1 Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental condition characterized by persistent differences in communication and social interaction, restricted and repetitive motor patterns, or behavioral patterns, interests, or activities[6]. It is essential from the outset to move away from the outdated, often stigmatized term "disease" when discussing autism. Autism is not a curable condition (unlike other conditions that can be treated solely with medication), but rather a unique way of experiencing and interacting with the world [7]. It represents a spectrum of diverse manifestations, with individuals displaying a wide range of strengths and challenges.

This discussion aims to highlight autism not as a negative condition, but as an important aspect of human neuro diversity. By focusing on understanding the core characteristics and features, the diverse expressions across the spectrum, and the importance of early detection, support, and affirmation in contemporary ways, we can promote awareness, acceptance, and inclusion of individuals with autism in our communities. This research will address the key features of autism, highlighting the importance of recognizing early signs and the impact of tailored interventions in enabling individuals with autism to ultimately succeed. The goal is to overcome misconceptions, achieve better detection accuracy, and build a society that values and supports the unique contributions of all its members, including those with autism.[8]

1.2 Understanding Autism Spectrum Disorder(ASD)

The term "autism spectrum disorder" does not directly refer to the medical and psychiatric term commonly used in everyday life for the neuro developmental condition known as autism spectrum disorder (ASD).

This appears to be a possible misunderstanding, a less common, and perhaps older, way of referring to autism, or perhaps a misinterpretation of the name. The more common, widely accepted, and arguably more conventional term is autism spectrum disorder (ASD).[9]

Let's break down what autism spectrum disorder (ASD) is:

Autism spectrum disorder (ASD) is a complex neuro developmental condition characterized by persistent difficulties with communication and social interaction, and by restricted and repetitive patterns of behavior, interests, or activities.[10]

Figure 1.1: Autism spectrum disorder
[11]

Autism Spectrum Disorder (ASD) Overview

This table is a more detailed explanation of the main characteristics that characterize the autism spectrum disorder (ASD) : [12][13][14][15][16][17]

Topic	**Description**
1. Social Communication Difficulties	Challenges in interacting and communicating with others.
- Social-emotional exchange	Difficulty in conversation, sharing feelings or interests, and initiating or responding to interactions.
- Nonverbal communication	Difficulties with eye contact, facial expressions, and gestures.
- Understanding relationships	Trouble forming friendships, imaginative play, or showing interest in peers.
2. Restricted and Repetitive Behaviors	Patterns of repetitive actions and narrow interests.
- Repetitive movements or speech	Hand-flapping, object-spinning, repeating words or actions.
- Strict adherence to routines	Distress from small changes, difficulty switching tasks.
- Intense or unusual interests	Focus on unusual or specific topics or objects.
- Sensory sensitivities	Unusual reactions to sound, touch, light, or movement.
3. Key Characteristics of ASD	Important aspects to consider about autism.
- Neurodevelopmental disorder	Caused by differences in brain development.
- Early onset	Symptoms usually appear in early childhood.
- Lifelong condition	It persists over a lifetime, though it may change.
- Diverse abilities	Ranges from intellectual challenges to high ability.
- No single cause	Likely due to a mix of genetic and environmental factors.
- Diagnosis	Based on behavioral observation and developmental history.
- Intervention and support	Early and ongoing personalized support improves outcomes.

1.3 Early Signs and Diagnosis of Autism

Early signs of autism vary greatly from child to child.[18] Some children may show signs within the first few months of life, while others may not show noticeable signs until later. It's important to remember that these are only potential indicators, and not every child who shows these signs will be diagnosed with autism.

1.3.1 Possible Early Signs of Autism

We will explain the possible early signs of autism in simple points :[18]

- Little or no eye contact.
- Not responding to name by 9 months.
- Absence of warm, cheerful expressions or limited social smiling.
- Rarely shows or points to things of interest.
- Does not participate in simple interactive games (e.g., peek-a-boo).
- Difficulty understanding and using gestures.
- Delayed or absent speech development.
- Loss of previously acquired language skills.
- Difficulty understanding others' feelings.
- Prefers playing alone.
- Difficulty making friends.

1.3.2 Restricted and Repetitive Behaviors or Interests

we have tow types of behaviors in our study or we can say interestes , in restricted and repetitive behaviors and interests : [18]

1.3.2.1 Repetitive Behaviors

the most repetitive behaviors are : [18]

- Hand flapping, rocking, or twirling
- Arranging objects and becoming upset if changed
- Playing with toys in a repetitive or unusual way (e.g., spinning wheels)
- Repeating words or phrases (echolalia)

1.3.2.2 Unusual Interests or Sensitivities

the most unusual interests or sensitivities are : [18]

- Intense interest in specific topics or objects
- Strong need for sameness, resistance to routine changes
- Unusual sensory interests or sensitivities (e.g., light, sound, texture, taste, or smell)

1.3.3 Autism Diagnosis

Autism diagnosis is a complex, multi-step process that requires the involvement of various specialists. It relies on observation, standardized tools, and input from a multidisciplinary team, as no single medical test can confirm the condition : [19][20][12][21]

Stage	**Description**
No Single Medical Test	Diagnosis is based on a comprehensive evaluation by a team of specialists.
Screening	Pediatricians perform routine developmental screenings. If concerns arise, a referral is made for detailed evaluation.
Comprehensive Diagnostic Evaluation	• Interviews and questionnaires with parents/caregivers • Direct observation of behavior and social interactions • Standardized diagnostic tools (e.g., ADOS, ADI-R) • Cognitive and language assessments • Medical examination • Multidisciplinary team involvement: – Developmental Pediatricians – Psychologists – Speech-Language Pathologists – Occupational Therapists – Social Workers
Important Considerations	• Early diagnosis and intervention are crucial • Autism is a spectrum disorder with varying effects • Diagnosis is based on DSM-5 criteria • If concerns exist, consult a pediatrician or qualified healthcare provider

1.4 Educational and The rapeutic Approaches

Effective educational approaches for individuals with ASD often emphasize structure,predictability,visual supports,and individualized strategies. Some key principles and methods include:

Figure 1.2: Educational and The rapeutic Approaches
[22][23][7][24]

1.5 Research and Innovations in Care

The field of Autism Spectrum Disorder (ASD) is constantly evolving, with ongoing research leading to new understandings and innovative approaches to care. Here's an overview of recent research and innovations:

1.5.1 Understanding the Causes and Mechanisms of Autism

Autism likely arises from a combination of genetic, environmental, and neurological factors. While its exact causes are still unknown, understanding these mechanisms is essential for improving diagnosis and treatment :

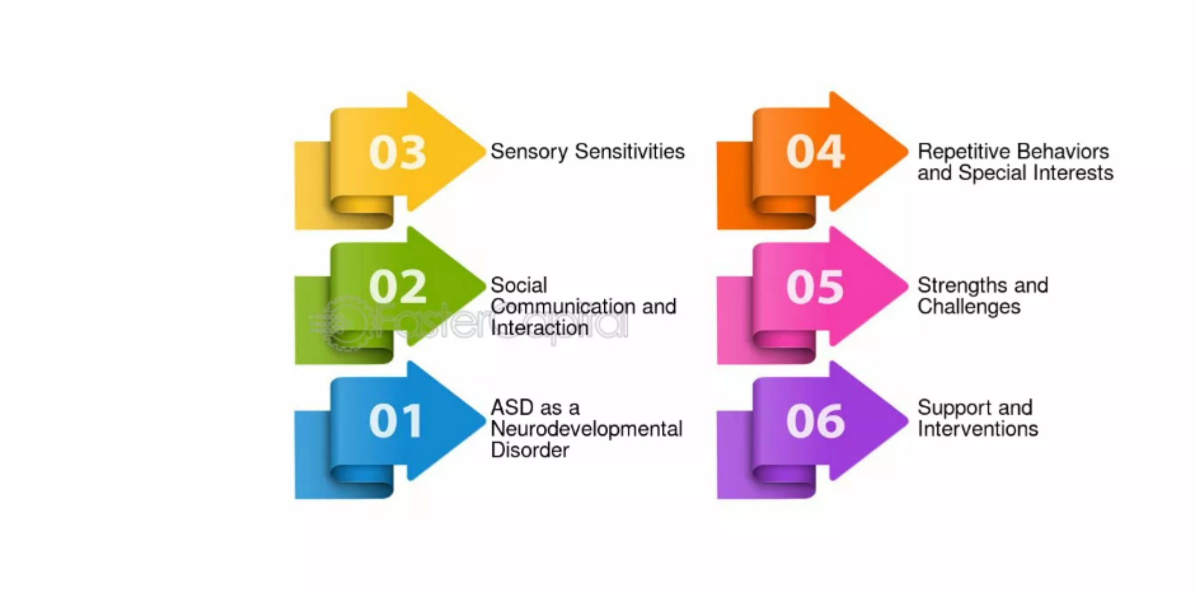

Figure 1.3: Understanding the Causes and Mechanisms of Autism
[25][26]

- Genetics:[27] Research continues to identify genes and genetic variations associated with an increased risk of ASD. Large-scale genetic studies are helping to understand the complex genetic architecture of autism.

- Environmental Factors:[28] Scientists are investigating various environmental factors that may interact with genetic predispositions to increase the risk of ASD. These include prenatal exposure to certain medications, air pollution, maternal health conditions, and birth complications.
- Neurobiology: [29] Studies using brain imaging techniques (fMRI), brain organoids, and post-mortem brain tissue analysis are revealing differences in brain structure, function, and connectivity in individuals with ASD. This research aims to understand the neural basis of autistic behaviors.
- Gut-Brain Axis: Emerging research is exploring the potential role of the gut microbiome in ASD, investigating the connection between gut health and brain function.

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1.5.2 Advancements in Diagnosis

- Early Detection: Research focuses on identifying early behavioral markers and developing screening tools for earlier diagnosis, ideally before the age of two.
- Biomarkers: Scientists are exploring potential biological markers (biomarkers) that could aid in the diagnosis of ASD, such as genetic markers or brain imaging patterns.[30]
- Technology-Assisted Diagnosis: Machine learning algorithms and advanced imaging techniques are being developed to analyze behavioral patterns and brain activity for earlier and more accurate diagnosis.

1.5.3 Innovations in Therapeutic Interventions

here we'll explain the inovations in therapeutic interventions in a simple schema :

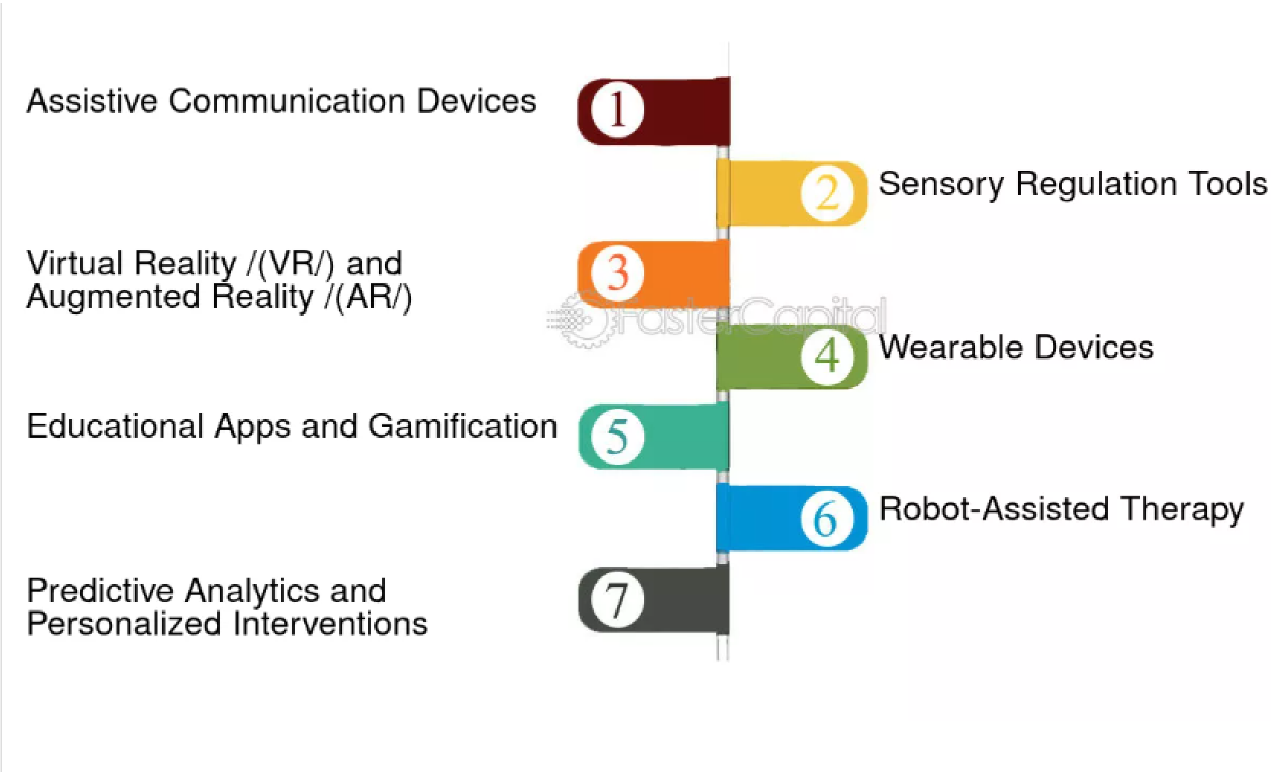


Figure 1.4: Innovations in Therapeutic Interventions
[31][23]

