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Patient monitoring using computer vision and IoT

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Patient monitoring using computer vision and Io-MT

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General introduction

The proportion of people with chronic diseases is increasing all over the world, as well as the death rate, and this is due to several reasons and factors[1].
In a report published by the World Health Organization in 2020, it mentioned a list of the top ten causes of death around the world and indicated that non-communicable diseases such as heart disease, diabetes, dementia, chronic diseases, respiratory infections, traffic accidents, substance use disorders and many others, etc.[2]
These diseases highlight the urgent need to radically improve primary health care, in a just and comprehensive manner. It is clear that robust primary health care is the foundation of everything from controlling noncommunicable diseases to managing global pandemics.[2]
In this regard, it has become necessary to establish a system that allows us to monitor patients 24 hours a day, to enable them to obtain medical assistance in the moment of need.
Therefore, a system that combines computer vision and the Internet of Medical Things must be used. In this project we aim to use computer vision and monitoring devices to watch a patient on his bed. Computer vision is used to determine patient behaviors – like sitting up, getting out of bed, coughing, falling, or gesturing for help, and the devices capture vital signs. This combination allows for example to distinguish between a normal situation (sleeping patient) and a crisis (heart attack, faintness, etc.). In our work, we propose a coughing monitoring system through facial expression, as well as voice and vital information of the patient to predict the possibility of the patient having a severe coughing fit on the one hand and on the one hand being informed of his injury. The pieces of information can be collected using electronic platforms such as Arduino or raspberry pi, then send through the internet to the concerned people (nurse, doctor, family members, etc.)

The first chapter presents general concepts about health and the reasons that affect it, as well as its relationship to computer science.
The second chapter is an overview of computer vision and the Internet of Things, in addition to the Raspberry Pi.
The third chapter presents concepts and explanations for the work done.
The fourth chapter is the practical part of the work

CHAPTER 1

Healthcare and computer science

1.1 Introduction

Today we are talking about our subject about health, which is the most precious blessing that God Almighty has bestowed on man. Mental-physical-social, all of these aspects are very important for a person to enjoy his full health.
Taking care of human health is the responsibility of the individual himself first, and then the responsibility of the state, which must provide the necessary treatment for everyone who suffers from diseases, and it is the person's duty to maintain his health, as maintaining health saves a person many material and moral consequences, treating diseases is expensive, and medicine it needs to be bought, so taking care of health as much as possible and avoiding diseases is much better than neglecting health, and receiving treatment that may be expensive and long and has side effects.

1.2 Definition of health

Health, in humans, the extent of an individual's continuing physical, emotional, mental, and social ability to cope with his or her environment. This definition is just one of many that are possible. What constitutes "good" health in particular can vary widely. The rather fragile individual who stays "well" within the ordinary environment of his or her existence may succumb to a heart attack from heavy shovelling after a snowstorm; Or a sea-level dweller may move to a new home in the mountains, where the atmosphere has a lower content of oxygen, and suffers from shortness of breath and anemia until his or her red blood cell count adjusts itself to the altitude. Thus, even by this definition, the conception of good health must involve some allowance for change in the environment[3].

1.3 Risks to human health

The World Health Organization has published a list of the most common causes that affect human life [4] and the figure showing 1.1

1. All kinds of diseases (Digestive diseases , Cancers, Cardiovascular diseases, Malaria, Diarrhoeal diseases, Communicable diseases...)

2. Maternal conditions

3. Perinatal conditions

4. Nutritional deficiencies

5. Collective violence

6. Intentional (violence)

7. Unintentional (accidents)

8. Injuries

9. Diabetes

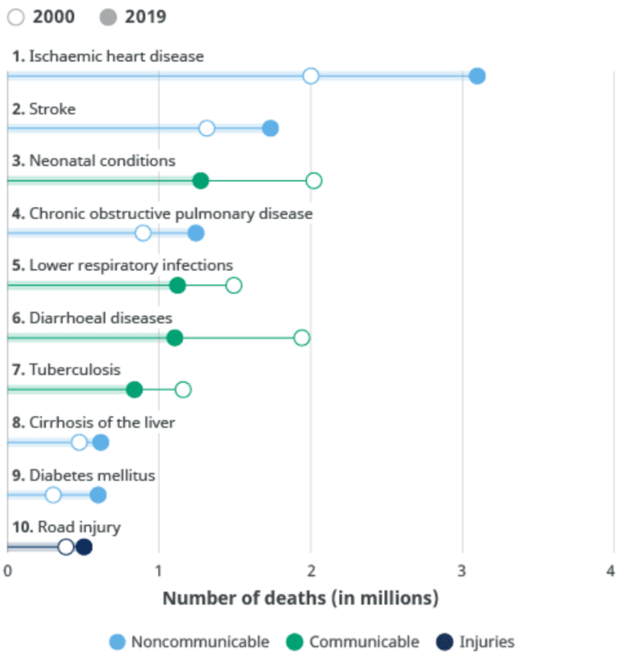

Figure 1.1: Leading causes of death globally [4]

1.4 The role of health care in increasing human life

In a research published by Kaplan Robert M and Arnold Milstein in 2019 entitled Contributions of health care to longevity, he reviewed four ways to know the extent of the impact of health care on health outcomes and increasing longevity, as the results revealed that health care has an impact, albeit a small percentage in increasing the length of life Age.
the reason is due to the fact that lack of health care is not the main cause of death in the world,

as there are several other factors that differ from one country to another, including social conditions, genetic predispositions, cigarette smoking, behavior patterns and others...[5] The figure 1.2 represent some countries.

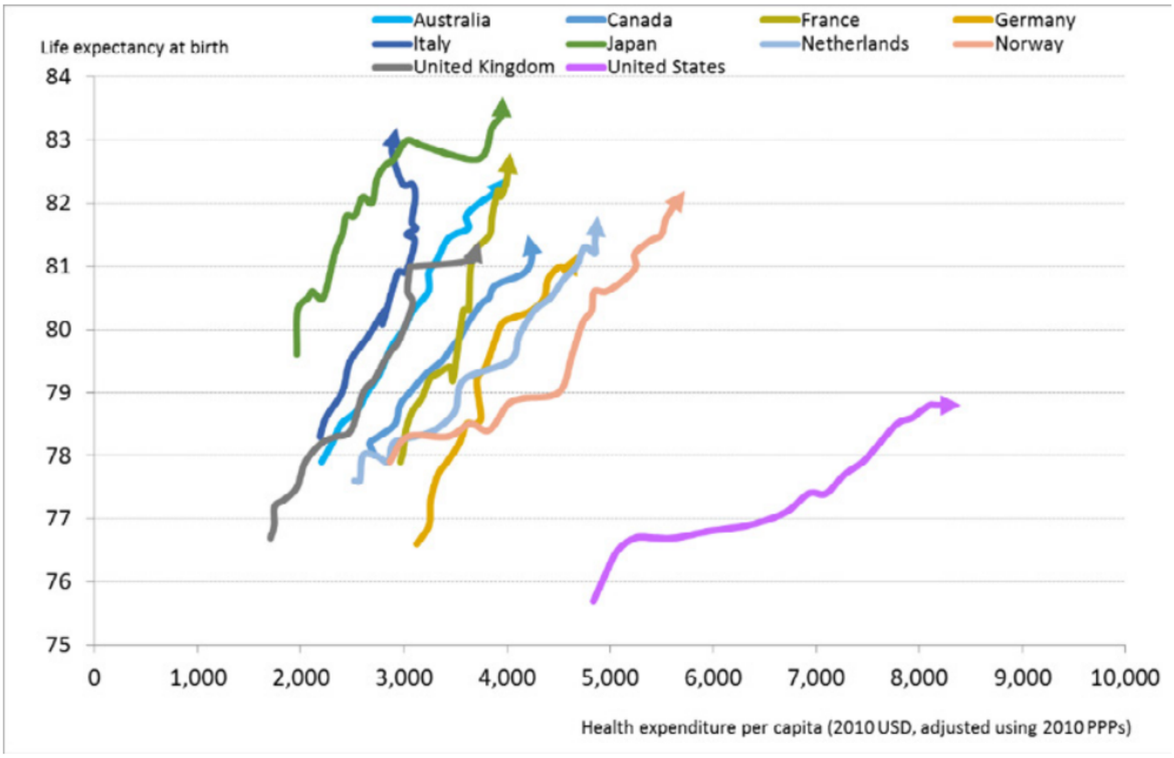

Figure 1.2: Life expectancy gains and increased health spending, selected high-income countries,1995-2015.[5]

1.5 Chronic obstructive pulmonary disease

1.5.1 Definition

It is one of the diseases that affect the human respiratory system and it is also called "chronic obstructive pulmonary disease" or "chronic obstructive airway disease", and it is a disease that manifests in a combination of chronic bronchitis and emphysema, which leads to difficulty breathing[6]. in the figure 1.3 the statistics of pulmonary disease in the world.

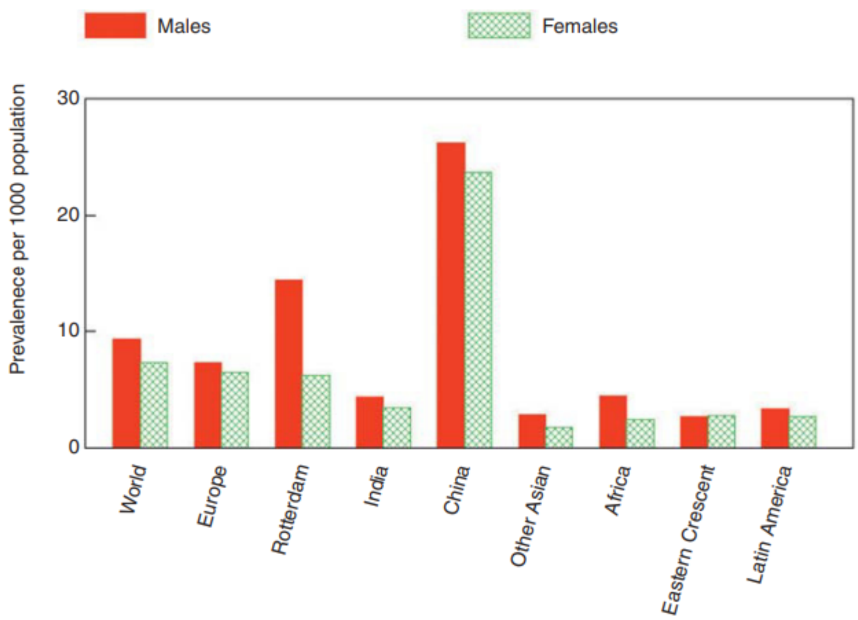

Figure 1.3: Statistics of the prevalence of obstructive pulmonary disease in the world [6]

1.5.2 Description

The respiratory system is divided into two parts : The first is the upper respiratory system, which is represented by the (nose, nasal cavity, sinuses, larynx and trachea), and the second is the lower respiratory system, which contains (bronchioles that branch off to become the bronchi, alveoli and lungs).

