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AKLI MOHAND OULHADJ UNIVERSITY -BOUIRA-

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Master memory

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Theme

Mobile Application for Early Prediction of Diabetic Retinopathy Using Deep Learning Approach

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Supervised by

- Dr.CHOUIREF Zahira

Realized by

- NACEF OUAIL
- MOHAMMEDI Amira

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Dedications

In the name of of Allah the Merciful

I dedicate this humble work:

To the person who always taught me how to do it success before failure, to the person who supported me all my school life, to the one who spared no effort for my country.

To my parents, my father and my mother always close to my heart, who taught me the true meaning of life also dedicate this work to my brothers mareouane and mohamed zine eddine, to all my family, old and young, to the entire NACEF family and the HICHOUR family.

To my dear friends: MOHAMMEDI Amira, LAMRI SIDALI, TAREK BERKAN.

NACEF OUAIL.

Dedications

MOHAMMEDI Amira.

Abstract

Diabetes is a chronic disease that affects millions of people worldwide, While it can be managed with proper care and treatment it can also lead to a range of complications that affect various parts of the body. One of the most common complications of diabetes is Diabetic Retinorathy (DR), which affects the eyes and is a leading cause of blindness in working-age adults. DR is caused by high levels of glucose in the blood that damage the blood vessels in the retina, leading to vision loss.

In modern medical science, images are the indispensable tool for precise diagnosis of patients. In the meantime evaluation of contemporary medical imageries remains complex. In recent times computer vision with Deep Neural Networks(DNN) can train a model perfectly and level of accuracy also will be higher than other Neural Network(NN) models. In this study fundus images containing Diabetic Retinopathy has been taken into consideration.

The main objective of this project is to develop an approach based on deep learning to help diagnose and predict Diabetic Retinopathy from a set of data relating to real patients.

The Deep Learning models are capable of quantifying the features as blood vessels, fluid drip, exudates, hemorrhages and micro aneurysms into different classes.

Model will calculate the weights which gives severity level of the patient's eye. The foremost challenge of this study is the accurate verdict of each feature class thresholds. The model will be helpful to identify the proper class of severity of diabetic retinopathy images.

The proposed approach helps predict disease risk, as it can clean data, normalize and extract relevant features from structured data, and represents these extracted features efficiently with low dimensional and specific weight using the selection of features to produce optimal results with two different validation methods in order to improve the performance and practical complexity of the proposed model and thus reduce the prediction error of

Diabetic Retinopathy. The proposed predictive model is tested on an application created for the purposes of this test.

The results show that the performances of the proposed predictive model .....

Keywords: Diabetic Retinopathy (DR), Retina, Data filtering, Feature selection, Classification, Deep Learning (DL), Deep Neural Network (DNN), Convolutional Neural Network (CNN), Evaluation metrics, Error metrics, Practical complexity.

ملخص

مرض السكري هو مرض مزمن يصيب ملايين الأشخاص في جميع أنحاء العالم، في حين أنه يمكن إدارته من خلال الرعاية والعلاج المناسبين، إلا أنه يمكن أن يؤدي أيضًا إلى مجموعة من المضاعفات التي تؤثر على أجزاء مختلفة من الجسم. يعد اعتلال الشبكية السكري من أكثر مضاعفات مرض السكري شيوعًا، والذي يؤثر على العينين وهو سبب رئيسي للعمى لدى البالغين في سن العمل. يحدث اعتلال الشبكية السكري بسبب ارتفاع مستويات الجلوكوز في الدم مما يؤدي إلى تلف الأوعية الدموية في شبكية العين، مما يؤدي إلى فقدان البصر.

في العلوم الطبية الحديثة، تعتبر الصور أداة لا غنى عنها للتشخيص الدقيق للمرضى. في غضون ذلك، يظل تقييم الصور الطبية المعاصرة معقدًا. في الآونة الأخيرة، يمكن للرؤية الحاسوبية مع الشبكات العصبية العميقة تدريب نموذج بشكل مثالي ومستوى الدقة سيكون أيضًا أعلى من نماذج الشبكات العصبية الأخرى. في هذه الدراسة، تم أخذ صور قاع العين التي تحتوي على اعتلال الشبكية السكري في الاعتبار.

الهدف الرئيسي من هذا المشروع هو تطوير نهج قائم على التعلم العميق للمساعدة في تشخيص والتنبؤ باعتلال الشبكية السكري من مجموعة من البيانات المتعلقة بمرضى حقيقيين.