Technique / Approach	Description
Applied Behavior Analysis (ABA) with Technology Integration	Technology enhances ABA therapy through real-time data collection, personalized interventions, and virtual reality environments for practicing social skills.
Augmentative and Alternative Communication (AAC) Devices	High-tech AAC devices, including speech-generating devices, apps, and tablets, along with low-tech options like PECS, are crucial for individuals with limited verbal communication. AI and gesture recognition are further advancing AAC tools.
Social Skills Training	Innovative approaches like VR and AR provide safe and controlled environments for practicing social interactions and reducing anxiety. Peer mediated interventions are also gaining prominence.
Sensory Integration Therapy	Sensory-friendly environments and wearable sensory tools are being developed to address sensory sensitivities common in ASD, promoting comfort and reducing stress.
Pharmacological Research	While there is no cure for ASD, research continues into medications to manage co-occurring conditions like anxiety, ADHD, and seizures. Recent progress includes FDA approval of trofinetide for Rett Syndrome.
Personalized Medicine	Focus is shifting toward personalized interventions based on an individual's unique needs, genetic profile, and challenges. Advances in genetic testing and technology support this approach.
Brain Stimulation Techniques	Research is exploring non-invasive brain stimulation to improve cognition and decision-making in individuals with mental health disorders, including ASD.
Play Therapy	Play-based approaches to improve social skills, language development, emotional regulation, and motor skills.
Occupational Therapy	Focused on developing daily living skills and addressing sensory processing issues.
Speech Therapy	Aims to improve communication skills, including speech, language, and social communication.
Parent Training and Education	Empowers caregivers with knowledge and strategies to support their children's development.
Mindfulness and Mind-Body Practices	Techniques such as mindfulness and meditation are being explored to help manage anxiety and sensory sensitivities.

Table 1.3: Modern Interventions and Technologies Supporting Individuals with Autism Spectrum Disorder (ASD)

1.5.4 Addressing Social Determinants of Health

Research is increasingly focusing on how social inequities [32], such as poverty and lack of access to education, impact autism diagnosis and outcomes. Efforts are underway to improve access to support and services for individuals from marginalized communities.

1.5.5 The Growing Role of Autistic Researchers

The increasing involvement [33] of autistic individuals in research is shaping priorities and ensuring that research addresses the needs and perspectives of the autistic community.

1.5.6 Focus on Lifespan

Research is expanding to address the needs of autistic individuals across the lifespan, including adolescence, adulthood, and aging. This includes studies on transition to adulthood, employment, social integration, and mental health in older autistic adults.

In conclusion, research and innovation in the care of ASD are dynamic and multifaceted. The field is moving towards earlier diagnosis, personalized interventions,a better under standing of the under lying causes,and a greater focus on improving the quality of life for individuals with autism and their families across the entire lifespan. [9][1]

1.6 Conclusion

In conclusion, it is crucial to understand that autism is a complex neuro developmental spectrum disorder, not a simple "spot disease." Using accurate terminology and understanding the nature of autism is essential for respectful and informed discussions.

Chapter 2

Deep learning techniques

2.1 Introduction

Autism Spectrum Disorder (ASD) is a complex neuro developmental condition that affects communication, social interaction, and behavior.[34] Early and accurate diagnosis of ASD is crucial for timely intervention and support. However, traditional diagnostic methods can be time-consuming and subjective.[35] Deep learning, a subset of artificial intelligence, has emerged as a promising tool for assisting in the diagnosis of ASD. By analyzing large datasets of images, videos, or other relevant data, deep learning models can learn to recognize patterns associated with ASD. This can potentially lead to more objective and efficient screening tools for ASD.[36][37] Several approaches are being exploredin this field, including:

1- Facial analysis: Deep learning models can analyze facial features, such as eye gaze, facial expressions, and head movements, to identify potential markers of ASD.[38]

2- Video analysis: Analyzing videos of children's social interactions can provide valuable insights into their communication and behavioral patterns.

3- Brain imaging analysis: Deep learning can be used to analyze brain scans to identify differences in brain structure and function between individuals with and without ASD.[8] While deep learning shows great promise in ASD detection, it is important to note that it is not intended to replace traditional diagnostic methods. Instead, it can be usedas a valuable tool to assist clinicians in making more informed diagnoses.[3]

2.2 Artificial intelligence(AI)

Artificial intelligence (AI) is like giving computers the power to think and learn, just like humans do. It's about creating machines that can understand, reason, and make decisions.[3] Think of AI as a super smart assistant. It can recognize your voice, understand your questions, and even help you with tasks. Imagine a computer that can drive a car, play games, or even write a story![39]

2.2.1 Artificial intelligence Architecture (organigramme)

this flowchart explain What does it consist of the artificial intelligence , in our project we use Deep Learning witch is part of Machine Learning , all that in the Artificial Intelligence :

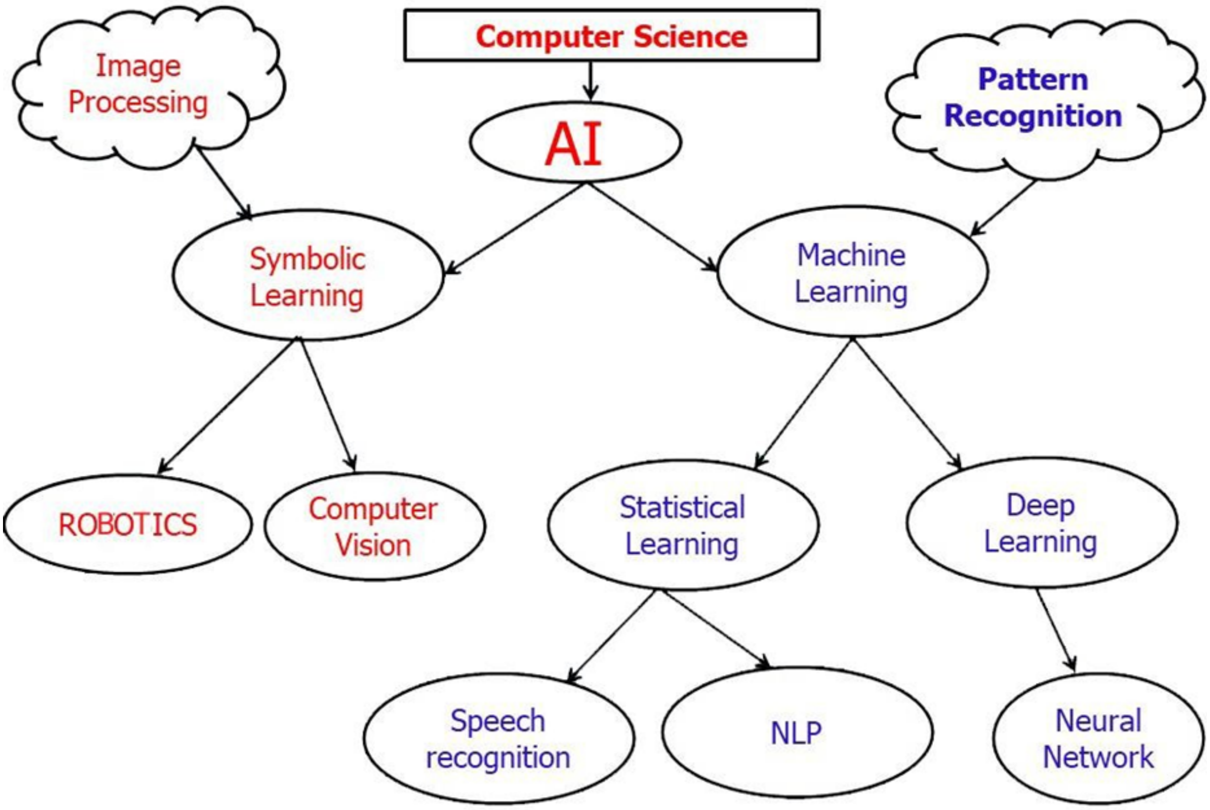


Figure 2.1: AI flowchart
[40]

2.2.2 Artificial intelligence mission

Artificial Intelligence (AI)[37] means the ability of machines to think and act like humans. It has various applications in many domains including reasoning, problem solving and decision making , which is one of the most important functions of AI .

2.2.3 Artificial intelligence staff

An AI team typically consists of a diverse range of professionals, each bringing unique skills and expertise to the table. Here are some common roles within an AI team:[3]

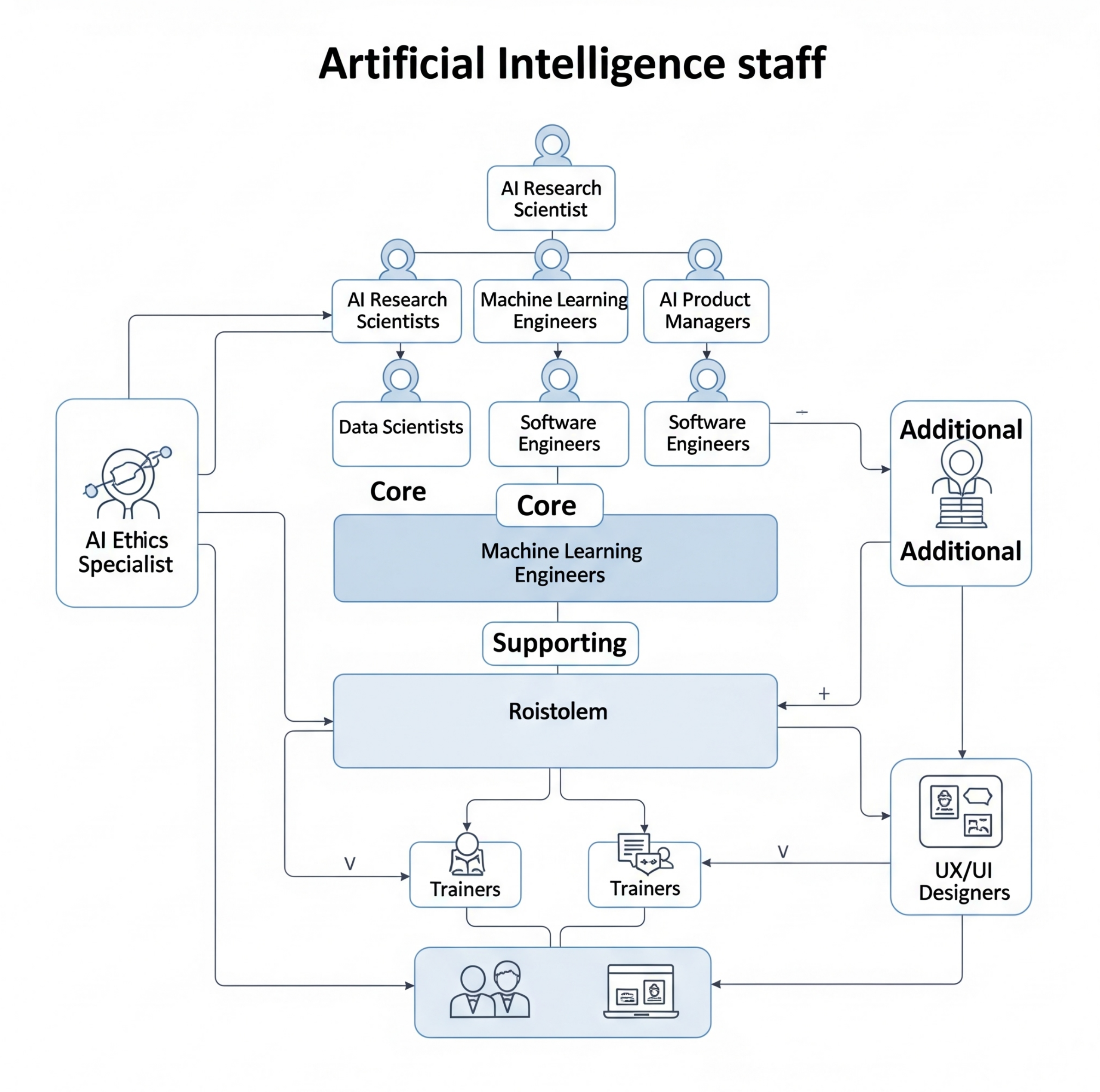


Figure 2.2: AI-staff
[41]

2.3 Introduction to Deep Learning(D L)

Deep Learning is a subset of machine Learning that utilizes artificial neural networks with multiple layers to learn complex patterns from vast amounts of data.[2] These networks, inspired by the human brain, are capable of processing and understanding intricate information, enabling breakthroughs in various fields like computer vision, natural language processing, and autonomous systems.