When breathing, the lungs absorb oxygen using the capillaries that form the alveoli, and in the same way, carbon dioxide is expelled from the body. What distinguishes the lungs is their natural flexibility, which allows them to excrete air, but in our case "COPD" this flexibility fades, which leads to their expansion and consequently the trapping of air inside the lungs[7].(figure 1.4 showing that).

1.5.3 The causes of this disease

We have the most common causes of disease : [8]:

1. Smoking is the main cause of disease.

2. Prolonged exposure to smoke, dust and toxic gases.

3. Genetic factors.

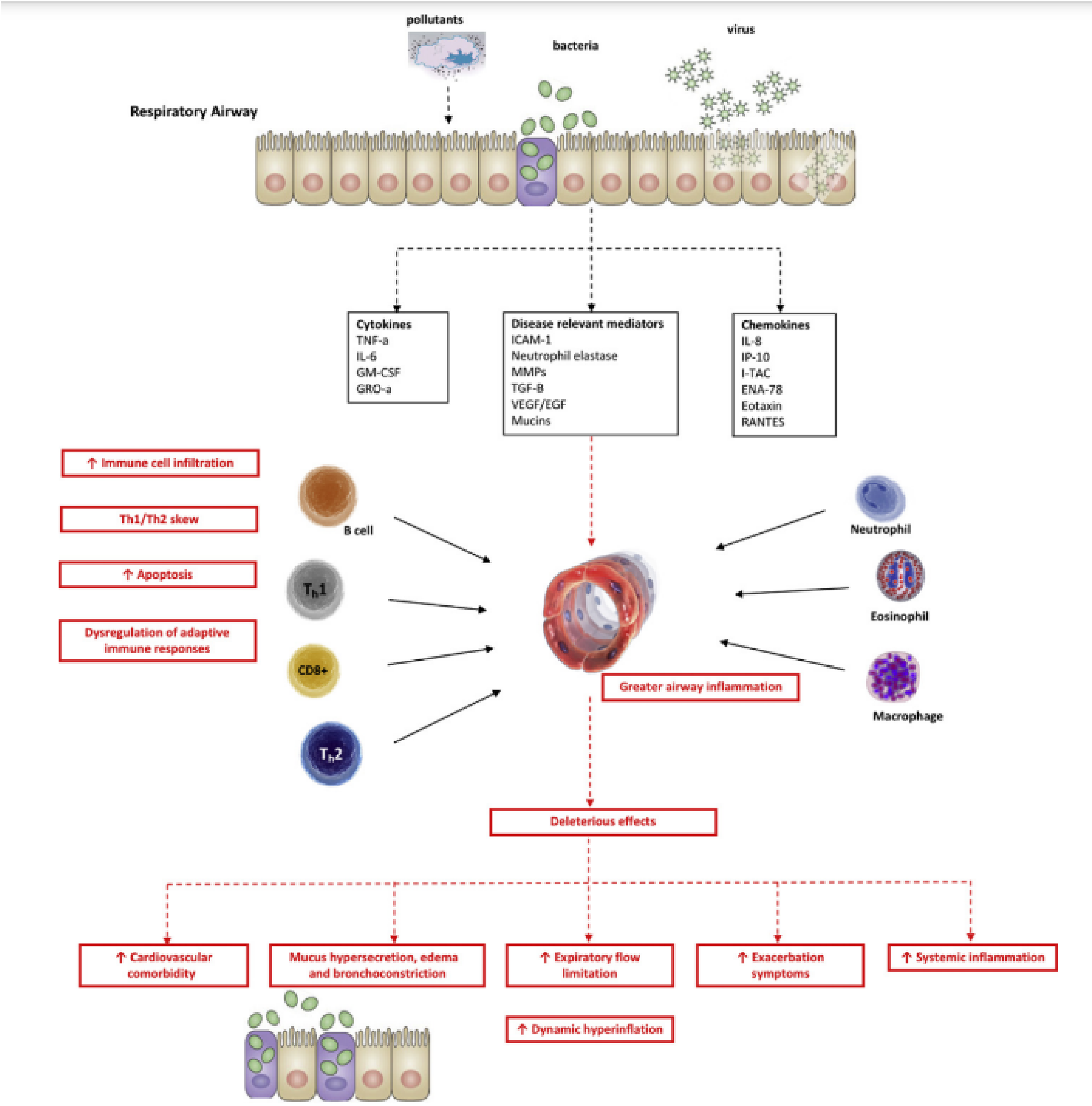

Figure 1.4: Diagram describing chronic obstructive pulmonary disease [7]

4. Using fire, whether for cooking or heating, without ventilation.

1.5.4 Symptoms

These symptoms are necessarily the cases closest to being [9]:

1. Chronic cough

2. Shortness and difficulty breathing

3. Fatigue
4. Wheezing
5. Frequent respiratory infections
6. Lack of activity
7. Losing weight for no reason
8. Swollen ankles, feet, or legs

1.5.5 Situations that require medical intervention

The persistence of symptoms for several days, and then the appearance of other symptoms, requires the urgent intervention of a doctor [10]:

1. Feeling dizzy or having trouble concentrating
2. Rapid heartbeat
3. Severe cyanosis of the lips
4. Difficulty catching a breath
5. Sputum change due to severe cough
6. Fever

1.6 The relationship between computer science and health care

Rapid advances in the information sciences, coupled with the political commitment to broad extensions of health care, promise to bring about basic changes in the structure of medical practice. Computing science will probably exert its major effects by augmenting and, in some cases, largely replacing the intellectual functions of the physician. As the intellectual use of the computer influences in a fundamental fashion the problems of both physician manpower and quality of medical care, it will also inevitably exact important social costs—psychologic, organizational, legal, economic and technical. Only through consideration of such potential costs will it be possible to introduce the new technology in an effective and acceptable manner. To accomplish this goal will require new interactions among medicine, the information sciences and the management sciences, and the development of new skills and attitudes on the part of policy-makers in the health-care system[11].

1.7 The role of technological development in preserving human life

In this regard, a set of experiments were conducted on patients to extract the role of prevention using the computer or prevention using traditional means, as these results resulted in the detection of several risks and problems of the patients' interface without their knowledge of their existence, using the computer-based health risk assessment, and from here we conclude the role of Technological development in maintaining health.[12].

1.8 Importance of Computer in Health and Medicine

With the tremendous technological development that the world is witnessing, the health sector has also witnessed a tremendous development, as the use of computers has become not only limited to routine work such as information management, but diseases have gone beyond to monitoring patients, detecting diseases, and surgical operations, among others.[13]. Some examples of the importance of computers in health and medicine :

1.8.1 Medical Informatics

The primitive use of medical notation led to the emergence of several errors that may sometimes be bad and can be fixed, but sometimes it may lead to death, such as poor writing of health prescriptions, and hence the role of technological development in improving and eliminating these errors, such as the use of some techniques that Allows you to quickly identify patients and their medical information...[13]

1.8.2 Medical Equipment

It is clear that computers are responsible for controlling various medical devices, from sensors and medical imaging devices such as magnetic resonance imaging and ultrasound imaging, and computers can show various results with the push of a button [13].

1.8.3 Patient Monitoring

Computers allowed us to monitor patients, laboratory equipment, as well as medical devices, such as blood pressure and oxygen measurements, in real-time. This contributed to saving lives by notifying employees in the event of potential problems or dangers, on the one hand, and on the other hand, preserving medical information[13].

1.8.4 Investigation

By saving medical information in databases, physicians can refer to the medical information of their patients, and through this information the physician can diagnose patients or come up with a treatment[13].

1.8.5 Medical Informatics of Communication and Telemedicine

Doctors are now able to chat and discuss various medical issues directly with each other and in real time, using advanced means. It has also facilitated the possibility of obtaining advice and directions for patients residing in rural and suburban areas.[13].

1.9 Artificial Intelligence and Health Care

1.9.1 Artificial Intelligence (AI)

Artificial intelligence is a field of computing that focuses primarily on the transmission of anthropomorphic intelligence and thinking into machines that can assist humans in many ways. Artificial intelligence was a term that John McCarthy used in 1956. AI has slowly sprung up and grown stronger in many fields such as engineering, mathematics, physics, technology all of which have led to the current tremendous shift in this field which we are witnessing now[14].

1.9.2 Artificial Intelligence in Health Care

Medicine was considered as one of the applications of Artificial Intelligence. Researchers developed many decision support systems since the mid of 20th century. In 1970, rule based approaches were a huge success and was used to interpret ECGs, choosing the correct treatment, diagnose disease and even to assist physicians. Since the required the frequent addition of rulesand updates, this rule based systems are costly. Also, it was difficult to encode the different knowledges obtained from different experts. The first generation medical AI was completely depended on expert knowledge and robust rules. But the modern AI made changes in the learning methods by which it can have many interactions and identify pattern[15].

1.9.3 How Artificial intelligence is changing health and health care

Artificial intelligence has led to a revolution in health and health care, as the capabilities of artificial intelligence are not limited to the care of patients and their families, but to the caregiving team of physicians, public health professionals, administrators, and health researchers. Hence, we ask the question of what is the potential future of the field of health under artificial intelligence. We conclude by offering a perspective on how AI can transform healthcare and by introducing high-level considerations to address the barriers to that future, an AI solution could become significantly more powerful if combined with augmented reality, virtual reality, faster computing systems, robotics, or the Internet. things (IoT)[15].

1.9.4 AI Solutions for patients and families

Now the field of artificial intelligence occupies an important axis in the management of chronic diseases, from heart diseases and diabetes to psychological diseases, as self-management can perform several tasks from taking medicines and food, injections, taking care of the surgeon, to monitoring medical devices, monitoring patients and forecasting dangers that you may face, etc.

1.9.5 Health Monitoring and Risk Prediction

AI can use raw data from accelerometers, gyroscopes, microphones, cameras, and other sensors, including smartphones. Machine-learning algorithms can be trained to recognize patterns from the raw data inputs and then categorize these patterns as indicators of an individual's behavior and health status. These systems can allow patients to understand and manage their own health and symptoms as well as share data with medical providers.

1.9.6 AI solutions for doctors

There are two main areas of AI capability in the field of assistance: expanding and improving the delivery of assistance, and improving information management, user experience, and cognitive support in the EHR. Behind the events that have been achieved, great strides have been made, mainly through rule-based applications developed by experts, which tend to focus on various occurrences or problems. AI technologies offer the potential for increased productivity.

1.10 conclusion

Technological development has revolutionized the healthcare industry, as AI systems have helped save busy doctors time by transcribing notes, entering and organizing patient data into portals and diagnosing patients. AI also has the ability to diagnose patients remotely, thus extending medical services to remote areas, outside the world's major urban centers. The future of AI in healthcare is bright and promising, yet there is still much to be done.

CHAPTER 2

Patient monitoring

2.1 Introduction

The great development in information technology has contributed to changing the ways modern health care systems acquire, store, access and communicate medical information. These developments offer significant benefits to patients and healthcare providers. Staffing shortages have made it difficult for hospitals to provide sufficient monitoring of patients who require immediate attention. Tragically, a wide range of patient behaviors – like sitting up, getting out of bed, coughing, falling, or gesturing for help – go unnoticed until it's too late to help the patient in need. Patient monitoring AI can be life saving in these situations.
In this new chapter present different approaches even using computer vision or Io-MT for patient Monitoring. We will also in the first part describe some basic concepts related to computer vision and IoT.