نماذج التعلم العميق قادرة على تحديد السمات مثل الأوعية الدموية ، تنقيط السوائل ، الإفرازات ، النزيف وتمدد الأوعية الدموية الدقيقة في فئات مختلفة.

سيحسب النموذج الأوزان التي تعطي مستوى خطورة عين المريض. التحدي الأكبر لهذه الدراسة هو الحكم الدقيق لكل عتبات فئة الميزة. سيكون النموذج مفيدًا في تحديد الفئة المناسبة لشدة صور اعتلال الشبكية السكري.

يساعد النهج المقترح على التنبؤ بمخاطر المرض ، حيث يمكنه تنظيف البيانات وتطبيعها واستخراج الميزات ذات الصلة من البيانات المنظمة ، ويمثل هذه الميزات المستخرجة بكفاءة مع وزن منخفض ومحدد باستخدام اختيار الميزات لتحقيق النتائج المثلى باستخدام طريقتين مختلفتين للتحقق في من أجل تحسين الأداء والتعقيد العملي للنموذج المقترح وبالتالي تقليل خطأ التنبؤ باعتلال الشبكية السكري. يتم اختبار النموذج التنبئي المقترح على تطبيق تم إنشاؤه لأغراض هذا الاختبار.

أظهرت النتائج أن أداء النموذج التنبئي المقترح .....

الكلمات الرئيسية اعتلال الشبكية السكري، شبكية العين، تصفية البيانات، اختيار الميزات، التصنيف، التعلم العميق، الشبكة العصبية العميقة، الشبكة العصبية التلافيفية، مقاييس التقييم، مقاييس الخطأ، التعقيد العملي.

Résumé

Le diabète est une maladie chronique qui touche des millions de personnes dans le monde. Bien qu'il puisse être géré avec des soins et un traitement appropriés, il peut également entraîner une série de complications qui affectent diverses parties du corps. L'une des complications les plus courantes du diabète est la rétinopathie diabétique (RD), qui affecte les yeux et est l'une des principales causes de cécité chez les adultes en âge de travailler. La RD est causée par des niveaux élevés de glucose dans le sang qui endommagent les vaisseaux sanguins de la rétine, entraînant une perte de vision.

Dans la science médicale moderne, les images sont l'outil indispensable pour un diagnostic précis des patients. En attendant l'évaluation des imageries médicales contemporaines reste complexe. Ces derniers temps, la vision par ordinateur avec Deep Neural Networks peut former un modèle parfaitement et le niveau de précision sera également plus élevé que les autres modèles de réseaux neuronaux. Dans cette étude, les images du fond d'œil contenant une rétinopathie diabétique ont été prises en considération.

L'objectif principal de ce projet est de développer une approche basée sur l'apprentissage profond pour aider à diagnostiquer et prédire la rétinopathie diabétique à partir d'un ensemble de données relatives à de vrais patients.

Les modèles d'apprentissage en profondeur sont capables de quantifier les caractéristiques telles que les vaisseaux sanguins, les gouttes de liquide, les exsudats, les hémorragies et les micro-anévrismes dans différentes classes.

Le modèle calculera les poids qui donnent le niveau de gravité de l'œil du patient. Le principal défi de cette étude est le verdict précis des seuils de chaque classe d'entités. Le modèle sera utile pour identifier la classe appropriée de gravité des images de rétinopathie diabétique.

L'approche proposée aide à prédire le risque de maladie, car elle peut nettoyer les données, normaliser et extraire les caractéristiques pertinentes des données structurées, et représente efficacement ces caractéristiques extraites avec un faible poids dimensionnel et

spécifique en utilisant la sélection des caractéristiques pour produire des résultats optimaux avec deux méthodes de validation différentes dans afin d'améliorer les performances et la complexité pratique du modèle proposé et ainsi réduire l'erreur de prédiction de la rétinopathie diabétique. Le modèle prédictif proposé est testé sur une application créée pour les besoins de ce test.

Les résultats montrent que les performances du modèle prédictif proposé .....

Mots-clés : Rétinopathie diabétique (RD), Rétine, Filtrage des données, Sélection de fonctionnalités, Classification, Apprentissage en profondeur (DL), Réseau de neurones profonds (DNN), Réseau de neurones convolutifs (CNN), Métriques d'évaluation, Métriques d'erreur, Complexité pratique.