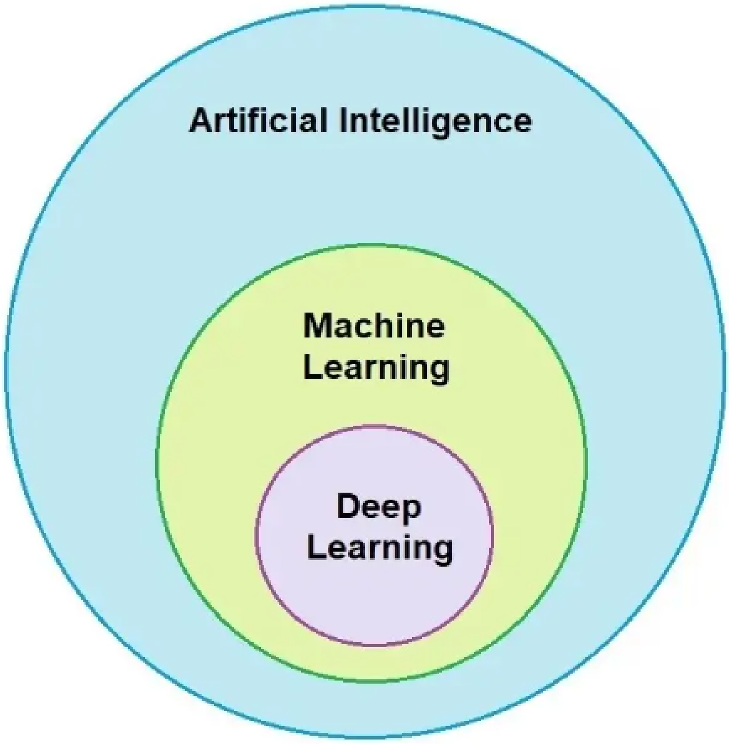


Figure 2.3: Deep Learning
[42]

2.3.1 Deep Learning Services

Deep Learning Services offer a range of solutions powered by advanced neural networks to tackle complex problems. These services include:

2.3.1.1 Core Service

Model Training and Optimization: Developing and fine-tuning deep learning models for specific tasks, such as image recognition, natural language processing, and predictive analytics.[3]

Model Deployment and Inference: Performing simulations in production environments for real-time predictions and decision making.

Data Preparation and Augmentation: Preparing and processing large datasets to ensure optimal model performance.

Hyperparameter Tuning: Optimizing model hyper parameters to achieve the best results.

2.3.1.2 Specialized Service

Computer Vision: Analyzing and understanding visual content, including image classification, object detection, and image segmentation.

Natural Language Processing (NLP): Processing and understanding human language, including sentiment analysis, text summarization, and machine translation.

Speech Recognition and Synthesis: Converting spoken language into text and vice versa, enabling voice-controlled interfaces and automated transcription.

Anomaly Detection: Identifying unusual patterns or outliers in data, useful for fraud detection, network security, and quality control.

Predictive Analytics: For forecasting future trends and conclusions based on historical data.

2.3.1.3 Additional Services

Custom Model Development: Tailoring deep learning model to specific business needs and industry-specific challenges. Cloud-

Based Solutions: Leveraging cloud platforms to deploy and scale deep learning applications efficiently. [43]

ML Ops: Managing the entire machine learning life cycle,from data ingestion to model deployment and monitoring.

2.3.2 The role and challenges of deep learning

2.3.2.1 Role of Deep Learning

Domain	**Description**
Revolutionizing Industries	Deep learning is driving innovation across various sectors, from healthcare to finance.
Enhanced Image and Video Analysis	Enables accurate object detection, facial recognition, and medical image analysis.
Advanced Natural Language Processing	Powers language translation, sentiment analysis, and chatbots.
Autonomous Systems	Facilitates self-driving cars, drones, and robotics.
Drug Discovery and Development	Accelerates the process of identifying new drug candidates.
Financial Modeling and Risk Assessment	Improves predictive analytics and fraud detection.

Table 2.1: Role of Deep Learning
[37]

2.3.2.2 Challenges of Deep Learning

Challenge	**Description**
Data Hunger	Requires massive amounts of high-quality data for effective training.
Computational Intensity	Demands significant computational resources, often relying on specialized hardware like GPUs and TPUs.
Model Complexity	Deep neural networks can be intricate and difficult to interpret, hindering understanding and debugging.
Overfitting and Underfitting	Models can become too specialized or too general, impacting performance.
Ethical Considerations	Raises concerns about bias, privacy, and the potential for misuse.
Talent Scarcity	A shortage of skilled professionals to develop and deploy deep learning solutions.

Table 2.2: Challenges in Deep Learning
[37][**?**][44]

2.3.3 Deep learning flowchart

this flowchart explain how Deep-Learnning work and that one using the Maching Learning algorithms :

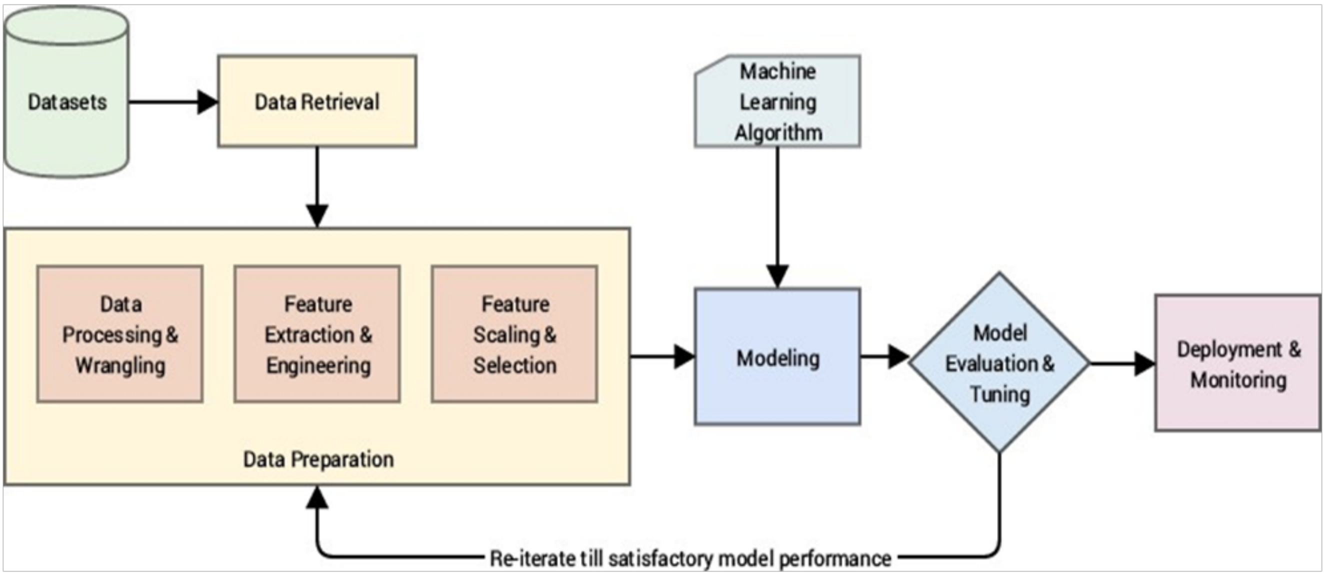


Figure 2.4: Deep Learning flowchart
[42]

2.4 Deep-learning models

2.4.1 Definition

A deep learning models [45] is a type of computer program that learns to make decisions or predictions by analyzing large amounts of data. It's built using layers of artificial neurons—just like how the human brain processes information. The more layers it has, the "deeper" the model is, which is why it's called deep learning.

2.4.2 Types

there are many types of deep-learning , In this diagram we show the most common and used types :[46][3]

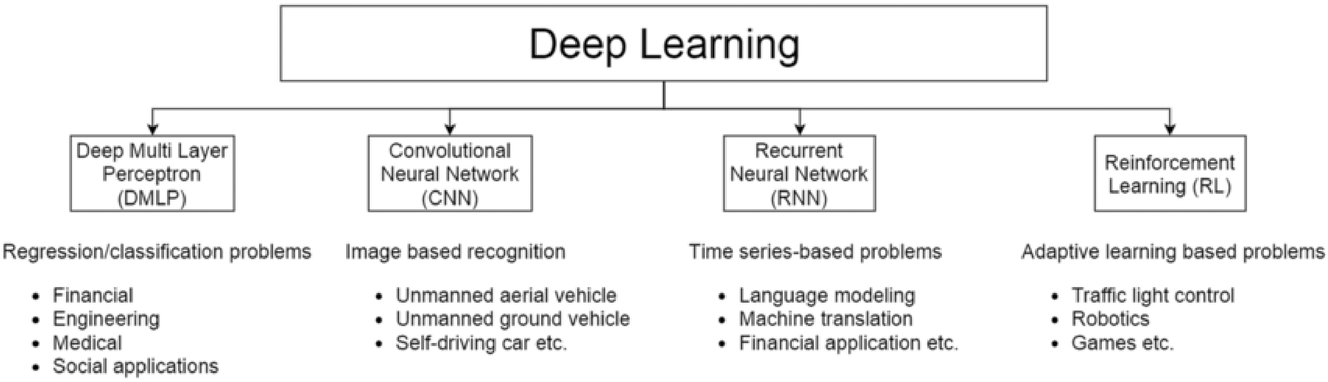


Figure 2.5: Deep-learning Models or Types

[42]

2.5 conclusion

In this chapter , Deep Learning, a subset of Machine Learning, has revolutionized AI by enabling machines to learn complex patterns from massive datasets. It utilizes artificial neural networks with multiple layers, allowing for hierarchical feature extraction and representation learning. This has led to breakthroughs in various fields, including image and speech recognition, natural language processing, and autonomous systems. However, Deep Learning requires substantial computational resources and large datasets for optimal performance, and its black-box nature can sometimes hinder interpret ability. Despite these challenges, Deep Learning continues to push the boundaries of AI, promising even more exciting advancements in the future.

Chapter 3

Architecture and process detection

3.1 Introduction

In this final chapter,our project focuses on the use of deep learning techniques, particularly convolutional neural networks (CNNs), for the automatic detection of Autism Spectrum Disorder (ASD) through image data such as eye-tracking or facial features. Two well-known CNN models were implemented: VGG19 and MobileNet. MobileNet is designed for efficiency and is suitable for real-time applications, while VGG19 is deeper and known for its strong performance in image classification tasks.

The process involved data preprocessing, model training, validation, and performance evaluation using metrics such as accuracy, recall, and F1-score. A comparative study was conducted to assess the strengths and limitations of each model in the context of ASD detection.

The final results highlight the differences in accuracy and computational efficiency between the two models, helping identify the most suitable architecture for practical autism screening applications.

3.2 Work environment and development

in our praticale party we use diffrent Tools , witch is :

3.2.1 Colab

Colab is a free service from Google that allows you to write and run Python code directly in a web browser.