2.2 Computer vision

2.2.1 Definition

Computer vision is a domain of AI that attempts to replicate the human visual apparatus The machine should be able to segment, identify, and track objects in still and moving images. For example, some automobile camera systems continuously monitor for speed limit signs, extract that information, and display it on the dashboard. More advanced systems can identify other vehicles, pedestrians, and local geographic features. As noted above, combining similar computer vision systems with reasoning systems is necessary for the general problem of autonomous driving[16](Figure 2.1).

A first idea to solve computer vision is to understand how human vision works, and transfer this knowledge to computers.

2.2.2 Humans vision

Definition of vision

Whether it's a computer or an animal, vision comes down to two things first, a detection device captures as many details of an image as possible. The eye will capture the light passing through the iris and projects it onto the retina, where specialized cells will transmit

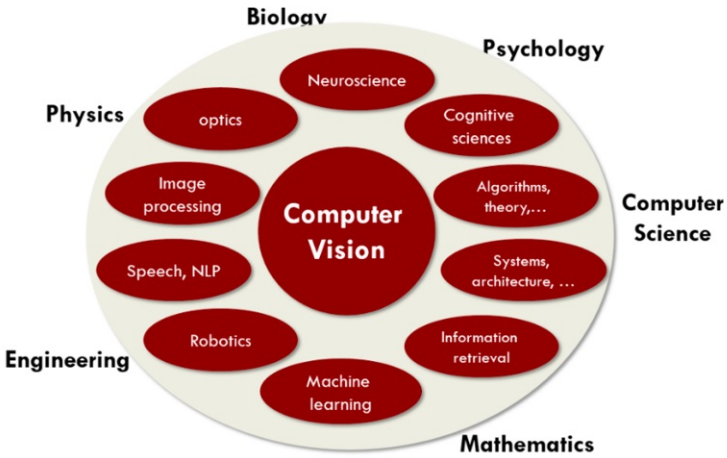

Figure 2.1: Computer vision [16]

information to the brain via neurons. A camera captures images in a similar way and transmit pixels to the computer. In this part, the cameras are better than humans because they can see infrared, see further or with more precision. Secondly, the interpretive device must process the information and make sense of it. The human brain solves this in several stages in different regions of the brain. Computer vision is still lagging behind human performance in this area[17](Figure 2.2).

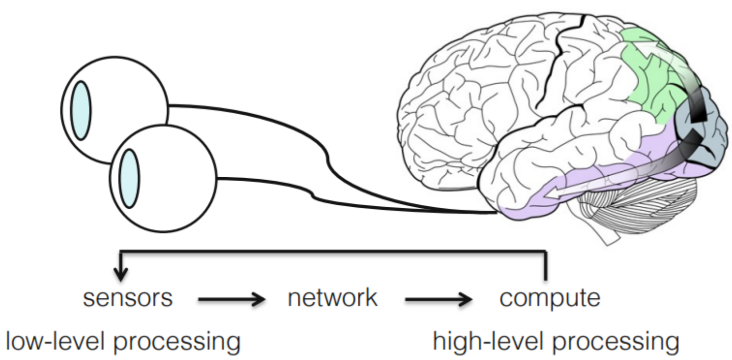

Figure 2.2: Shows the cross section of the human eye [17]

2.2.3 The Visual System

The visual system consists of two parts :

1. The eyes act as image receptors: The eyes act as image receptors.

2. The brain acts as an image processing and interpretation unit.

The Human Eye

The structure of the human eye is analogous to that of a camera[18].The basic structure of the eye is displayed in figure 2.3.

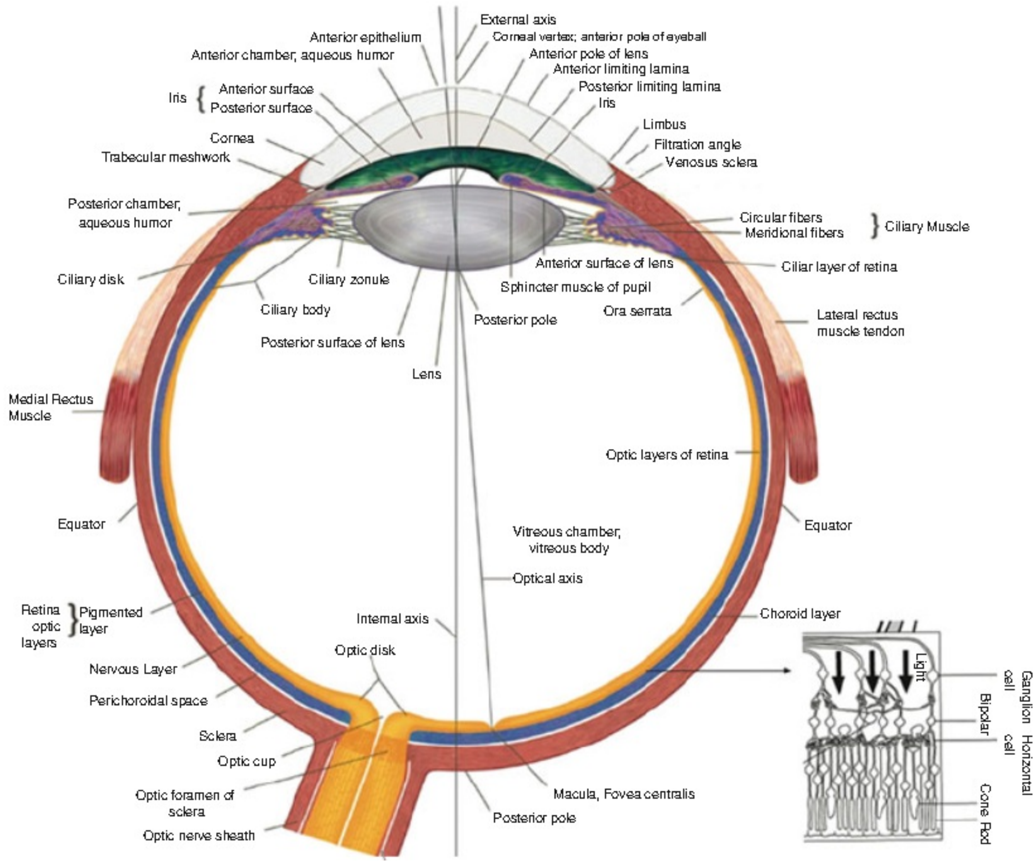

Figure 2.3: Shows the cross section of the human eye [18]

1. The cornea and aqueous humour act as a primary lens which perform crude focusing of the incoming light signal(Figure 2.4).

2. A muscle called the Zonula controls both the shape and positioning (forward and backwards) of the eye's lens. This provides a fine control over how the light entering the eye is focused.

3. The iris is a muscle which, when contracted, covers all but a small central portion of the lense. This allows dynamic control of the amount of light entering the eye, so that the

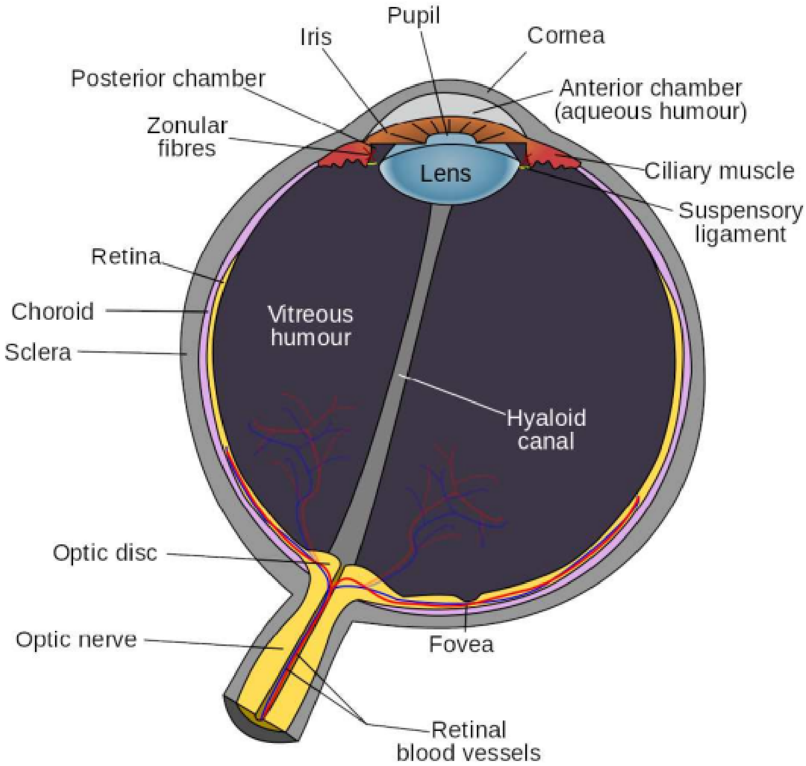

Figure 2.4: all [18]

eye can work well in a wide range of viewing conditions, from dim to very bright light. The portion of the lens not covered by the iris is called the pupil(Figure 2.5).

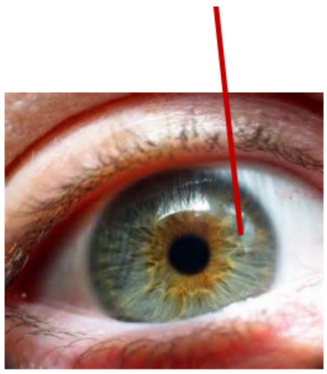

Figure 2.5: The iris [18]

4. The retina provides a photo-sensitive screen at the back of the eye, which incoming light is focused onto. Light hitting the retina is converted into nerve signals (Figure 2.6).

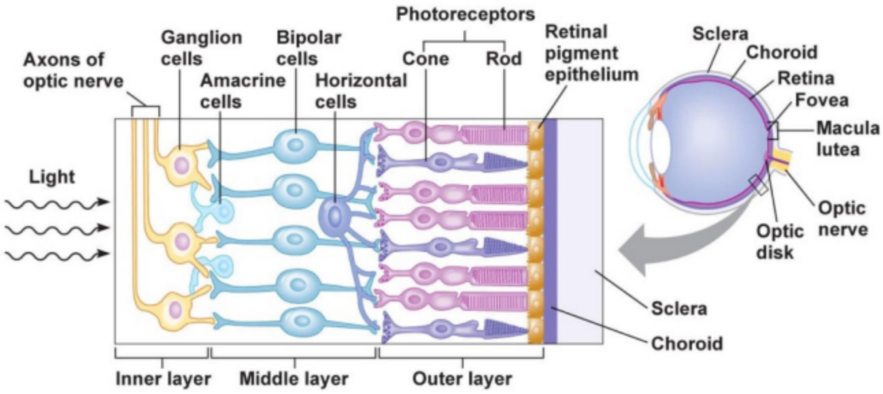

Figure 2.6: the ratina work [18]

5. A small central region of the retina, called the fovea, is particularly sensitive because it is tightly packed with photo-sensitive cells. It provides very good resolution and is used for close inspection of objects in the visual field.