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Abreviations list

DR	Diabetic Retinopathy
MA	microaneurysms
HM	Haemorrhages
EX	soft and hard Exudates
DL	Deep Learning
DNN	Deep Neural Network
CNN	Convolutional Neural Network
WHO	World Health Organization
DME	Diabetic Macular Edema
AI	Artificial intelligence
SVM	support vector machine
PCA	Principal component analysis
SVD	single value decomposition
MA	microaneurysms
MA	microaneurysms

General Introduction

Clinicians can identify DR by the presence of lesions associated with the vascular abnormalities caused by the disease. While this approach is effective, its resource demands are high. The expertise and equipment required are often lacking in areas where the rate of diabetes in local populations is high and DR detection is most needed. As the number of individuals with diabetes continues to grow, the infrastructure needed to prevent blindness due to DR will become even more insufficient.

Currently, detecting DR is a time-consuming and manual process that requires a trained clinician to examine and evaluate digital color fundus photographs of the retina. By the time human readers submit their reviews, often a day or two later, the delayed results lead to lost follow up, miscommunication, and delayed treatment.

The manual diagnosis process of DR retina fundus images by ophthalmologists is time, effort, and costconsuming and prone to misdiagnosis unlike computer-aided diagnosis systems. Recently, deep learning has become one of the most common techniques that has achieved better performance in many areas, especially in medical image analysis and classification

The purpose of this project is how to peform early detection of Diabetic Retinopathy and image classification using deep computer vision by proposing an efficient hybrid approach tested on an application made for the purposes of this test.

Our manuscript is structured in three chapters:
First chapter, will talk about the general information on diseases Diabetic retinopathy
Second chapter, In this chapter we will describes the work of the existing literature.
Third chapter, we will gives an overview of the proposed methodology.
Fourth chapter, describes evaluates and discusses the experimental results and tests the

proposed predictive model on a desktop application made for the purposes of this test.

Chapter 1

General information on diseases Diabetic retinopathy

1.1 Introduction

Diabetic Retinopathy (DR) is a major cause of vision loss and blindness affecting millions of people across the globe. Retina regular screening is essential for diabetes patients to diagnose and to treat DR at an early stage to avoid the risk of blindness. DR is detected by the appearance of different types of lesions on a retina image. These lesions are microaneurysms (MA), haemorrhages (HM), soft and hard exudates (EX).

Early detection and timely treatment are critical to prevent or slow down the progression of DR. In this chapter, we will provide an overview of DR, including, its causes, risk fasters symptoms, diagnosis, treatment options, and prevention. strategies. We will also discuss the importance of patient education, and self- management in preventing, and managing, DR, as well as the need for further research and technological advancements to improve the diagnosis and treatment of this debilitating complication of diabetes.

1.2 General definitions

1.2.1 Diabetes:

Diabetes is a chronic disease that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. Insulin is

a hormone that regulates blood glucose.The number of people with diabetes is 422 million in 2014. Prevalence has been rising more rapidly in low- and middle-income countries than in high-income countries. Diabetes is a major cause of **blindness**, kidney failure, heart attacks, stroke and lower limb amputation.In 2019, diabetes caused an estimated 2 million deaths.

Symptoms of diabetes:

Symptoms of diabetes may occur suddenly. In type 2 diabetes, the symptoms can be mild and may take many years to be noticed.

- feeling very thirsty
- needing to urinate more often than usual
- blurred vision
- feeling tired
- losing weight unintentionally

Consequences of Diabetes:

Over time, diabetes can damage blood vessels in the heart, eyes, and kidneys and nerves.

- Diabetes can cause permanent vision loss by damaging blood vessels in the eyes.
- People with diabetes have a higher risk of health problems including heart attack, stroke and kidney failure.
- Many people with diabetes develop problems with their feet from nerve damage and poor blood flow. This can cause foot ulcers and may lead to amputation.

Type 1 diabetes:

Type 1 diabetes (previously known as insulin-dependent, juvenile or childhood-onset) is characterized by deficient insulin production and requires daily administration of insulin.

Type 2 diabetes:

Type 2 diabetes affects how your body uses sugar (glucose) for energy. It stops the body from using insulin properly, which can lead to high levels of blood sugar if not treated. Early diagnosis is important to prevent the worst effects of type 2 diabetes. The best way to detect diabetes early is to get regular check-ups and blood tests with a healthcare provider. Symptoms of type 2 diabetes can be mild. They may take several years to be noticed. Symptoms may be similar to those of type 1 diabetes but are often less marked. As a result, the disease may be diagnosed several years after onset, after complications have already arisen.