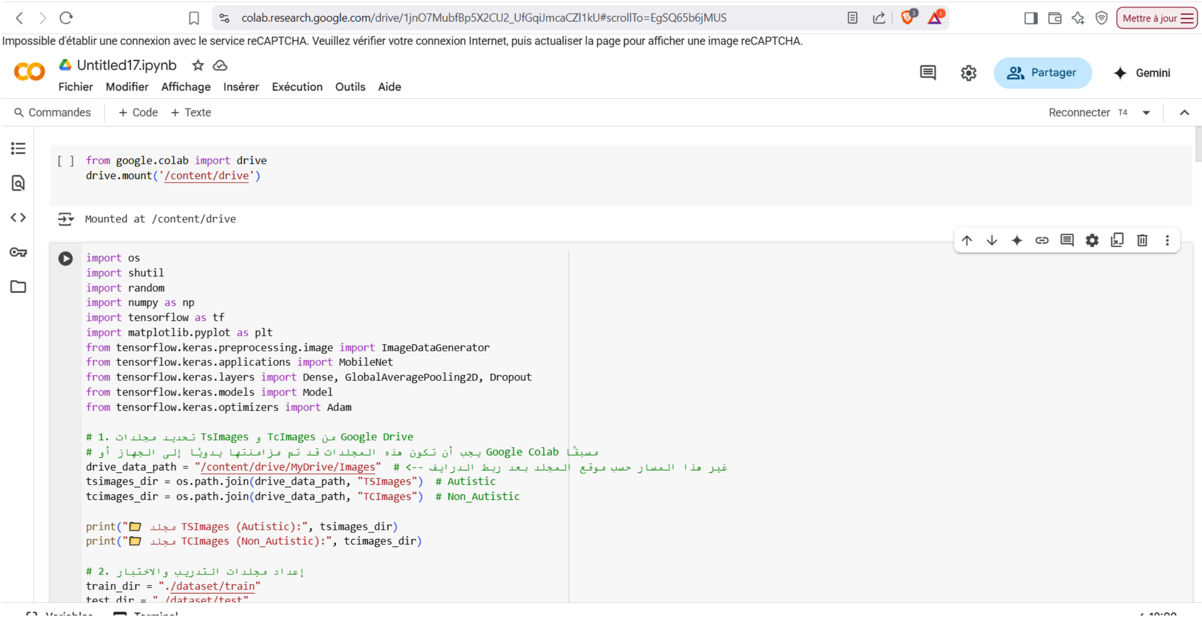


Figure 3.1: Colab
[47]

3.2.2 Kaggle

Kaggle is a free online platform where people can find datasets, learn machine learning, and participate in data science competitions. It's a popular place for beginners and experts alike to practice solving real-world problems with artificial intelligence.

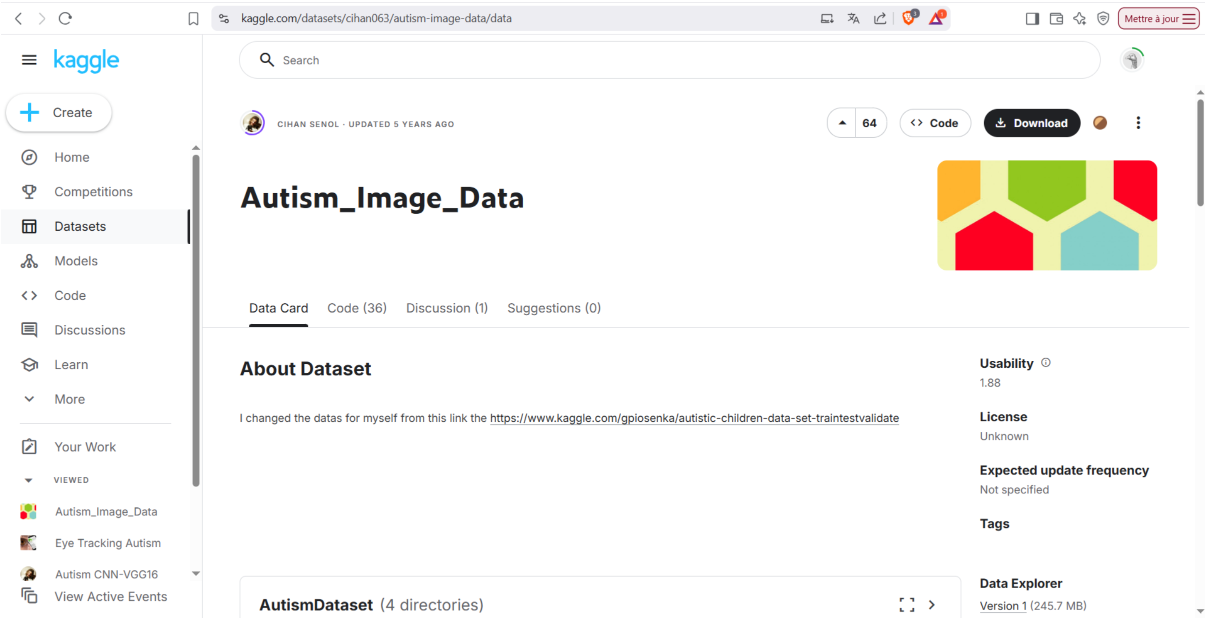


Figure 3.2: Kaggle
[48]

3.2.3 Python

Python is a simple and easy-to-learn programming language. It is used to create websites, games, applications, analyze data, and program artificial intelligence.

Figure 3.3: python
[49]

3.2.4 The detection Steps

this flowchart explain the steps of detection that our project based on :

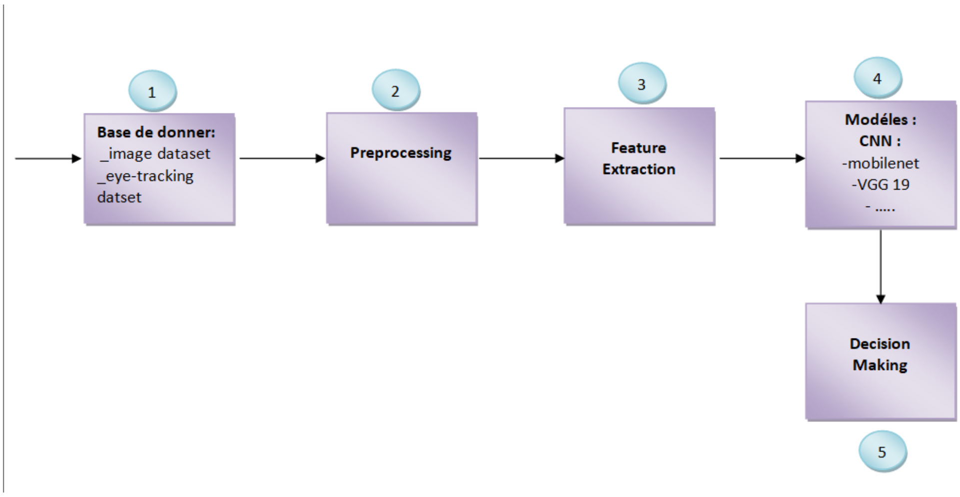


Figure 3.4: The Detection Steps

3.2.5 Theoretical explanation of the detection steps

3.2.5.1 First step

refers to an individual image within a dataset used to train, validate, or test neural networks. These images are typically labeled and serve as input data for models to learn patterns, features, or representations for tasks such as classification, object detection, or image segmentation.[50]

3.2.5.2 Second step

Transforming raw data (e.g., resizing images, normalization) into a suitable format for model input.

3.2.5.3 Third step

Identifying and isolating important patterns or attributes (like edges or textures) from input data.

3.2.5.4 Fourth step

Models CNN: MobileNet, VGG19: Predefined convolutional neural network architecture :

- **MobileNet:** Lightweight, efficient CNN optimized for mobile and embedded devices.

- **VGG19:** Deeper CNN with 19 layers, known for simplicity and strong performance in image tasks.

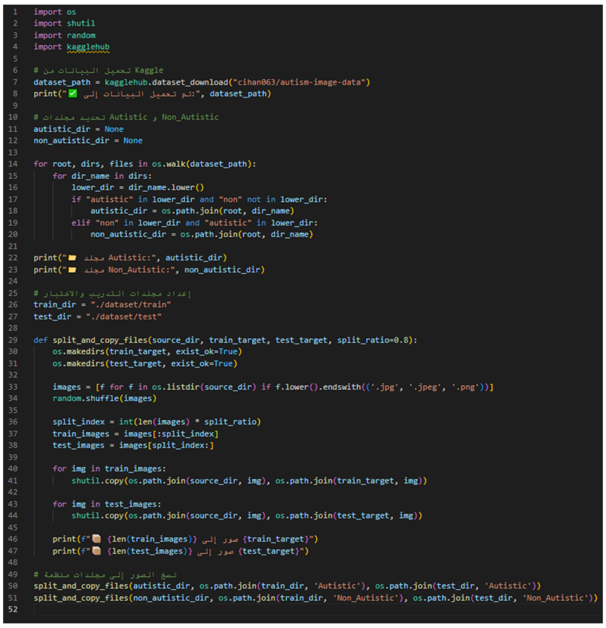
3.2.5.5 fifth step:

Using model predictions (like class probabilities) to classify input or trigger a specific action.

3.2.6 Practical explanation of the five steps

We'll take one modèle as an example , we'll choose mobilenet working with image-autism dataset :

3.2.6.1 First step (Base de données : image dataset):



```python
import os
import shutil
import random
import kagglehub

# تحميل البيانات من Kaggle
dataset_path = kagglehub.dataset_download("cihan063/autism-image-data")
print("✅ تم تحميل البيانات إلى:", dataset_path)

# تحديد مجلدات Autistic و Non_Autistic
autistic_dir = None
non_autistic_dir = None

for root, dirs, files in os.walk(dataset_path):
    for dir_name in dirs:
        lower_dir = dir_name.lower()
        if "autistic" in lower_dir and "non" not in lower_dir:
            autistic_dir = os.path.join(root, dir_name)
        elif "non" in lower_dir and "autistic" in lower_dir:
            non_autistic_dir = os.path.join(root, dir_name)

print("📁 مجلد Autistic:", autistic_dir)
print("📁 مجلد Non_Autistic:", non_autistic_dir)

# إعداد مجلدات التدريب والاختبار
train_dir = "./dataset/train"
test_dir = "./dataset/test"

def split_and_copy_files(source_dir, train_target, test_target, split_ratio=0.8):
    os.makedirs(train_target, exist_ok=True)
    os.makedirs(test_target, exist_ok=True)

    images = [f for f in os.listdir(source_dir) if f.lower().endswith(('.jpg', '.jpeg', '.png'))]
    random.shuffle(images)

    split_index = int(len(images) * split_ratio)
    train_images = images[:split_index]
    test_images = images[split_index:]

    for img in train_images:
        shutil.copy(os.path.join(source_dir, img), os.path.join(train_target, img))

    for img in test_images:
        shutil.copy(os.path.join(source_dir, img), os.path.join(test_target, img))

    print(f"📦 {len(train_images)} صور إلى {train_target}")
    print(f"📦 {len(test_images)} صور إلى {test_target}")

# نسخ الصور إلى مجلدات منظمة
split_and_copy_files(autistic_dir, os.path.join(train_dir, 'Autistic'), os.path.join(test_dir, 'Autistic'))
split_and_copy_files(non_autistic_dir, os.path.join(train_dir, 'Non_Autistic'), os.path.join(test_dir, 'Non_Autistic'))
```

Figure 3.5: first step

3.2.6.2 Second step(Preprocessing)

```python
import numpy as np
import tensorflow as tf
from tensorflow.keras.preprocessing.image import ImageDataGenerator

# إعداد مولد البيانات
datagen = ImageDataGenerator(rescale=1.0/255.0, validation_split=0.2)

train_data = datagen.flow_from_directory(
    train_dir,
    target_size=(224, 224),
    batch_size=32,
    class_mode='binary',
    subset='training'
)

validation_data = datagen.flow_from_directory(
    train_dir,
    target_size=(224, 224),
    batch_size=32,
    class_mode='binary',
    subset='validation'
)
```

Figure 3.6: second step

3.2.6.3 Third step(Feature Extraction)

```python
from tensorflow.keras.applications import MobileNet

# تحميل MobileNet
base_model = MobileNet(weights='imagenet', include_top=False, input_shape=(224, 224, 3))
base_model.trainable = False  # تجميد الطبقات لاستخدامها كأداة استخراج ميزات
```