6. The optic nerve transmits the signals generated by the retina to the vision processing centres of the brain (Figure 2.7).

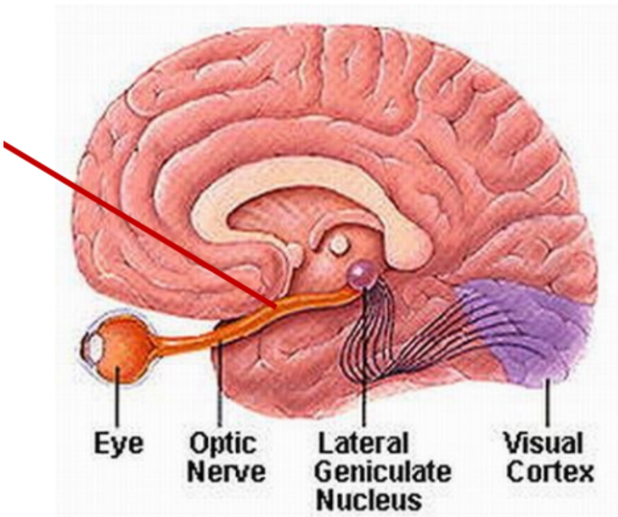

Figure 2.7: The optic nerve [18]

The human brain

The vast amount of visual information in the world is contained in the light that reaches the eye. What we perceive and how we perform depends on the information processed by each successive structure of the visual system. From the photoreceptors to the optic cortex, photoreceptors are transducers that convert a stimulus of light energy into an electrical signal called a nerve impulse, thus inserting information about the outside world into our neural structures. To simplify it, the human brain is a processor and translator of information coming from the eye. Because the eye is a camera that takes pictures (Figure 2.8).

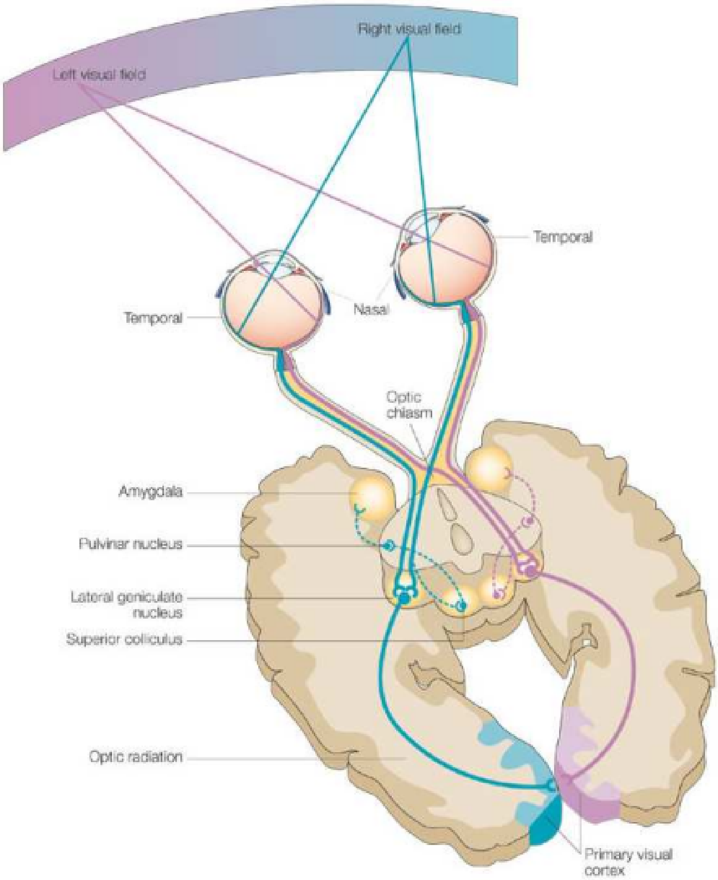

Figure 2.8: transfer the data from the eyes to brain[18]

2.2.4 History of Computer Vision

It is generally accepted that the father of computer vision is Larry Roberts, who received his Ph.D. I discussed the thesis (cir. 1960) at the Massachusetts Institute of Technology. The idea began with the possibility of extracting three-dimensional geometric information from the perspective of a two-dimensional perspective of the blocks.

Later the need to process images from the real world arose, and here researchers realized the need to research so-called "low-level" vision tasks such as edge detection and segmentation. A major milestone was the framework proposed by David Marr (cir. 1978) at the Massachusetts Institute of Technology.

Low-level image processing algorithms are applied to 2D images to obtain the "primal sketch" (directed edge segments, etc.), from which a 2.5 D sketch of the scene is obtained using binocular stereo. Finally, high-level (structural analysis, a priori knowledge) techniques are used to get 3D model representations of the objects in the scene.
Nonetheless, more recently a number of computer vision researchers realized some of the limitation of Marr's paradigm, and advocated a more top-down and heterogeneous approach. Basically, the program of Marr is extremely difficult to carry out, but more important, for many if not most computer vision applications, it is not necessary to get complete 3D object models. This new paradigm is sometimes called "Purposive Vision" implying that the algorithms should be goal driven and in many cases could be qualitative.
Because of the widespread use of computer vision, there is a need to integrate computer vision with other closely related fields . These include: Image processing (the raw images have to be processed before further analysis). Photogrammetry (cameras used for imaging have to be calibrated. Determining object poses in 3D is important in both computer vision and photogrammetry).Computer graphics (3D modeling is central to both computer vision and computer graphics. Many exciting applications need both computer vision and computer graphics)[19].

2.2.5 Application of Computer Vision

Past and present applications of computer vision include: Autonomous navigation, robotic assembly, and industrial inspections. At best, the results have been mixed. The main difficulty is that computer vision algorithms are almost all brittle; an algorithm may work in some cases but not in others. some of the exciting computer vision applications which can be potentially very successful include:

1. Image/video databases-Image content-based indexing and retrieval.
2. Vision-based human computer interface - e.g., using gesture (combined with speech) in interacting with virtual environments.
3. Virtual agent/actor - generating scenes of a synthetic person based on parameters extracted from video sequences of a real person.

4. It is heartening to see that a number of researchers in computer vision have already started to delve into these and related applications.

2.2.6 Computer vision fields

2.2.7 Some applications of computer vision

In this section, some of the systems that were created using computer vision[20]

Transportation

The transportation sector is witnessing a tremendous acceleration in the number of transportation users, which has led to the emergence of several obstacles and problems. Computer vision field applications represent the best solutions, from autonomous vehicles to parking occupancy detection and Intelligent Transportation System (ITS)(Figure 2.9).

Figure 2.9: System of Transportation [20]

Pedestrian detection

Using street cameras, pedestrians and cars are tracked. This type of system is applied in autonomous driving, traffic management, transportation safety and efficiency (Figure 2.10.

Healthcare

With the technological development witnessed by the world, the health care field has become one of the fastest companies in adopting new automation solutions.

Figure 2.10: System of Pedestrian detection[20]

X-Ray analysis

In the context of medical x-ray imaging, scientists have begun to combine this field with the field of computer vision, by establishing systems that work on reconstructing magnetic resonance imaging or planning surgeries and others...(Figure 2.11)

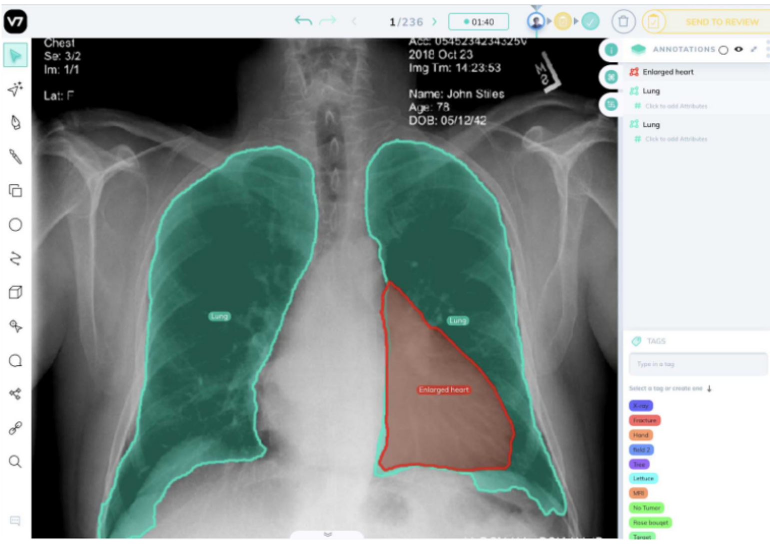

Figure 2.11: X-Ray analysis [20]

Cancer detection

This system allows comparison of cancerous and non-cancerous cells through images, which allows doctors to early detection of some types of cancer, such as breast or skin cancer and others (Figure 2.12).

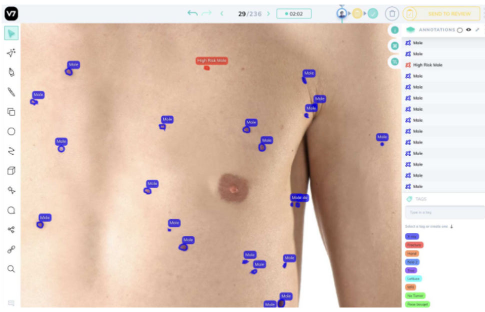

Figure 2.12: System of Cancer detection [20]

Defect inspection

Various companies of a productive nature suffer from the problem of the emergence of some defects in the production line, whether at the total or partial level in the production line. In this regard, a computer vision-based system was established that collects data in real time and takes advantage of it (Figure 2.13).

Figure 2.13: System of Defect inspection [20]

Reading text and barcodes

This type of system is usually used in factories through the feature of converting texts on labels or picture packages into words and then matching these words with the database, This procedure helps identify products that have been mislabeled, provides information about expiration dates ...(Figure 2.14).

Figure 2.14: System of Reading text and barcodes [20]

2.3 Internet of Things (IoT)

2.3.1 Definition

It is difficult to find a comprehensive definition of the Internet of Things due to the tremendous development in this field. This definition can be summarized as a group of intelligent objects connected to each other using the Internet. This property allows them to transfer and share information as well as the automatic organization of data, in addition to The ability to interact and act in various circumstances and the changes that occur[21].(Figure 2.15).

Figure 2.15: Internet of Things (IoT)[21]

2.3.2 Objectives of IoT

The Internet of Things has new goals compared to the traditional technologies [22].

More comprehensive connection

The development witnessed by the Internet of Things has allowed us to expand the interconnection between devices from the computer to the phone, and from smart devices to non-smart devices, which have prominent characteristics, most notably :

1. Expansion of the number of devices, which allows the use of billions of devices in various fields.
2. Expanding the type of devices, communication devices are used with various available energy means.
3. Expansion in the connection mode, i.e. diversifying the connection from a wired network to a wireless network.