Diagnosis and treatment:

Early diagnosis can be accomplished through relatively inexpensive testing of blood glucose. People with type 1 diabetes need insulin injections for survival.
One of the most important ways to treat diabetes is to keep a healthy lifestyle.

Additional medical care may be needed to treat the effects of diabetes:

- eye exams to screen for retinopathy (which causes blindness).
- foot care to treat ulcers
- screening and treatment for kidney disease

WHO response:

World Health Organization (WHO) aims to stimulate and support the adoption of effective measures for the surveillance, prevention and control of diabetes and its complications, particularly in low- and middle-income countries. [1]

1.2.2 Diabetic Eye Disease:

Diabetic eye disease is a term for several eye problems that can all result from diabetes. Diabetic eye disease includes:

- diabetic retinopathy,

- diabetic macular edema,
- cataract, and
- glaucoma.[2]

Diabetic retinopathy:

Diabetic retinopathy is when blood vessels in the retina swell, leak or close off completely. Abnormal new blood vessels can also grow on the surface of the retina.[2]

1.2.3 Diabetic Retinopathy:

Diabetic retinopathy is an eye condition that can cause vision loss and blindness in people who have diabetes. It affects blood vessels in the retina. [3]

Anyone with any kind of diabetes can get diabetic retinopathy including people with type 1, type 2, and gestational diabetes.[1][3]

1.2.4 Retina:

The retina is the light-sensitive layer of tissue at the back of the eyeball. Images that come through the eye's lens are focused on the retina. The retina then converts these images to electric signals and sends them along the optic nerve to the brain.[4]

[1] A type of diabetes that can develop during pregnancy.

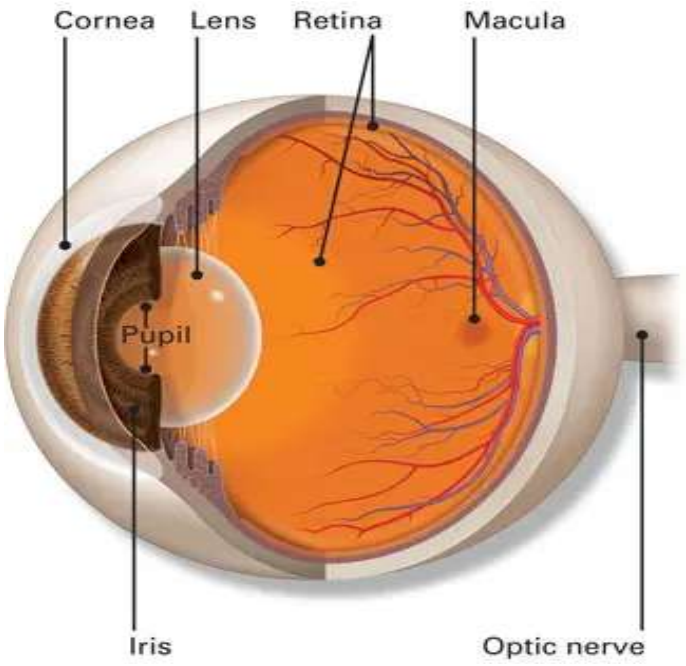

Figure 1.1: Retina

La figure 1.1 It represents the organizational structure of the High Council for the Arabic Language[3]

The retina is the layer of cells lining the back wall inside the eye. This layer senses light and sends signals to the brain so you can see.

Several parts of the eye are associated with the retina. They include:

- Peripheral retina

-Macula

Fovea Photoreceptors Rods Cones[3]

1.3 What causes diabetic retinopathy:

Diabetes damages blood vessels all over the body. Diabetic retinopathy is caused by high blood sugar. The damage to your eyes starts when sugar blocks the tiny blood vessels that go to your retina, causing them to leak fluid or bleed. To make up for these blocked blood vessels, your eyes then grow new blood vessels that don't work well. These new blood vessels can leak or bleed easily.[3]

1.4 How Ophthalmologists check for diabetic retinopathy:

Ophthalmologists can check for diabetic retinopathy as part of a dilatational eye exam. The examination is simple and painless. Your doctor will give you some eye drops to dilate (dilate) your pupil and then check your eyes for diabetic retinopathy and other eye problems. If you have diabetes, it is very important to have regular eye exams. If you do develop diabetic retinopathy, early treatment can stop the damage and prevent blindness.[3]