Figure 3.7: third step

3.2.6.4 Fourth step(CNN: MobileNet)

```python
from tensorflow.keras.layers import Dense, GlobalAveragePooling2D, Dropout
from tensorflow.keras.models import Model
from tensorflow.keras.optimizers import Adam

# بناء النموذج
x = base_model.output
x = GlobalAveragePooling2D()(x)
x = Dense(128, activation='relu')(x)
x = Dropout(0.5)(x)
output = Dense(1, activation='sigmoid')(x)
model = Model(inputs=base_model.input, outputs=output)

# تجميع النموذج
model.compile(optimizer=Adam(learning_rate=0.0001),
              loss='binary_crossentropy',
              metrics=['accuracy'])

# تدريب النموذج
history = model.fit(
    train_data,
    steps_per_epoch=train_data.samples // train_data.batch_size,
    validation_data=validation_data,
    validation_steps=validation_data.samples // validation_data.batch_size,
    epochs=20
)
```

Figure 3.8: fourth step

3.2.6.5 fifth step(Decision Making):

```
import matplotlib.pyplot as plt

# تقييم النموذج
loss, accuracy = model.evaluate(validation_data)
print(f"✅ الدقة على مجموعة التحقق: {accuracy * 100:.2f}%")

# رسم النتائج
plt.plot(history.history['accuracy'], label='Training Accuracy')
plt.plot(history.history['val_accuracy'], label='Validation Accuracy')
plt.title('Accuracy Over Epochs')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()

plt.plot(history.history['loss'], label='Training Loss')
plt.plot(history.history['val_loss'], label='Validation Loss')
plt.title('Loss Over Epochs')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()
```

Figure 3.9: fifth step

3.2.6.6 result of pratical explanation :

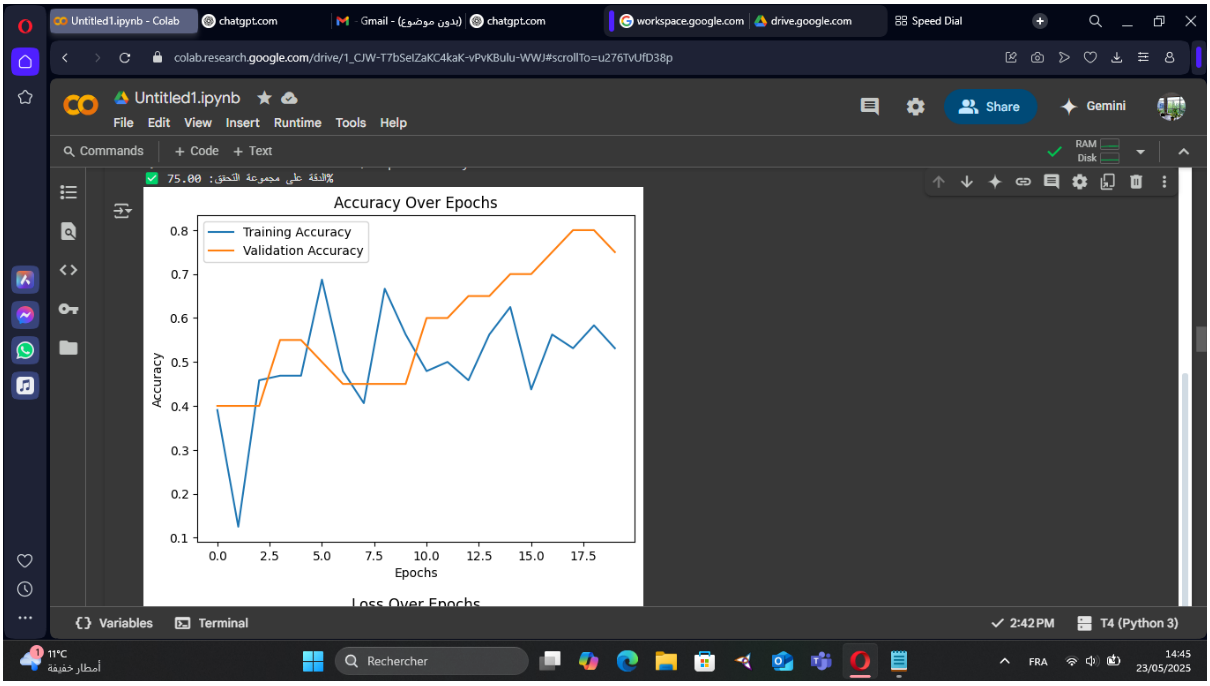


Figure 3.10: result of pratical explanation

3.3 CNN Architecture

3.3.1 Definition

A convolutional neural network (CNN) is a deep[44] neural network architecture designed for machine learning, particularly in pattern recognition tasks, such as image recognition and classification.[**?**]

3.3.2 CNN Architecture Layer

A CNN Architecture Layer is a step or block in a CNN that transforms input images to help the computer recognize shapes, objects, or patterns. Each layer has a specific role, such as detecting edges, reducing image size, or learning important features.

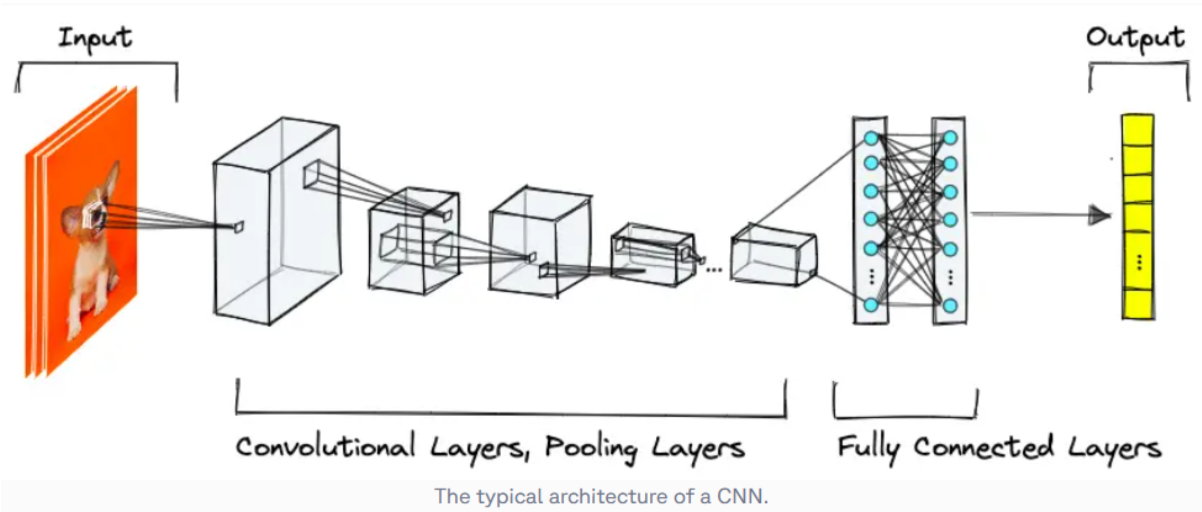


Figure 3.11: CNN Architecture Layer
[42]

3.3.3 Modeles in CNN that we use in our project

In our project we use two models in CNN which are :

3.3.3.1 Mobile net

MobileNet is a lightweight CNN model designed to run efficiently on mobile and low-power devices.[51] It uses special layers called depthwise separable convolutions to reduce the size and speed up the model.

- **Positives:** Fast and small, ideal for phones, embedded systems, or real-time applications.
- **Negatives:** - Slightly lower accuracy than heavier models like VGG.

3.3.3.1.1 Mobilenet architecture layer

This figure explane the architecture layer of MobileNet :

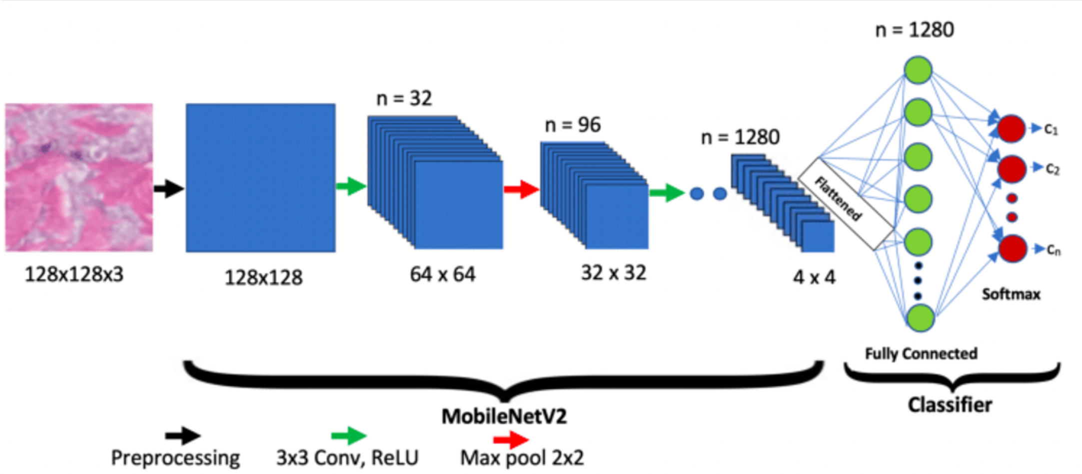


Figure 3.12: The Architecture Layer of MOBILENET
[52]

3.3.3.2 VGG19

VGG19 is a deep CNN model with 19 layers developed by the Visual Geometry Group (VGG) at Oxford. It uses many simple 3x3 convolution layers stacked on top of each other.

- **Positives:** Very good accuracy on large image datasets like ImageNet.
- **Negatives:** Large and slow, needs a lot of memory and processing power.

3.3.3.2.1 VGG 19 architecture layer

This figure explane the architecture layer of VGG 19 :

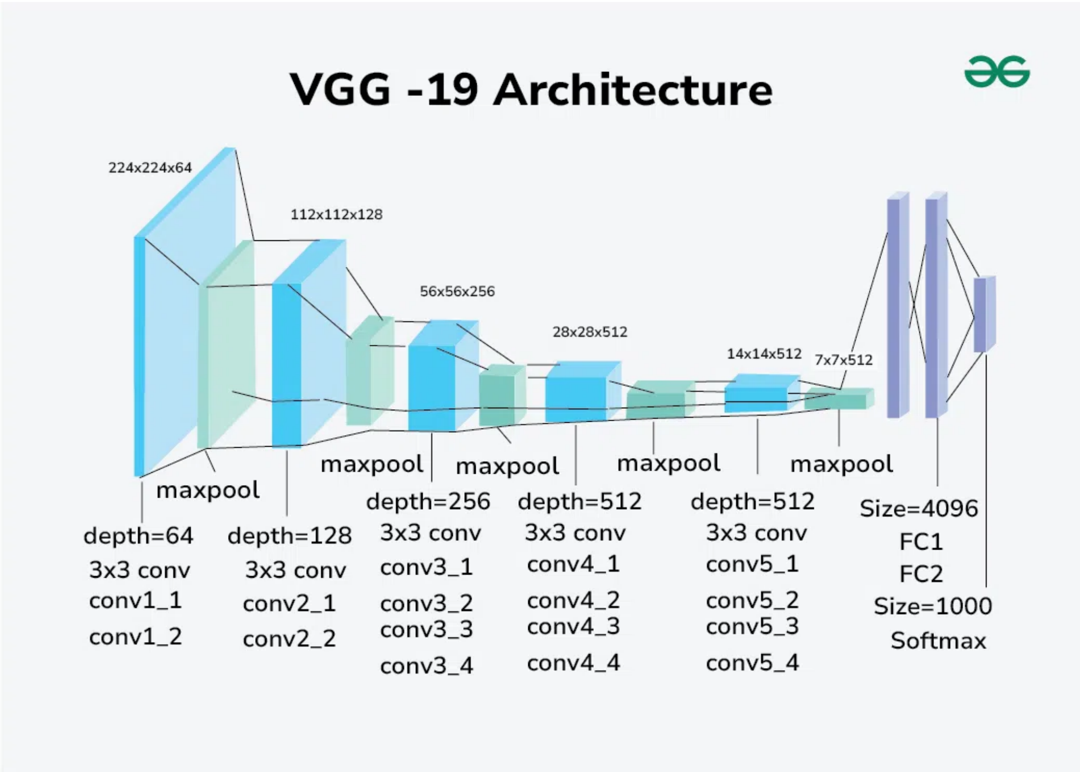


Figure 3.13: The Architecture Layer of VGG 19
[53]

3.3.4 Datasets

We'll work with tow datasets on our project , which are :

3.3.4.1 Autism-image-dataset

this table down here explain the first dataset that we work with , witch we imported from kaggle :

Aspect	Description
Total Images	2940 images
Image Dimensions	640 × 480 (default size)
Main Folders	• consolidated (2940 images) • test (300 images) • train (2540 images) • valid (100 images)
Subfolders in 'consolidated'	• Autistic • Non-Autistic
Image Distribution	1470 images labeled as Autistic, and 1470 labeled as Non-Autistic

Table 3.1: Autism image dataset
[54]

3.3.4.2 Eye-Tracking-Autism

Aspect	Description
Total Images	547 images
Image Dimensions	640 × 480 (default size)
Main Folders	• Images • Metadata
Subfolders in 'Images'	• TCImages (Non-ASD) • TSImages (ASD)
Image Distribution	328 Non-ASD images (TC), 219 ASD-diagnosed images (TS)
Metadata File	`MetadataParticipants.csv` – formatted file containing participant data
File Naming Convention	`ClassParticipantID`. For example, `TC00239.png` denotes an image of a Non-ASD participant with ID 239
Class Labels	• TS → ASD-Diagnosed • TC → Non-ASD

Table 3.2: Structure and Details of the Dataset
[54]

3.3.5 Comparative study

Here is the table that explaine the comparative accuracy , between the tow modeles MOBILENET and VGG19 witch is work with tow dataset the first one "image autism dataset" and the second one "eye tracking dataset".