More Intensive Information Perception

The difference and diversity of sensors has led to the expansion of the use of these devices by IoT developers, whether the individual use of these devices or models that combine different types, this merger may lead to the emergence of several problems or malfunctions of them :

1. Lack of uniformity due to the diversity of formats in different devices.
2. Incompleteness, which poses a challenge to the Internet of things due to incomplete access to complete information
3. Lack of comprehensiveness due to lack of information
4. Interruptions, network outages often occur for one reason or another
5. Inaccuracy due to the diversity of information and the diversity of methods of obtaining it
6. Inconsistency There is inconsistent information due to distortion of space-time mapping

More Comprehensive Intelligent Service

The Internet of Things enables us to obtain smart services in various fields. With the different problems and obstacles that we face, this is due to the great interdependence between the various devices and their diversity. Examples of these services are transportation services, environmental monitoring services, health, weather and many more.

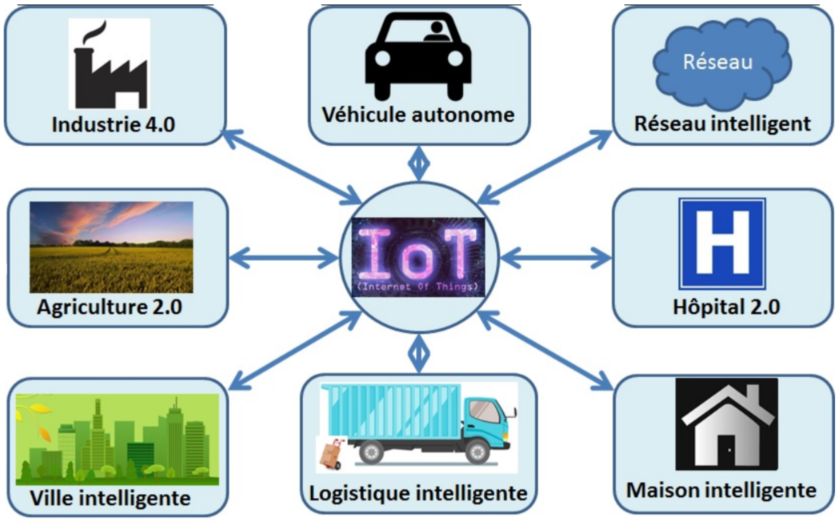

Figure 2.16: Areas of use Internet of Things[22]

What distinguishes the Internet of Things is the hybrid interconnection of devices, which gave it an advantage that distinguishes it from the rest of the networks, and for the flexibility and comprehensiveness of the smart services it provides, and on the other hand, it poses a new challenge such as the highly efficient interconnection of the elements of the large-scale heterogeneous network and others (Figure 2.17showing that).

2.4 Rasepberry pi microcontroller

2.4.1 Description

Developed by the Raspberry Pi Foundation and in collaboration with Broadcom, it is a single-board, or in other words, a series of small computers, a fully functional device in a small, low-cost package. Raspberry Pi can be used to surf the web, play games, start programming and create its own program, previously it was used in schools by learning various basic computer sciences, but later as a result of its use by several people and due to its low cost

Figure 2.17: logo of Raspberry Pi [29]

and open design the model became more popular than expected. In the end, the world began to use it in several areas[23].

2.4.2 Uses of Raspberry Pi

We can use the Raspberry Pi computer for the following[24]:

1. Playing games
2. Browsing the internet
3. Word processing
4. Spreadsheets
5. Editing photos
6. Paying bills online
7. Managing your accounts.
8. make electronic projects or programs

2.4.3 Raspberry Pi ingredients

(This image represents the components of the Raspberry Pi 2.18)

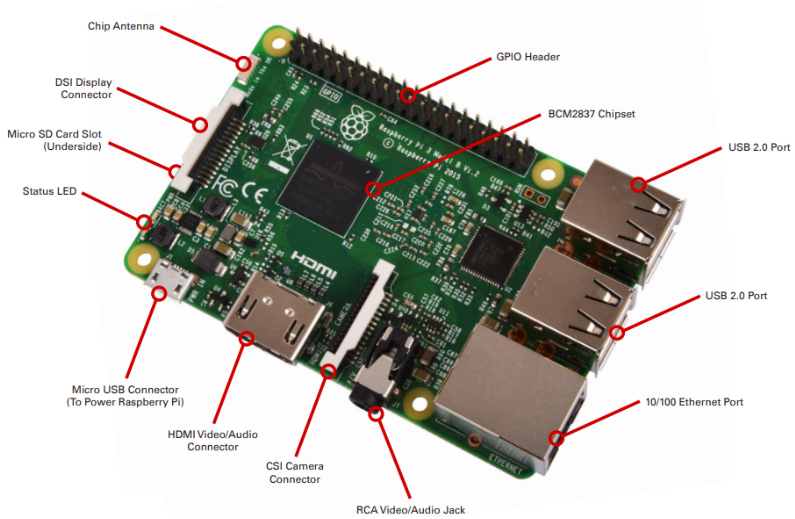

Figure 2.18: Raspberry Pi 3 model B ingredient [24]

2.4.4 Kinds of Raspberry Pi

1. Raspberry Pi Model B [30]: See figure 2.19

   This version of the Raspberry Pi set the baseline for its size for all future Pi devices. However, a couple of things you will notice are quite different compared to the more modern Pi's.

   There are a couple of standout features of this Pi. The first is that the device contained an RCA jack for composite video, allowing you to use the device with old displays.

   Additionally, the device used a full-sized SD card slot and not a MicroSD card slot that has become standardized in future versions.

   This Pi also only sports a single CPU core, so the performance of this device would quickly fall apart when you throw heavy tasks at it.

   The Raspberry Pi 1 Model B did feature a slight change six months after its initial release. The amount of memory included with the device was increased from 256MB to 512MB.

2. Raspberry Pi Model A [30]: See figure 2.20

   Unlike future releases of the Model A, this version was the same form factor as the standard board, just with components removed.

   The Raspberry Pi foundation removed two components from the board to try and reduce the costs of the device. The first of these components is the Ethernet jack. Without using a USB dongle, there is no network connectivity on this board.

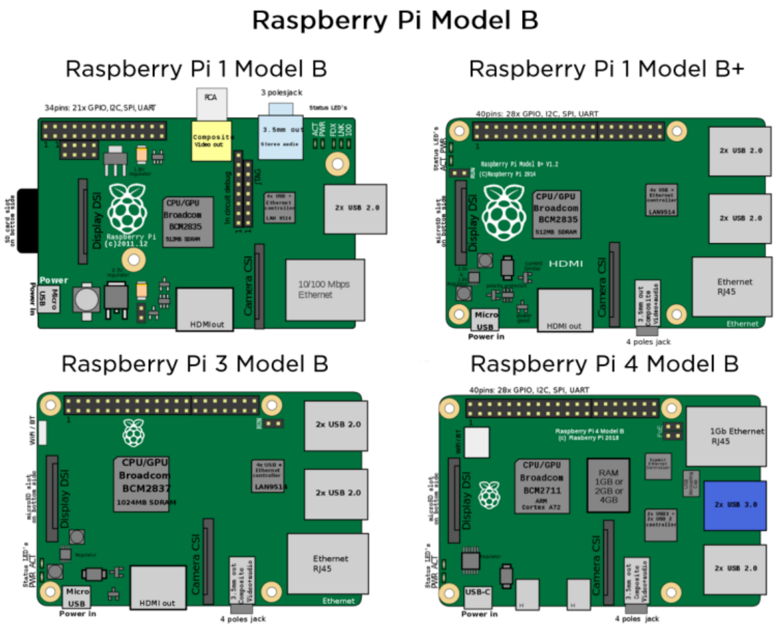

Figure 2.19: Raspberry Pi 3 model B [24]

The second change with this board is the removal of a USB port. Unfortunately, the removal of this port means the Pi 1 Model A only contained a single USB port.

Other than removing these two components, this version of the Raspberry Pi remains precisely the same as the Model B.

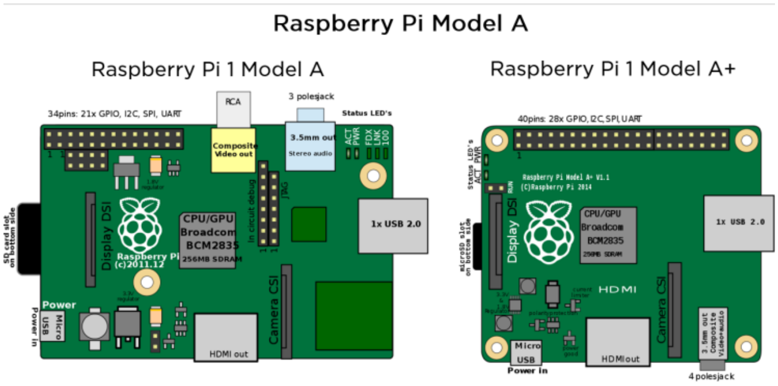

Figure 2.20: Raspberry Pi 3 model A [24]

3. Raspberry Pi Model Zero [30]: See figure

   The Raspberry Pi Zero was one of the biggest surprise releases from the foundation. The reason for this is how tiny this device was when compared to the mainline models.2.21

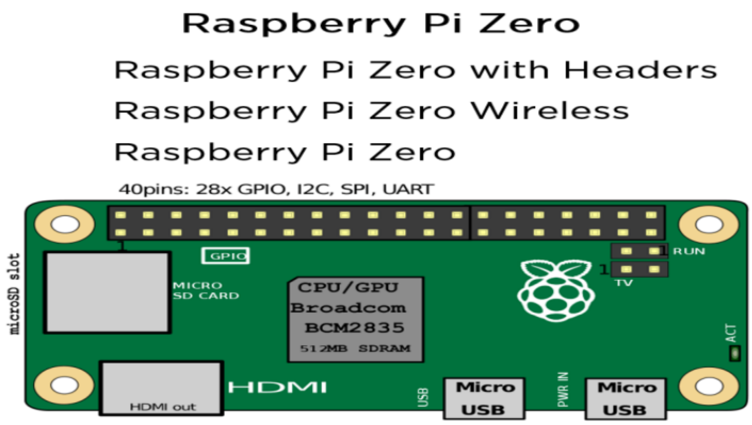

Figure 2.21: Raspberry Pi 3 model Zero [24]

2.5 Patient monitoring - state of the art

2.5.1 Different existing approaches

With the widespread use of systems based on the Internet of things for remote monitoring, and in various fields. It led to the creation of several systems, including car monitoring systems, children monitoring, communication network monitoring, animal monitoring... Among them are also applications in the field of health care to monitor the health status of the patient, as these systems allow the use of medical devices with high efficiency. In this regard, we review some projects for several different cases in the field of health care :

Remote patient monitoring system using only camera

In this system, the camera is used to capture all the vital signs of the patient, from the heartbeat to breathing and others, then these images are transferred to the system, which in turn identifies the information from these images, and then circulates it to doctors and others. In this system, the status of the patient does not matter. The patient only matters vital information[25] (Figure 2.22).