1.5 Symptoms of Diabetic Retinopathy:

Early prediction of diabetic retinopathy is difficult. Some people notice changes in their vision, such as difficulty reading or seeing distant objects. These changes may come and go. In later stages of the disease, the retinal blood vessels begin to bleed into the vitreous [2]. If this happens, you may see dark, floating spots or lines that look like cobwebs. [1]

1.6 Problems can diabetic retinopathy cause:

Diabetic retinopathy can lead to other serious eye conditions:

- **Diabetic Macular Edema (DME)**: Over time, about 1 in 15 people with diabetes will develop DME. DME happens when blood vessels in the retina leak fluid into the macula (a part of the retina needed for sharp, central vision). This causes blurry vision.

- **Neovascular glaucoma**: Diabetic retinopathy can cause abnormal blood vessels to grow out of the retina and block fluid from draining out of the eye. This causes a type of glaucoma (a group of eye diseases that can cause vision loss and blindness).

[2] the jelly-like fluid that fills your eye.

- **Retinal detachment**: Diabetic retinopathy can cause scars to form in the back of your eye. When the scars pull your retina away from the back of your eye, it's called tractional retinal detachment.[3]

1.7 How to treat diabetic retinopathy and DME:

In the early stages of diabetic retinopathy, your eye doctor will likely monitor your eye condition. Some people with diabetic retinopathy may need a comprehensive dilatation eye exam every two to four months. In advanced stages of the disease, it is important to start treatment immediately especially if there are changes in vision. Although it will not remove any damage to eyesight, treatment can prevent vision deterioration. It is also important to take steps to control diabetes, blood pressure, and cholesterol.

- **Injections**: Medicines called anti-VEGF drugs can slow down or reverse diabetic retinopathy. Other medicines, called corticosteroids, can also help.
- **Laser treatment**: To reduce swelling in your retina, eye doctors can use lasers to make the blood vessels shrink and stop leaking.
- **Eye surgery**: If your retina is bleeding a lot or you have a lot of scars in your eye, your eye doctor may recommend a type of surgery called a vitrectomy.[3]

1.8 Conclusion

We have done an

Chapter 2

State of knowledge

2.1 Introduction

In various domains like business, healthcare, industries, and military, there is widespread use of terms related to artificial intelligence, machine learning, and deep learning in the modern era. Regardless of the size of the data, accurate prediction and analysis of data are critical in these fields. However, due to the rapid growth and extensive development in public life, using big data can be confusing and requires significant human effort to extract valuable information from it.

Healthcare systems store large amounts of patient data and medical knowledge in databases, necessitating the need for new data analysis and classification tools and technologies to exploit this information. Artificial intelligence plays a crucial role in analyzing big data based on scientific techniques, particularly in machine learning, where it can identify decision-making patterns and minimize human intervention. As a result, the importance of artificial intelligence, machine learning, and deep learning is rapidly increasing.

Currently, machine learning and deep learning algorithms are utilized for the automatic analysis of medical data. The techniques employed in machine learning can be considered part of a broader process known as knowledge discovery in databases or data mining. This chapter discusses

2.2 Artificial intelligence:

It is the science and creation of intelligent machines, that is, the simulation of human intelligence processes by machines, especially intelligent computer systems. Specific applications of AI include expert systems, natural language processing, speech recognition, and machine vision (deep learning), and it is related to the similar task of using computers to understand human intelligence, but Artificial Intelligence (AI) does not have to be limited to biologically observable methods.[5]

2.3 Machine learning:

Machine learning is a branch of artificial Intelligence (AI) and computer science that uses data and algorithms to teach machines to mimic the way humans learn, gradually improving their accuracy, as opposed to traditional programming which consists of executing algorithms and giving predetermined results.[6]

2.3.1 Machine learning methods:

Machine learning models fall into three basic categories.

Supervised machine learning

Supervised learning is defined by its use of labeled datasets to train algorithms to classify data where the algorithm has prior knowledge of what the model's output values should be. Thus, predicting results accurately. When input data is entered into the form, the model adjusts its weights until it is appropriately fitted. This happens as part of the cross validation process to ensure that the model avoids overfitting or improper fitting. Some of the approaches used in supervised learning include neural networks, linear regression, logistic regression, random forests, and support vector machine (SVM).