/	image dataset	eye tracking dataset
MOBILENET	75.00%	80.46%
VGG 19	55.00%	83.65%

3.3.6 Experimantal Results

here is our results for praticale part :

3.3.6.1 MOBILENET work with image autism dataset

Reading image Dataset :

```
✅ تم تحميل البيانات إلى: /kaggle/input/autism-image-data
📁 مجلد Autistic: /kaggle/input/autism-image-data/AutismDataset/valid/Autistic
📁 مجلد Non_Autistic: /kaggle/input/autism-image-data/AutismDataset/valid/Non_Autistic
📦 40 صور إلى ./dataset/train/Autistic
📦 10 صور إلى ./dataset/test/Autistic
📦 40 صور إلى ./dataset/train/Non_Autistic
📦 10 صور إلى ./dataset/test/Non_Autistic
Found 80 images belonging to 2 classes.
Found 20 images belonging to 2 classes.
```

Figure 3.14: Reading image Dataset

Execution the Epochs :

```
Epoch 1/20
/usr/local/lib/python3.11/dist-packages/keras/src/trainers/data_adapters/py_dataset_adapter.py:121: UserWarning: Your `PyDataset` class should call `sup
  self._warn_if_super_not_called()
2/2 ━━━━━━━━━━━━━━━━━━━━ 8s 3s/step - accuracy: 0.3854 - loss: 1.0286 - val_accuracy: 0.4000 - val_loss: 0.7283
Epoch 2/20
1/2 ━━━━━━━━━━━━━━━━━━━━ 3s 4s/step - accuracy: 0.1250 - loss: 1.3308/usr/local/lib/python3.11/dist-packages/keras/src/trainers/epoch_iterator.py:107: U
  self._interrupted_warning()
2/2 ━━━━━━━━━━━━━━━━━━━━ 4s 385ms/step - accuracy: 0.1250 - loss: 1.3308 - val_accuracy: 0.4000 - val_loss: 0.7244
Epoch 3/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 2s 690ms/step - accuracy: 0.4514 - loss: 0.8457 - val_accuracy: 0.4000 - val_loss: 0.7188
Epoch 4/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 1s 659ms/step - accuracy: 0.4688 - loss: 0.9553 - val_accuracy: 0.5500 - val_loss: 0.7166
Epoch 5/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 1s 556ms/step - accuracy: 0.5104 - loss: 0.8957 - val_accuracy: 0.5500 - val_loss: 0.7120
Epoch 6/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 147ms/step - accuracy: 0.6875 - loss: 0.6071 - val_accuracy: 0.5000 - val_loss: 0.7105
Epoch 7/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 1s 324ms/step - accuracy: 0.4444 - loss: 0.9074 - val_accuracy: 0.4500 - val_loss: 0.7080
Epoch 8/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 249ms/step - accuracy: 0.4062 - loss: 0.9067 - val_accuracy: 0.4500 - val_loss: 0.7053
Epoch 9/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 1s 324ms/step - accuracy: 0.6528 - loss: 0.7193 - val_accuracy: 0.4500 - val_loss: 0.6979
Epoch 10/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 201ms/step - accuracy: 0.5625 - loss: 0.8057 - val_accuracy: 0.4500 - val_loss: 0.6948
Epoch 11/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 1s 515ms/step - accuracy: 0.5069 - loss: 0.7720 - val_accuracy: 0.6000 - val_loss: 0.6895
Epoch 12/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 172ms/step - accuracy: 0.5000 - loss: 0.7463 - val_accuracy: 0.6000 - val_loss: 0.6876
```

Figure 3.15: Execution the Epochs

Accuracy over Epochs :

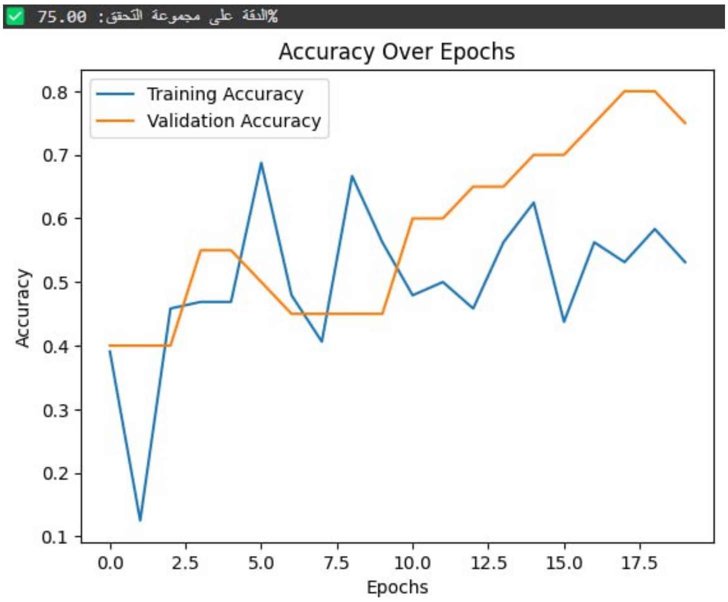


Figure 3.16: Accuracy over Epochs

Loss over epochs :

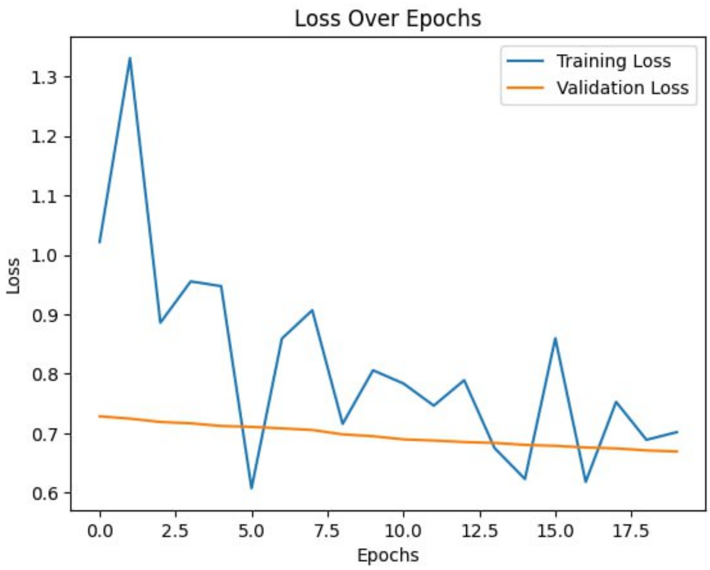


Figure 3.17: Loss over epochs

Confusion matrix :

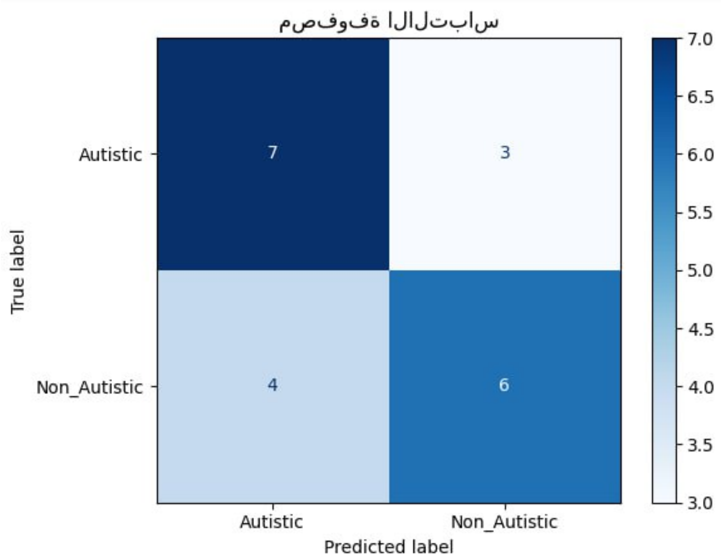


Figure 3.18: Confusion matrix

ROC curve :

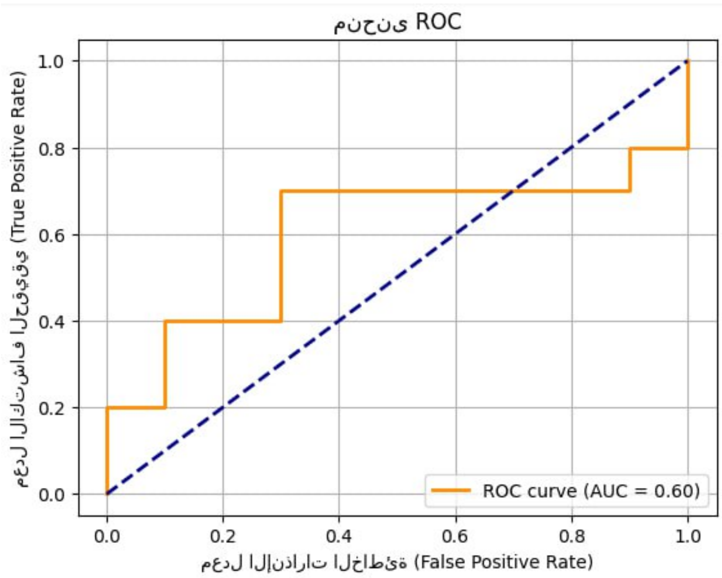


Figure 3.19: ROC curve

3.3.6.2 MOBILENET work with eye tracking dataset (ASD)

Reading the Dataset :

```
📁 مجلد TSImages (Autistic): /content/drive/MyDrive/Images/TSImages
📁 مجلد TCImages (Non_Autistic): /content/drive/MyDrive/Images/TCImages
📦 175 صور إلى ./dataset/train/Autistic
📦 44 صور إلى ./dataset/test/Autistic
📦 262 صور إلى ./dataset/train/Non_Autistic
📦 66 صور إلى ./dataset/test/Non_Autistic
Found 350 images belonging to 2 classes.
Found 87 images belonging to 2 classes.
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/mobilenet/mobilenet_1_0_224_tf_no_top.h5
17225924/17225924 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
```