A Remote Patient Monitoring System for Congestive Heart Failure

This system allows the transfer of medical information to the patient through medical devices such as measuring devices for diabetes or blood pressure and others to a database specific to the hospital, then this information is transferred to a website that is browsed through the

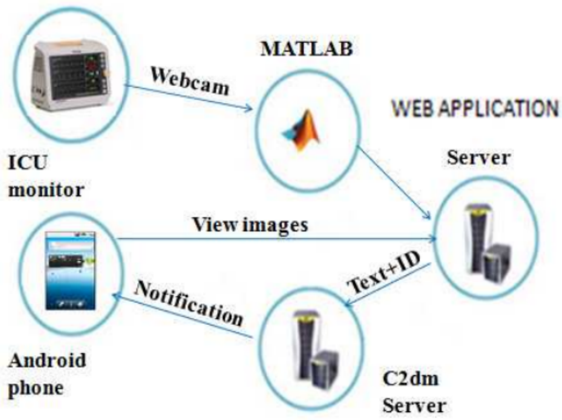

Figure 2.22: Remote system using camera [25]

computers in the hospital or applications in the smartphone[26] (Figure 2.23 represent that system).

Figure 2.23: A Remote Patient Monitoring System for Congestive Heart Failure [26]

A robust and anonymous patient monitoring system using wireless medical sensor networks

This system is one of the latest systems, as it contains the latest technological means in the field of medicine. This system works by implanting sensors inside patients' bodies, in a wireless medical sensor network (WMSN) to sense sensitive patient information, then the information is transmitted to remote medical centers for further processing, by specialists and from all over the world, the information is transmitted in a secure environment to ensure

Do not steal information[27] (Figure 2.24 showing some example).

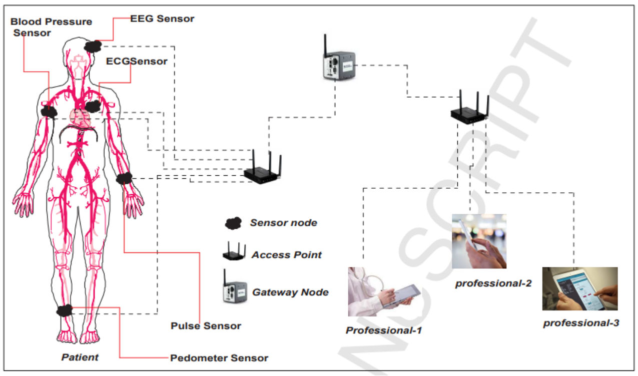

Figure 2.24: The proposed patient monitoring architecture using WMSN[27].

2.5.2 Patient monitoring for Pulmonary disease

In the same field

In a research conducted by the Korean University KAIST in the field of deep learning, on the possibility of identifying cough from the camera, it combined three techniques to increase the rate of cough recognition, which is a digital camera and a special thermal camera that captures particles emitted from the human mouth and compares them with cough particles, in addition to To a device that captures sounds and compares them with coughing sounds, the results of this research, although not highly accurate, resulted in the identification of coughs, whether for people who are still or in a state of movement[28] (Figure 2.25 represent that system).

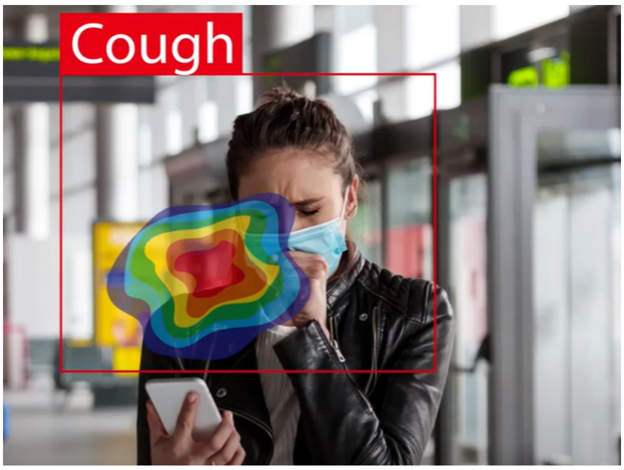

Figure 2.25: Cough detection using camera KAIST University [28].

In this research

In this project of ours, we will create a system that monitors the health status of COPD patients. And predict the risks that can afflict patients.
This system is based on computer vision and the Internet of things, computer vision that allows us to know the patient's position (such as sitting, sleeping, facial expressions, or even gestures for asking for help) using special algorithms, and the Internet of things that allows information to be transferred to our system from various devices such as oxygen meters And blood or pollution measuring devices...
The system obtains information from various devices and then analyzes it, and acts on these results, for example, when the patient is in a critical condition, in this case the system notifies the concerned authorities such as doctors.

2.6 Conclusion

In the end, we say that the development we are witnessing today in the health field (exactly in the field of patient monitoring) or in any other field, is nothing but a product of the previous sciences and the challenges that scientists faced.

CHAPTER 3

Conception

3.1 Introduction

In this chapter, we will review the theoretical part of the project, in other words the general and private structure of the system, starting from the available facial detection and facial recognition algorithms to sensors and medical devices.

3.2 System architecture

In this diagram, we will clarify the stages of the system's work, and address the various algorithms and means available in it, and in the figure 3.1 a detailed diagram of the stages of the system's work.

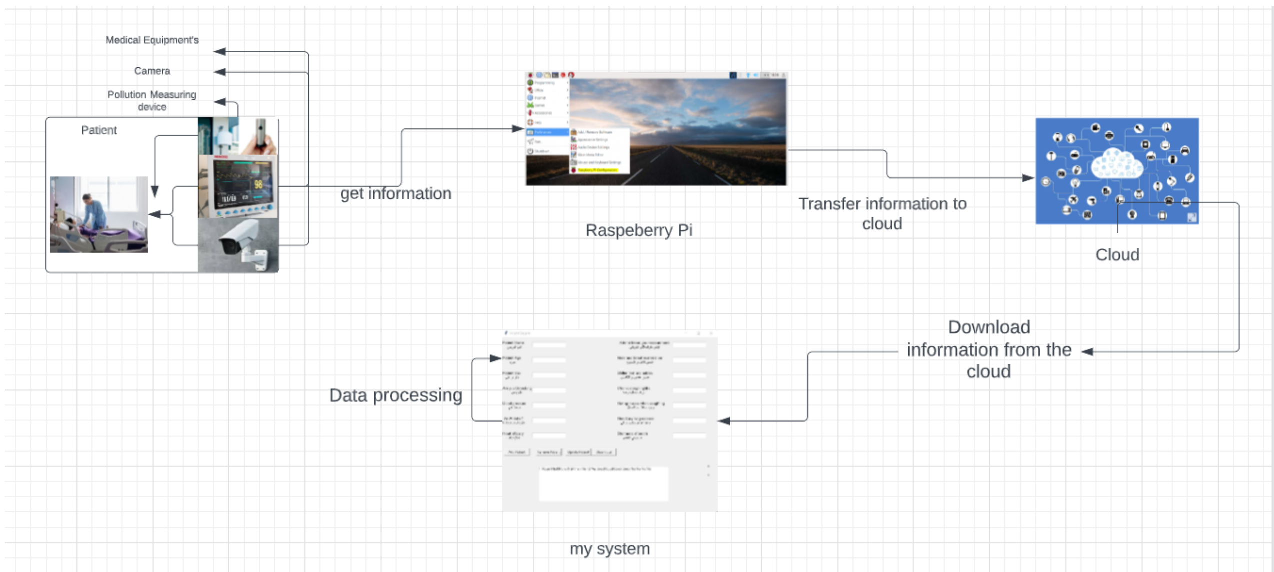

Figure 3.1: System outline.

In general, the system works to identify the patient's health status by processing real-time snapshots, as well as voice and vital information of the patient to predict the possibility of the patient having a severe coughing fit on the one hand and on the one hand being informed of his injury, using the techniques of facial recognition and recognition of facial expressions, supported by an algorithm Recognizing cough through sound, and for more details we address it through the next section.

3.3 System work stages

3.3.1 Patient room to Raspberry pi

The information of the used devices in the patient's room is transferred to the Raspberry Pi, as explained belows.

Camera

Videos of the patient are captured in real time, using a digital camera, and then these videos are transmitted to Raspberry Pi, whether the camera is wirelessly transmitted via Wi-Fi or via cables (Figure **??**.

Figure 3.2: Camera.

Pollution Measuring Device

They are small devices that measure the percentage of pollution in the air, we use them to avoid the patient from falling into a state of suffocation, so that they, in turn, measure the percentage of pollution in the room, and then these results are transmitted in real time to the Raspberry Pi via Wi-Fi, Bluetooth, or others (Figure 3.3).

Medical Equipment's

They are the devices that measure the patient's breathing and pressure, moment by moment. Medical devices can include other devices. The information is transmitted to the Raspberry Pi,

Figure 3.3: Pollution Measuring Device.

using a cable that connects to it, or through Wi-Fi, Bluetooth, or any other available network (Figure 3.4).

Figure 3.4: Medical Equipment's.

3.3.2 Raspberry Pi

We install the Windows operating system, the version for Raspberry Pi, in order to facilitate the possibility of dealing with it, and then we install the special system that deals with the electronic cloud, which is the Windows IOT Core system, this system allows the smooth organization of the channels that transmit information to and from the Raspberry, and from Then through the wireless connection, we connect to the camera installed on the wall, as well as the air pollution measuring device on the one hand, and on the other hand, using a wired connection we connect to an oxygen meter, all the information is collected in real time in the Raspberry Pi to be transmitted over the network to the cloud (Figure 3.5).

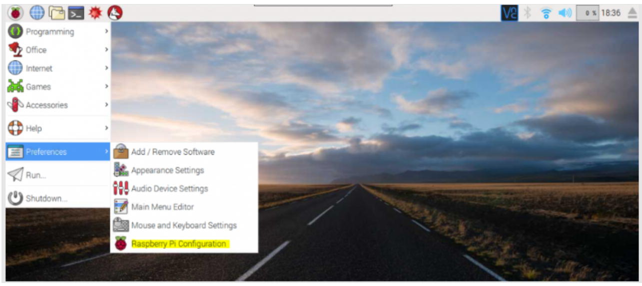

Figure 3.5: System's Raspberry Pi (windows).

Cloud Computing Services

Cloud computing : is an infrastructure in which servers and computers are used for remote storage, enabling users to access information through a secure connection to the Internet, and with any device possible, such as smart phones, computers, or others. The electronic cloud connects several devices and their diversity (Figure 3.6).

Figure 3.6: Cloud Computing Services.

In it, possible information about the patient (images and real-time oxygen level) and patient room (room air purity) are collected from the Raspberry Pi to the cloud to be transmitted to the system.

3.3.3 Cloud Computing

In which the information is kept, or in other words, the information that was collected in the Raspberry Pi is saved to be transferred and used in the system. The cloud acts as a mediator for the system to avoid the loss of information in the event of damage or theft of information, in addition to the large volume of information that is dealt with.