Unsupervised machine learning

Unsupervised learning uses machine learning algorithms to analyze and aggregate unlabeled data sets. This method's ability to detect similarities and differences in information makes it ideal for exploratory data analysis, the goal of which is then to infer clusters in

our data. It is also used to reduce the number of features in a model through a dimension reduction process. Principal component analysis (PCA) and single value decomposition (SVD) are two common approaches for this.

Semi-supervised learning

Semi-supervised learning provides a hybrid between supervised and unsupervised learning. During training, it uses a smaller, labeled dataset to guide classification and extract features from a larger, unlabeled dataset. There are various methods such as: generative models, low-intensity separation, graph-based methods, heuristic methods etc.

Reinforcement machine learning

Reinforcement learning is a field of artificial intelligence that aims to learn to follow optimal policy from a very weak supervisory signal. Reinforcement machine learning is a machine learning model similar to supervised learning, but the algorithm has not been trained using data samples. This model learns as you try it and see what's wrong. Successful results chain will be strengthened for better development.[6]

2.4 Machine learning:

Deep learning is a subset of machine learning in which artificial neural networks and algorithms inspired by the human brain learn from large amounts of data, and it is basically a neural network with three or more layers. These neural networks try to simulate the behavior of the human brain, albeit far from matching its ability to "learn" from large amounts of data. The deep learning algorithm performs the learning task iteratively, each time adjusting the weights of the neural networks slightly to improve the result. We talk about deep learning because neural networks have several (deep) layers that enable learning. Any problem that requires "thinking" to solve is a problem that deep learning can learn to solve. Deep learning is driving many artificial intelligence (AI) applications and services that improve automation, perform analytical and physical tasks without human intervention, and this is a staggering 2.6 quintillion bytes of data that we produce every day, and it is this resource that makes deep learning possible. Deep learning technology underlies everyday products and services (such as digital assistants,

voice-enabled TV remote controls, and credit card fraud detection) as well as emerging technologies (such as self-driving cars).[7]

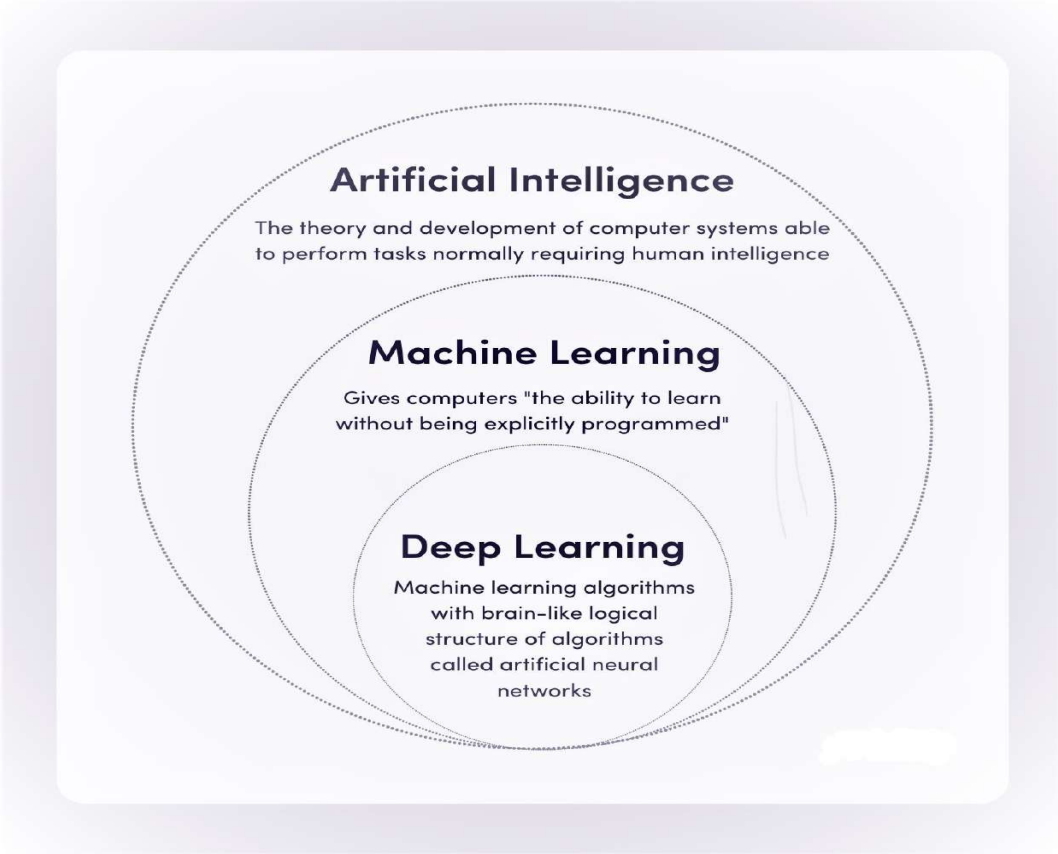

Figure 2.1: AI

La figure 2.1 It represents Machine Learning is a type of Artificial Intelligence. Deep Learning is an especially complex part of Machine Learning.[8]

2.5 Neural networks:

Before describing artificial neural networks, we begin by describing biological neurons.