Figure 3.20: Reading the Dataset

Execution the Epochs :

```
Epoch 1/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 19s 1s/step - accuracy: 0.4744 - loss: 0.8802 - val_accuracy: 0.6406 - val_loss: 0.6524
Epoch 2/20
 1/10 ━━━━━━━━━━━━━━━━━━━━ 0s 37ms/step - accuracy: 0.4688 - loss: 0.8063/usr/local/lib/python3.11/dist-packages/keras/src/trainers/epoch_iterator.py:107: UserWarning: Your input rar
  self._interrupted_warning()
10/10 ━━━━━━━━━━━━━━━━━━━━ 2s 172ms/step - accuracy: 0.4688 - loss: 0.8063 - val_accuracy: 0.5938 - val_loss: 0.6776
Epoch 3/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 10s 698ms/step - accuracy: 0.5554 - loss: 0.7549 - val_accuracy: 0.7188 - val_loss: 0.5594
Epoch 4/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 1s 55ms/step - accuracy: 0.5625 - loss: 0.6232 - val_accuracy: 0.7188 - val_loss: 0.6031
Epoch 5/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 10s 778ms/step - accuracy: 0.6873 - loss: 0.6276 - val_accuracy: 0.7656 - val_loss: 0.5420
Epoch 6/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 1s 90ms/step - accuracy: 0.5938 - loss: 0.6142 - val_accuracy: 0.7500 - val_loss: 0.5423
Epoch 7/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 5s 281ms/step - accuracy: 0.6175 - loss: 0.6183 - val_accuracy: 0.7969 - val_loss: 0.4852
Epoch 8/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 1s 54ms/step - accuracy: 0.5938 - loss: 0.7115 - val_accuracy: 0.7969 - val_loss: 0.5048
Epoch 9/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 3s 254ms/step - accuracy: 0.7052 - loss: 0.5694 - val_accuracy: 0.7812 - val_loss: 0.4942
Epoch 10/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 1s 55ms/step - accuracy: 0.8438 - loss: 0.4522 - val_accuracy: 0.7344 - val_loss: 0.5313
Epoch 11/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 5s 306ms/step - accuracy: 0.7023 - loss: 0.5430 - val_accuracy: 0.7656 - val_loss: 0.4957
Epoch 12/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 1s 119ms/step - accuracy: 0.6562 - loss: 0.6298 - val_accuracy: 0.7656 - val_loss: 0.5000
Epoch 13/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 3s 232ms/step - accuracy: 0.7363 - loss: 0.5559 - val_accuracy: 0.7500 - val_loss: 0.5346
Epoch 14/20
10/10 ━━━━━━━━━━━━━━━━━━━━ 1s 55ms/step - accuracy: 0.7188 - loss: 0.5346 - val_accuracy: 0.7656 - val_loss: 0.5101
```

Figure 3.21: Execution the Epochs

Accuracy over epochs :

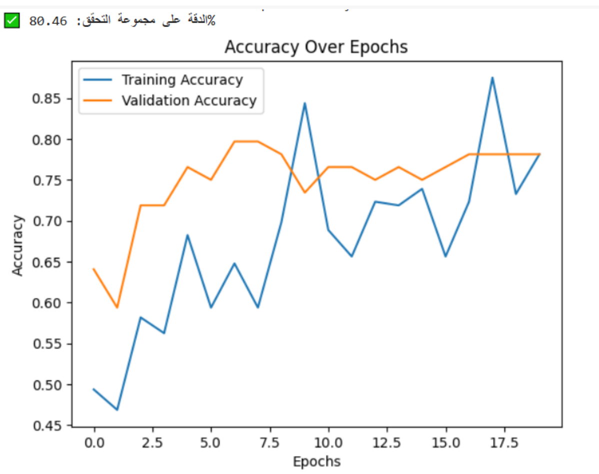


Figure 3.22: Accuracy over epochs

Loss over Epochs :

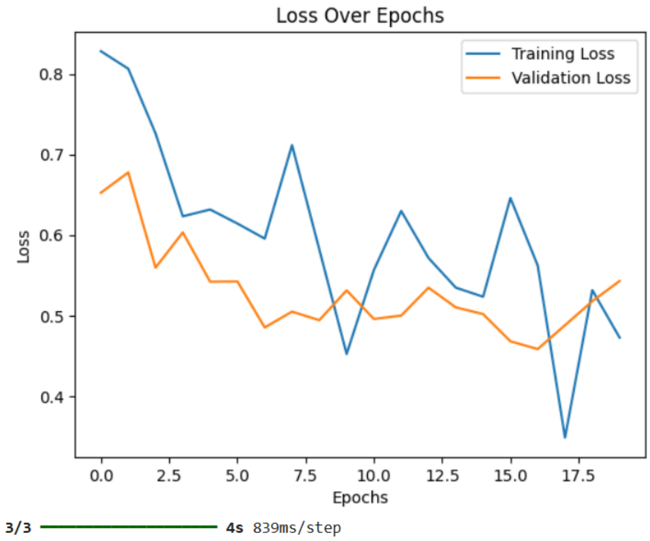


Figure 3.23: Loss over Epochs

Confusion Matrix :

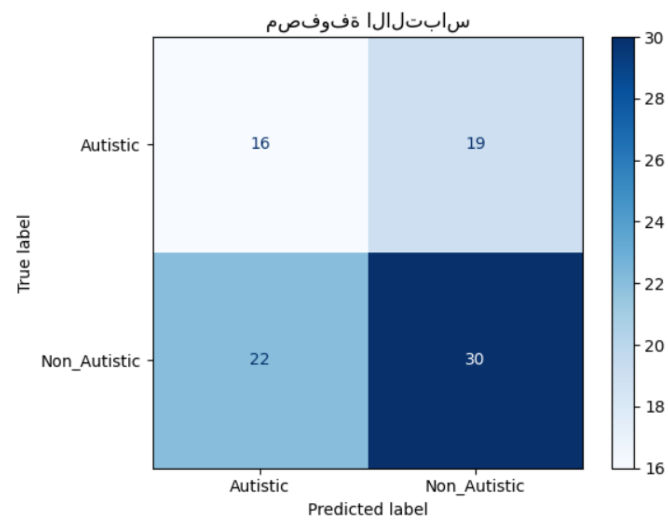


Figure 3.24: Confusion Matrix

ROC Curve :

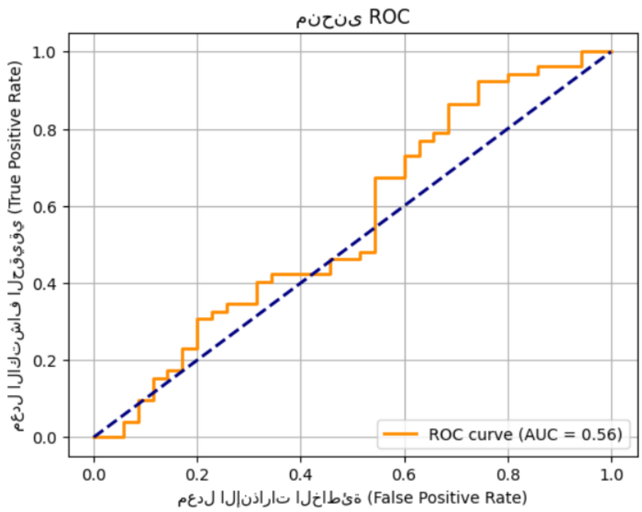


Figure 3.25: ROC Curve

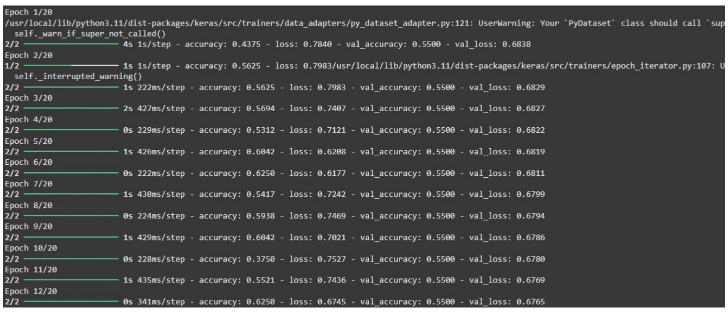
3.3.6.3 VGG 19 work with image autism dataset

Reading the Dataset :

```
✅ تم تحميل البيانات إلى: /kaggle/input/autism-image-data
📁 مجلد Autistic: /kaggle/input/autism-image-data/AutismDataset/valid/Autistic
📁 مجلد Non_Autistic: /kaggle/input/autism-image-data/AutismDataset/valid/Non_Autistic
📦 40 صور إلى ./dataset/train/Autistic
📦 10 صور إلى ./dataset/test/Autistic
📦 40 صور إلى ./dataset/train/Non_Autistic
📦 10 صور إلى ./dataset/test/Non_Autistic
Found 80 images belonging to 2 classes.
Found 20 images belonging to 2 classes.
```

Figure 3.26: Reading the Dataset

Execution the Epochs :



```
Epoch 1/20
/usr/local/lib/python3.11/dist-packages/keras/src/trainers/data_adapters/py_dataset_adapter.py:121: UserWarning: Your `PyDataset` class should call `sup
  self._warn_if_super_not_called()
2/2 ━━━━━━━━━━━━━━━━━━━━ 4s 1s/step - accuracy: 0.4375 - loss: 0.7840 - val_accuracy: 0.5500 - val_loss: 0.6838
Epoch 2/20
1/2 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step - accuracy: 0.5625 - loss: 0.7983/usr/local/lib/python3.11/dist-packages/keras/src/trainers/epoch_iterator.py:107: U
  self._interrupted_warning()
2/2 ━━━━━━━━━━━━━━━━━━━━ 1s 222ms/step - accuracy: 0.5625 - loss: 0.7983 - val_accuracy: 0.5500 - val_loss: 0.6829
Epoch 3/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 2s 427ms/step - accuracy: 0.5694 - loss: 0.7407 - val_accuracy: 0.5500 - val_loss: 0.6827
Epoch 4/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 229ms/step - accuracy: 0.5312 - loss: 0.7121 - val_accuracy: 0.5500 - val_loss: 0.6822
Epoch 5/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 1s 426ms/step - accuracy: 0.6042 - loss: 0.6208 - val_accuracy: 0.5500 - val_loss: 0.6819
Epoch 6/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 222ms/step - accuracy: 0.6250 - loss: 0.6177 - val_accuracy: 0.5500 - val_loss: 0.6811
Epoch 7/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 1s 430ms/step - accuracy: 0.5417 - loss: 0.7242 - val_accuracy: 0.5500 - val_loss: 0.6799
Epoch 8/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 224ms/step - accuracy: 0.5938 - loss: 0.7469 - val_accuracy: 0.5500 - val_loss: 0.6794
Epoch 9/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 1s 429ms/step - accuracy: 0.6042 - loss: 0.7021 - val_accuracy: 0.5500 - val_loss: 0.6786
Epoch 10/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 228ms/step - accuracy: 0.3750 - loss: 0.7527 - val_accuracy: 0.5500 - val_loss: 0.6780
Epoch 11/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 1s 435ms/step - accuracy: 0.5521 - loss: 0.7436 - val_accuracy: 0.5500 - val_loss: 0.6769
Epoch 12/20
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 341ms/step - accuracy: 0.6250 - loss: 0.6745 - val_accuracy: 0.5500 - val_loss: 0.6765
```

Figure 3.27: Execution the Epochs

Accuracy over epochs :

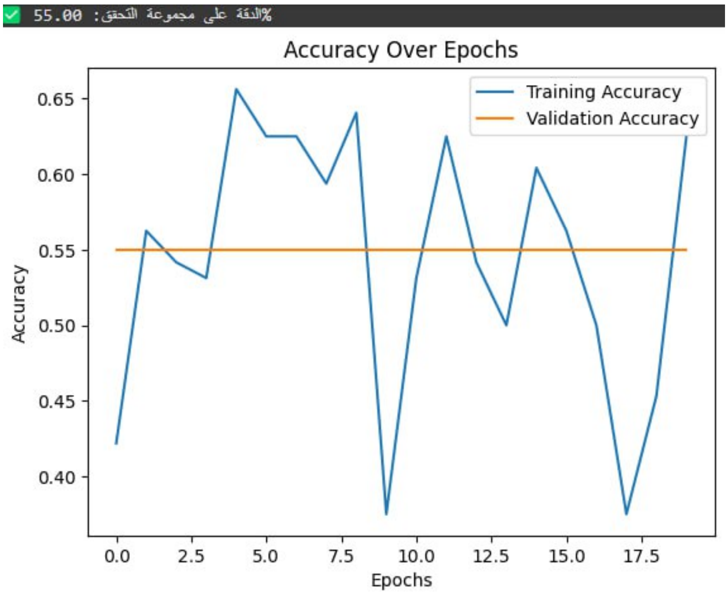


Figure 3.28: Accuracy over epochs

loss over epochs :