3.3.4 The Coughing monitoring system through facial expression

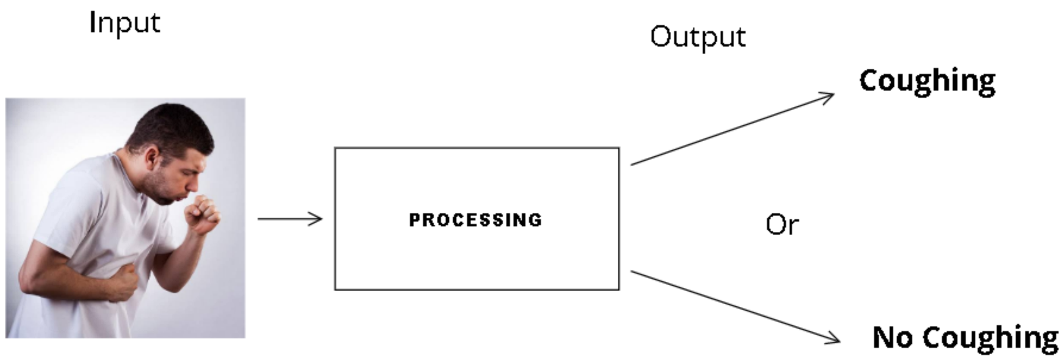

Figure 3.7: Detecting cough.

The first picture shows the inputs and outputs of the cough recognition system3.7 The cough monitoring system through facial expressions is a computer vision-based system. The system initially contains a list of patients who have been cared for before, and information about them, such as name, age, results of some tests for the patient, the possibility of the presence of hereditary lung diseases and others, All this information saved in the database gives the doctor an overview of the patient, and on the other hand helps the system to predict the possibility of the patient suffering from severe coughing or chest pain, because this information represents the main causes of infection, and it also allows the possibility of changing this information due to the change in the health status to the patient.
For new patients, we enter the patient's medical information, in this case the system automatically connects to the cloud, to start the process of monitoring the patient, through facial expression recognition technology, which is a technology that allows extracting some cases and behaviors of a person because the human face is the most complex and diverse of all animals. Using our face alone, we can communicate a wealth of information to others, based on this identification, we have created an algorithm that allows us to recognize a cough from several snapshots of a patient in real time. for sound.

After knowing the results of the two algorithms, all the results are collected in real time, from the patient's oxygen percentage as well as the percentage of pollution in the room, and then compared with the results. The information is also shown through graphic curves for

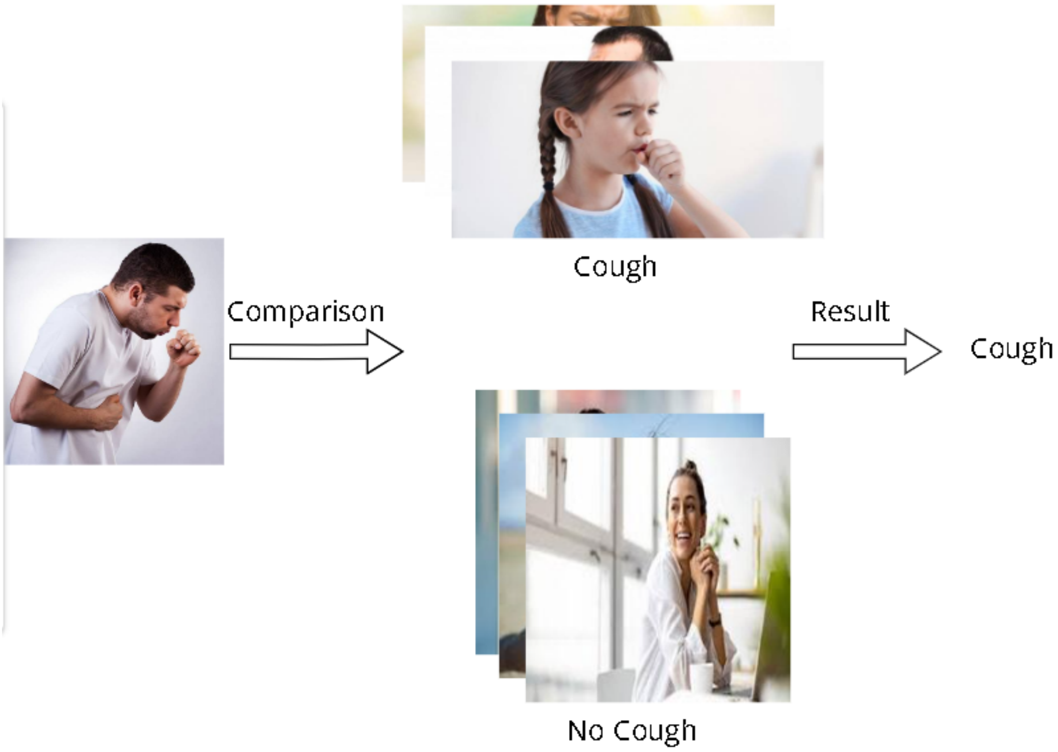

Figure 3.8: The result of cough detection.

each information, for example in the case of the patient having a persistent coughing fit and the pollution index is high, the hospital is informed of the existence of a defect in ventilation and others, after the patient is finished.

The second image shows the data through which the comparison is made3.8

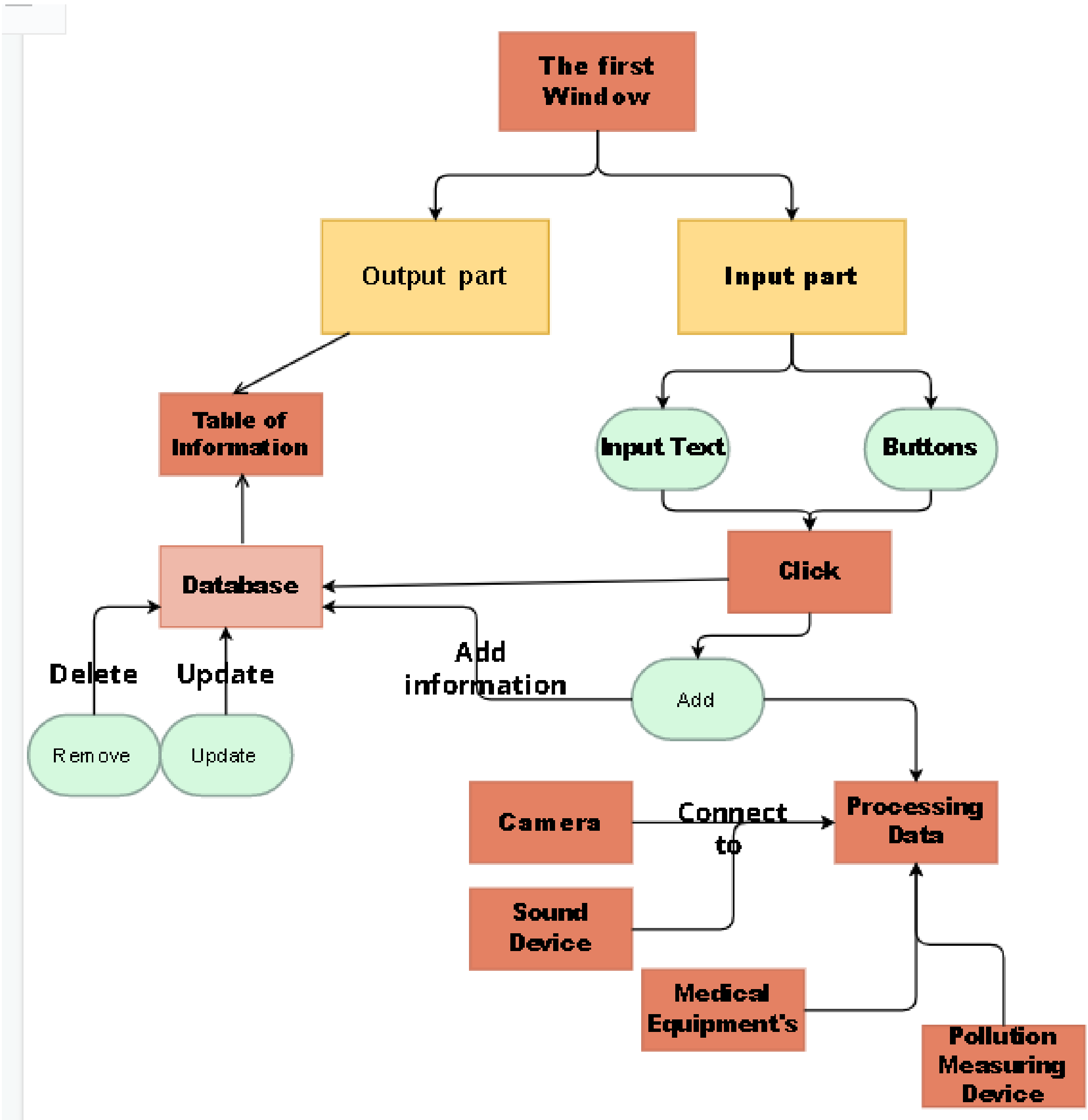

Figure 3.9: Flipchart.

A general scheme that explains the stages of the system's operation (Figure 3.9).

3.4 Conclusion

This chapter represents the theoretical part of the system, that is, the scheme on which the project is built, in addition to the stages of the system's work and the means used in it.

CHAPTER 4

Implementation and results

4.1 Introduction

This chapter represents the obtained results of our proposed system used to monitor patient.

4.2 The means used

4.2.1 Programming language and Library

Python

Python is a high-level, interpreted, general-purpose programming language,It is dynamically-typed and garbage-collected. It supports multiple programming paradigms, including structured (particularly procedural), object-oriented and functional programming. It is often described as a "batteries included" language due to its comprehensive standard library[31] (Figure 4.1).

Figure 4.1: Python logo.

Opencv

The open source software library for computer vision, which aims mainly to develop computer vision, was created by Intel Corporation, and it is a free library that can be used on all systems, and it focuses mainly on image processing in real time [32](Figure 4.2).

Figure 4.2: OpenCV logo.

Numpy

Numpy is the fundamental package for scientific computing in Python. It is a Python library that provides a multidimensional array object, various derived objects (such as masked arrays and matrices), and an assortment of routines for fast operations on arrays, including mathematical, logical, shape manipulation, sorting, selecting, I/O, discrete Fourier transforms, basic linear algebra, basic statistical operations, random simulation and much more [33] (Figure 4.3).

Figure 4.3: Numpy logo.

TensorFlow

It is an open source software library, often used in deep learning algorithms, and artificial neural network. It is a flexible language that can be used in several programming languages, such as JavaScript, C++, and even Python[34] (Figure 4.4).

Figure 4.4: TensorFlow logo.

Matplotlib

Matplotlib is a plotting library for the Python programming language and its numerical mathematics extension NumPy. It provides an object-oriented API for embedding plots into applications using general-purpose GUI toolkits like Tkinter, wxPython, Qt, or GTK. There is also a procedural ”pylab” interface based on a state machine[35] (like OpenGL)(Figure 4.5),

Figure 4.5: Matplotlib library logo.

Librosa

Librosa is a Python toolkit for analyzing and processing audio and music. Some common functions such as time frequency processing, feature extraction, and audio graphics drawing are available, and the functions are very powerful[36] (Figure 4.6).

Tkinter

The tkinter package (”Tk interface”) is the standard Python interface to the Tcl/Tk GUI toolkit. Both Tk and tkinter are available on most Unix platforms, including macOS, as well as on Windows systems[37] (Figure 4.7).