2.5.1 Biological neurons:

In living organisms, the brain is the control unit of a neural network. A neuron is a basic cell in the nervous system of living organisms. The human brain contains tens of billions of them. A neuron is the basic building block of neural networks. In biological systems, a neuron is a cell just like any other cell in the body. Each nerve cell consists of:

* A cell body that contains a nucleus.
* dendrites, numerous and branching, which transmit nerve impulses from their periphery to the cell body.
* the axon, which transmits the action potential emitted at the level of the cell body to the dendrites of other neurons. The nerve impulses are then chemically transmitted at the synapses. Axons can measure several tens of centimeters in length and are surrounded by myelin sheaths to improve the transmission of nerve impulses.

Dendrites receive signals from surrounding neurons, so each neuron receives signals from other neurons as input, transmitted by dendrites to the cell body where they are added. The significance of each signal received is modulated by the length of the dendrite that allows it to reach the cell body and by the efficiency of the synaptic connection between the presynaptic axon and the postsynaptic dendrite. If it exceeds a certain threshold, the signal generated at the level of the cell body can then trigger an action potential, that is, an electrical potential peak that propagates through the axon to other neurons to which the dendrites are connected.[9]

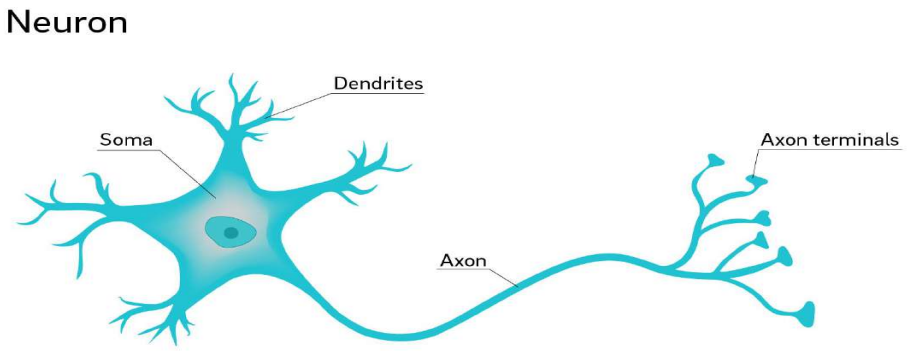

Figure 2.2: Biological Neuron

La figure 2.2 It represents Biological Neuron.[9]

2.5.2 Why do we understand neurobiological networks

We understand biological neural networks to create artificial neural networks, so it is important to theoretically analyze biological neural networks because they have a very close relationship.

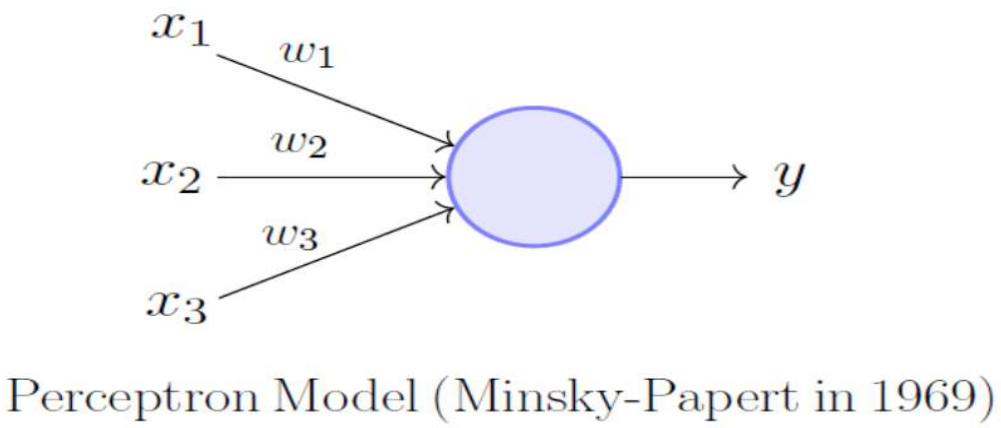

Figure 2.3: Perceptron Model

La figure 2.3 It represents Perceptron Model.[10]

2.5.3 formal neuron:

Perceptrons, or the so-called artificial neurons or formal neurons, are the transfer of the action of biological neurons to artificial neurons. There are different levels of making artificial neurons, depending on the accuracy of the modeling required.