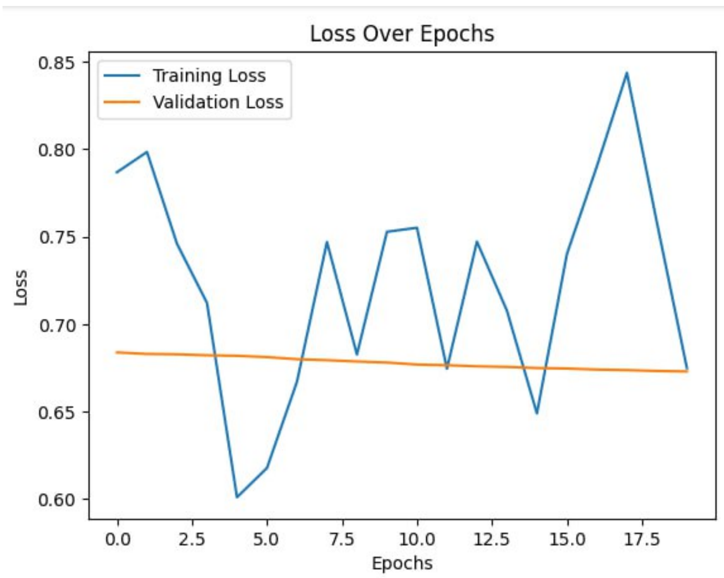


Figure 3.29: loss over epochs

confusion matrix :

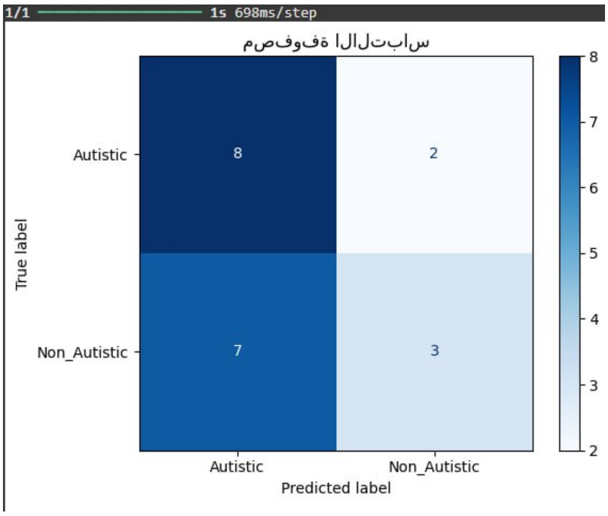


Figure 3.30: confusion matrix

ROC curve :

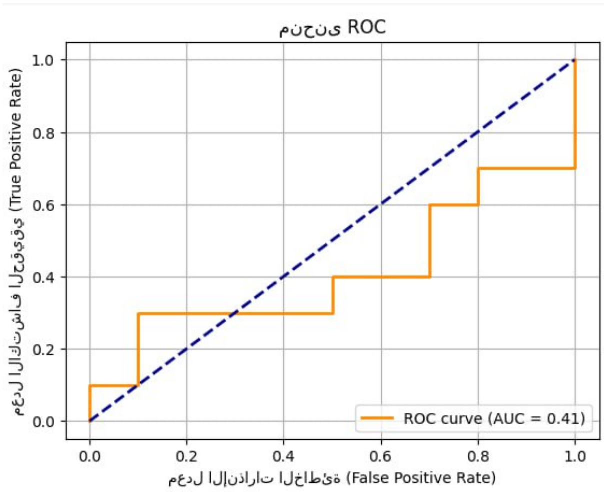


Figure 3.31: ROC curve

3.3.6.4 VGG 19 work with eye tracking dataset (ASD)

Reading the Dataset :

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
📁 مجلد TSImages (Autistic): /content/drive/MyDrive/Images/TSImages
📁 مجلد TCImages (Non_Autistic): /content/drive/MyDrive/Images/TCImages
📦 175 صور إلى ./dataset/train/Autistic
📦 44 صور إلى ./dataset/test/Autistic
📦 262 صور إلى ./dataset/train/Non_Autistic
📦 66 صور إلى ./dataset/test/Non_Autistic
Found 422 images belonging to 2 classes.
Found 104 images belonging to 2 classes.
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg19/vgg19_weights_tf_dim_ordering_tf_kernels_notop.h5
80134624/80134624 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
```

Figure 3.32: Reading the Dataset

execution the epochs :

```
Epoch 1/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 23s 765ms/step - accuracy: 0.5193 - loss: 0.7916 - val_accuracy: 0.8021 - val_loss: 0.6279
Epoch 2/20
 1/13 ━━━━━━━━━━━━━━━━━━━━ 2s 188ms/step - accuracy: 0.5625 - loss: 0.7282/usr/local/lib/python3.11/dist-packages/keras/src/trainers/epoch_iterator.py:107: UserWarning: Your input
  self._interrupted_warning()
13/13 ━━━━━━━━━━━━━━━━━━━━ 2s 152ms/step - accuracy: 0.5625 - loss: 0.7282 - val_accuracy: 0.5625 - val_loss: 0.6569
Epoch 3/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 4s 342ms/step - accuracy: 0.5576 - loss: 0.6940 - val_accuracy: 0.6458 - val_loss: 0.6077
Epoch 4/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 1s 70ms/step - accuracy: 0.5000 - loss: 0.7157 - val_accuracy: 0.7188 - val_loss: 0.6035
Epoch 5/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 5s 394ms/step - accuracy: 0.6361 - loss: 0.6437 - val_accuracy: 0.7396 - val_loss: 0.5681
Epoch 6/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 1s 73ms/step - accuracy: 0.5000 - loss: 0.7082 - val_accuracy: 0.7188 - val_loss: 0.5717
Epoch 7/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 10s 473ms/step - accuracy: 0.6660 - loss: 0.6142 - val_accuracy: 0.7188 - val_loss: 0.5509
Epoch 8/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 1s 71ms/step - accuracy: 0.5938 - loss: 0.7188 - val_accuracy: 0.7292 - val_loss: 0.5532
Epoch 9/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 10s 566ms/step - accuracy: 0.7089 - loss: 0.5864 - val_accuracy: 0.7292 - val_loss: 0.5999
Epoch 10/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 1s 70ms/step - accuracy: 0.6875 - loss: 0.5926 - val_accuracy: 0.7917 - val_loss: 0.5822
Epoch 11/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 4s 278ms/step - accuracy: 0.6551 - loss: 0.6291 - val_accuracy: 0.7708 - val_loss: 0.5229
Epoch 12/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 1s 70ms/step - accuracy: 0.7812 - loss: 0.5216 - val_accuracy: 0.7604 - val_loss: 0.5274
Epoch 13/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 5s 392ms/step - accuracy: 0.6922 - loss: 0.5822 - val_accuracy: 0.7396 - val_loss: 0.5349
Epoch 14/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 1s 68ms/step - accuracy: 0.6875 - loss: 0.6095 - val_accuracy: 0.7500 - val_loss: 0.5116
Epoch 15/20
13/13 ━━━━━━━━━━━━━━━━━━━━ 4s 269ms/step - accuracy: 0.6718 - loss: 0.6091 - val_accuracy: 0.8438 - val_loss: 0.5206
Epoch 16/20
```

Figure 3.33: execution the epochs

Accuracy over epochs :

```
4/4 ━━━━━━━━━━━━━━━━━━━━ 5s 2s/step - accuracy: 0.8617 - loss: 0.4912
✅ الدقة على مجموعة التحقق: 83.65%
```

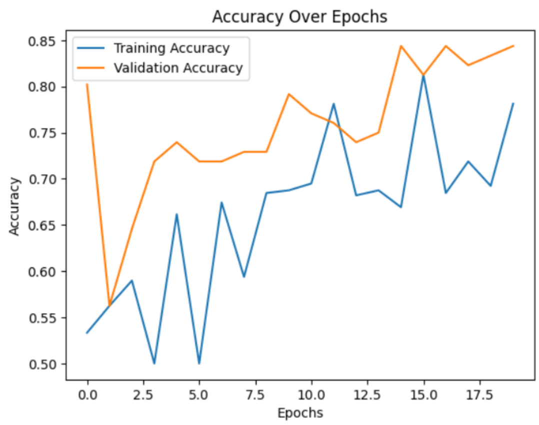


Figure 3.34: Accuracy over epochs

Loss over Epochs :

Figure 3.35: Loss over Epochs

Confusion Matrix :

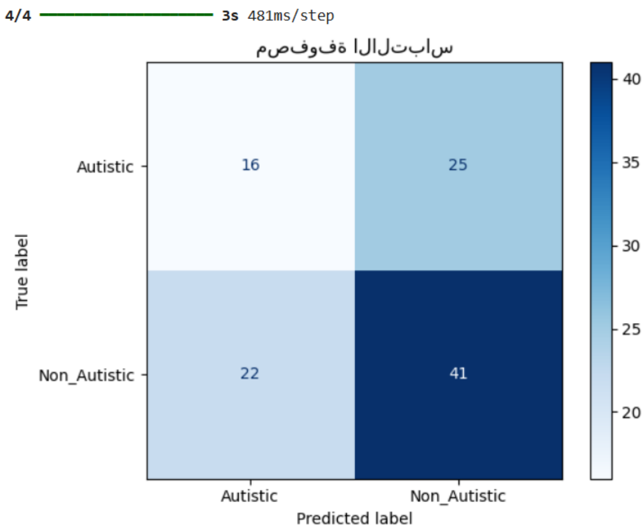


Figure 3.36: Confusion Matrix

ROC curve :

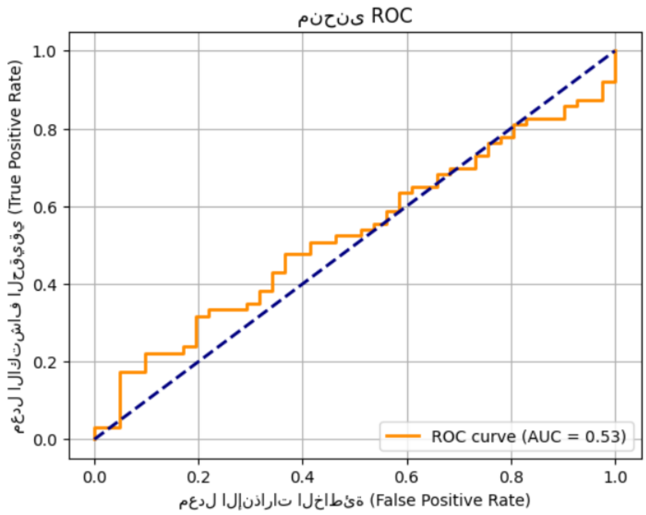


Figure 3.37: ROC curve

3.4 Conclusion

In this chapter,In this section, we have put all the tools and mechanisms that we used in creating the practical part of this project, which can be summarized as follow tow datasets , 'image autism ' witch we imported from kaggle , and 'eye tracking ' witch imported from google drive , and we apply tow models of CNN witch is 'Mobile Net' and 'VGG 19 ' all this tow models are from Deep Learning , and we use google colab for our execution , then we add our experimantal results .

General Conclusion

In conclusion, this project demonstrates that the integration of deep learning technologies into the medical field represents a paradigm shift in diagnostic and healthcare methods, particularly with regard to autism spectrum disorder. It has become imperative to seek innovative technical solutions that reduce the time and effort required for diagnosis and provide accurate and effective tools to support doctors and specialists. Through this project, a model based on convolutional neural networks (CNNs) was developed to classify individuals based on facial images or eye-tracking data. Effective models such as MobileNet and VGG19 were used to achieve a balance between accuracy and efficiency.

The experimental results showed that the proposed model was able to accurately distinguish between individuals with and without autism, demonstrating the effectiveness of these models in handling complex medical data. Furthermore, relying on data available from public sources such as Kaggle demonstrates the importance of open sources in accelerating scientific research and providing diverse and comprehensive training data.

In addition to its high accuracy, this system is characterized by speed and objectivity, making it an effective aid in medical settings that suffer from a shortage of specialists or require large-scale initial screening techniques. The scalability of this model also opens the door to future improvements, such as integrating behavioral and audio data, or building practical applications for use in clinics and specialized centers.

Therefore, this project not only represents a successful application of modern technologies, but also a real contribution to the digital transformation of the healthcare sector. We recommend continuing to develop such systems, in collaboration with specialists in psychology and neurology, to ensure the reliability of the results and the safety of their use in real-world settings. We also call for investment in interdisciplinary research that integrates artificial intelligence and medical expertise to improve the quality of care and healthcare services provided to autism patients and others.

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