* x : inputs, in vector form, representing dendrites.

* y : output, representing an axon.

∗ w and b : parameters, which affect the functioning of neurons.

∗ Formal neuron equation:

y = f (⟨w, x ⟩ + b)

This equation shows how to calculate the output. By multiplying each entry by a weight (w factor). All inputs are then summed and added to bias b. The result of the sum is then passed through the transfer function f.

(usually non-linear). This function then produces the desired classification.[11]

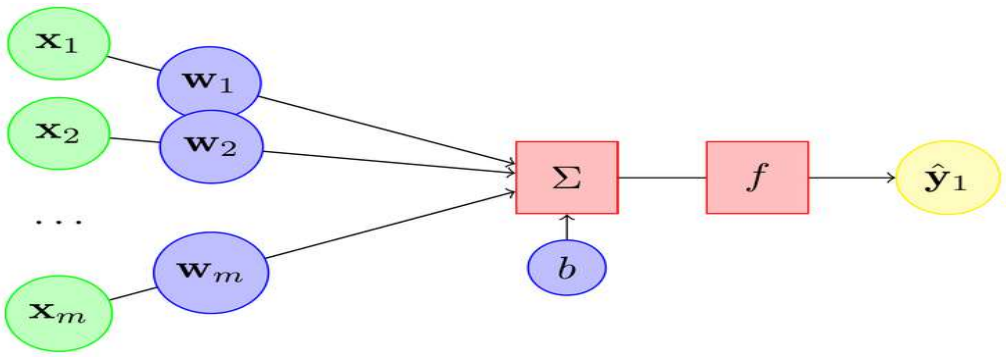

Figure 2.4: Neurone Formel

La figure 2.4 It represents Neurone Formel.[11]

2.6 Data mining

2.7 Conclusion

In this chapter, we have introduced the analysis and design phase of our mobile application needs, clarifying the needs. The objective of this analysis and design is to materialize the information system during the implementation phase. Then we designed our system using case diagrams using UML to create a final project view, a UML (sequence diagram) graphical representation and class diagram design. We will start realizing our system by introducing the programming languages, tools, and development environment used to implement our application. Among other things, we present some graphical interfaces of the application which we will discuss in the next chapter.

Chapter 3

Proposed methodology

3.1 Introduction:

After completing the application design stage, in this chapter we will start the implementation and evaluation stage by presenting the work environments and technology used in creating the application, which made it possible to reach the final result, and we will also display the interfaces while implementing the application functions, and at the end we provide an explanation of the most important features of the application.

3.2 Work environment:

3.3 Conclusion

In this chapter, we have provided a brief and clear explanation of the programming languages used in developing the application and the programs that were used without forgetting the devices used, and we also touched on showing the various application interfaces, functions and provide a clear explanation of the most important feature of the application, which is the multilingual smart search feature.

Chapter 4

Experimental results

4.1 Introduction:

After completing the application design stage, in this chapter we will start the implementation and evaluation stage by presenting the work environments and technology used in creating the application, which made it possible to reach the final result, and we will also display the interfaces while implementing the application functions, and at the end we provide an explanation of the most important features of the application.

4.2 Work environment:

4.3 Conclusion

In this chapter, we have provided a brief and clear explanation of the programming languages used in developing the application and the programs that were used without forgetting the devices used, and we also touched on showing the various application interfaces, functions and provide a clear explanation of the most important feature of the application, which is the multilingual smart search feature.

General conclusion

Prevention diabetic retinopathy by keeping blood sugar levels in a healthy range. You can do this by getting regular physical activity, eating healthy food, and carefully following your doctor's instructions about insulin or other diabetes medications. A healthy diet, regular physical activity, maintaining a normal body weight and avoiding tobacco use are ways to prevent or delay the onset of type 2 diabetes.

If you have diabetes, it's important to get a comprehensive dilated eye exam at least once a year. Diabetic retinopathy may not have any symptoms at first — but finding it early can help you take steps to protect your vision.

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