Figure 4.6: Librosa logo.

Figure 4.7: Tkinter logo.

Pandas

Pandas is a Python package that provides fast, flexible, and expressive data structures designed to make working with ”relational” or ”labeled” data both easy and intuitive. It aims to be the fundamental high-level building block for doing practical, real world data analysis in Python. Additionally, it has the broader goal of becoming the most powerful and flexible open source data analysis / manipulation tool available in any language. It is already well on its way towards this goal [38](Figure 4.8).

Figure 4.8: Pandas library logo.

PySQLite

The PySQLite provides a standardized Python DBI API 2.0 compliant interface to the SQLite database. If your application needs to support not only the SQLite database but also other databases such as MySQL, PostgreSQL, and Oracle, the PySQLite is a good choice[39].

PySQLite is a part of the Python standard library since Python version 2.5 (Figure 4.9).

Figure 4.9: PySQLite library logo.

4.2.2 working platform

Pycharm

Pycharm is an integrated development environment used in computer programming, especially programming in the Python language. Produced by the Czech company JetBrains, the software provides code analysis, a graphical error detector, a built-in unit test tool, integration with audit control systems, support for Django web development and work on Anaconda data science applications[40] (Figure 4.10).

Figure 4.10: Pycharm logo.

4.2.3 Techniques and methods

Deep Learning

Deep learning is part of artificial intelligence, more precisely, a branch of machine learning, and basically a neural network consisting of three layers, aimed at simulating human behavior or some of its behaviors, albeit almost impossible, and through learning from large amounts From the information, he can predict some things (Figure 4.11).

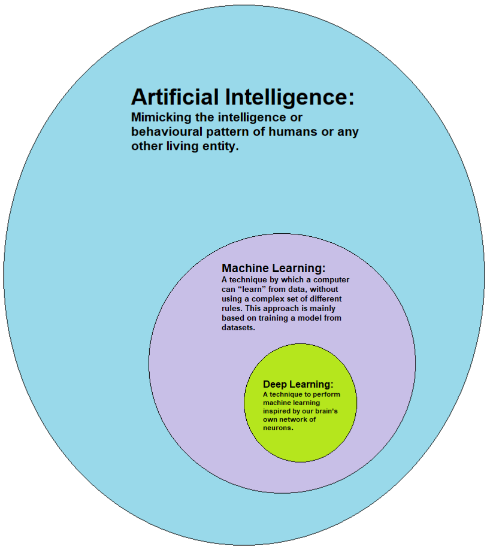

Figure 4.11: Deep learning.

4.3 Results

Our proposed system processes data from video, audio, and vital signs of the patient in real time, as well as some room-specific data such as measuring the level of pollution (Figure 4.12).
The first image represents the first window of the system or the main interface, which contains two sections. The first section is represented by a set of explanatory texts next to it, the input boxes that allow entering the patient's medical information as well as modifying it, in addition to the four buttons responsible for commands, while the second section contains a table patients and their information(Figure 4.12).

After the doctor fills in the patient's information, and click on Add a patient, all data is

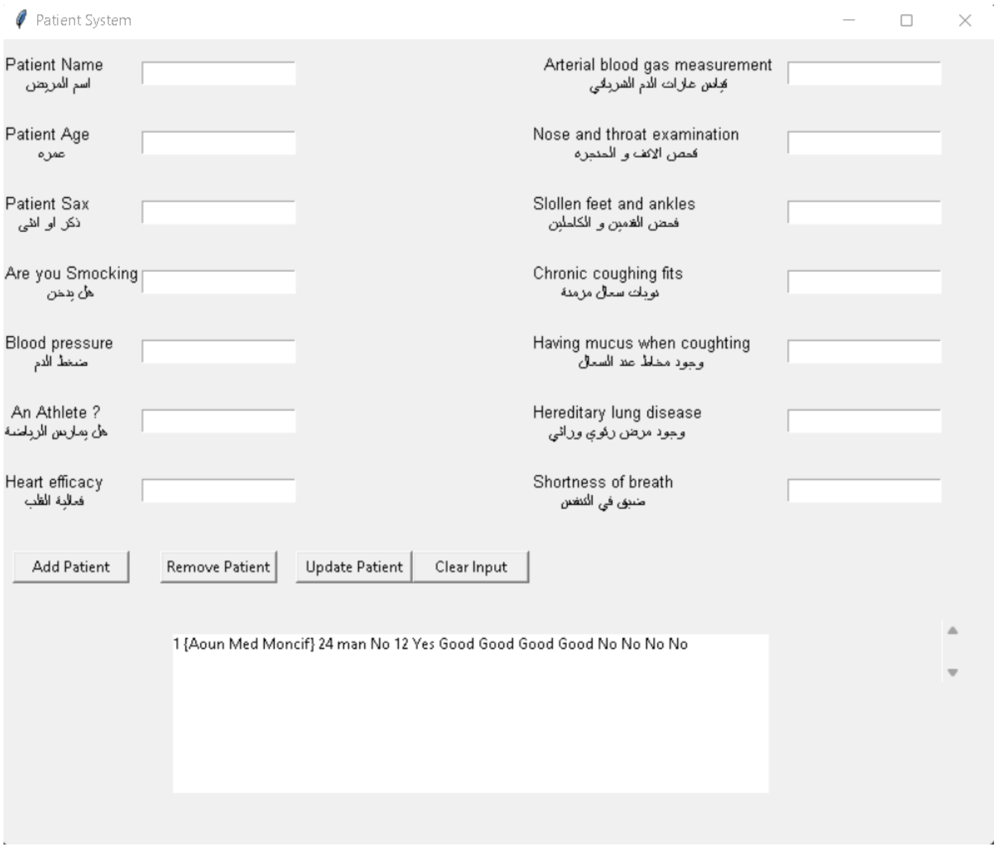

Figure 4.12: The first window in the system.

verified. After that, this information is automatically saved into the database, which contains 15 tables.

After saving the patient's information in the database, the system now begins the process of data processing, through the camera, the patient is monitored in real time, so that it processes the snapshots to extract the important information, and in our case the patient's face (face identification), then using deep learning techniques, The patient's condition is identified by classifying the face into two parts, the first section or the first classification, which is coughing, while the second classification is the normal condition (classification). pollution measurement (Figure 4.13).

On the other hand, the sound is processed in real time using deep learning techniques, to separate coughing from other sounds, where the sound of coughing differs from the sound of speech. Streamlined , the deep learning algorithm compares the patient's voice with several other cough sounds (by counting the number of gradations of cough during the duration of the cough) and counts the number of gradations that exceed the threshold in real time for the patient, if the results do not match, the sound is no longer a cough , All this to increase the

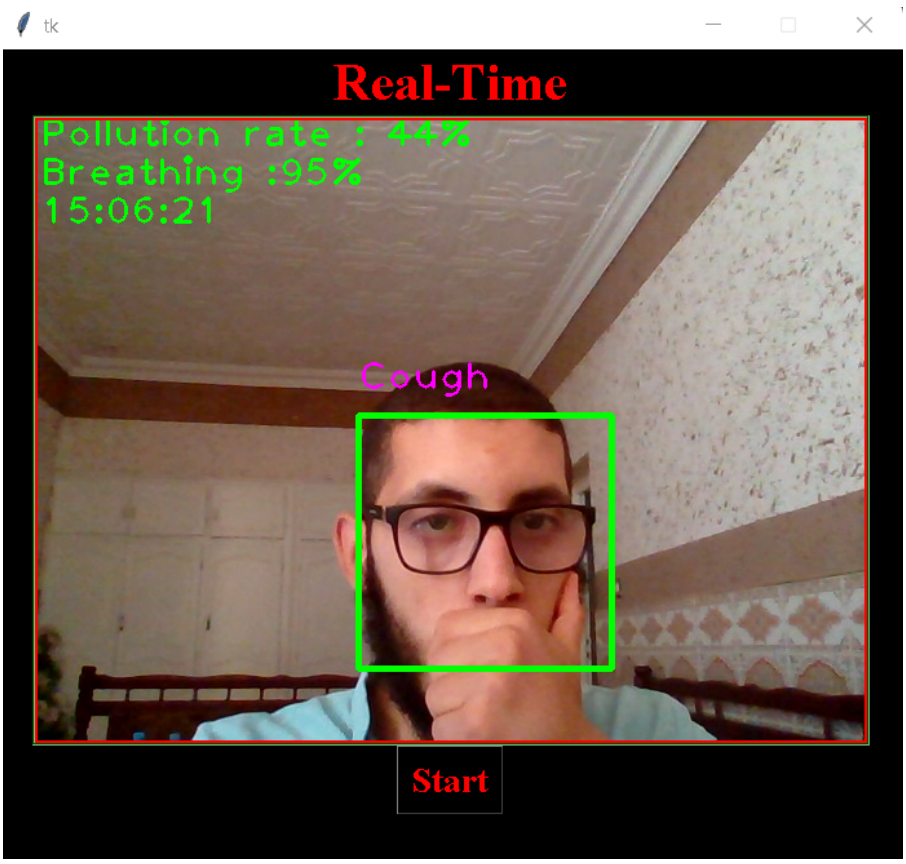

Figure 4.13: The second window in the system.

percentage of certainty that the patient has a cough (Figures 4.14 and 4.15).

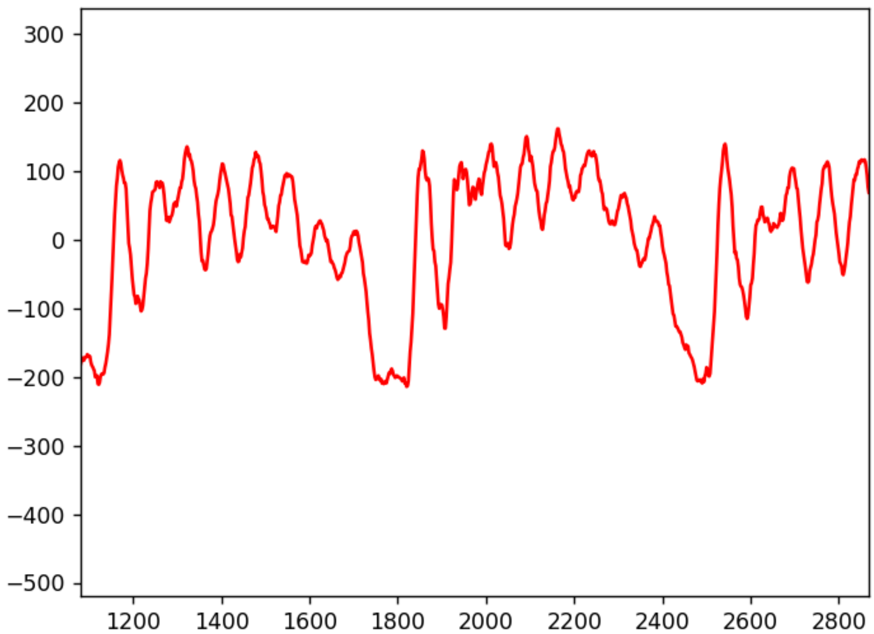

Figure 4.14: Speech sound.

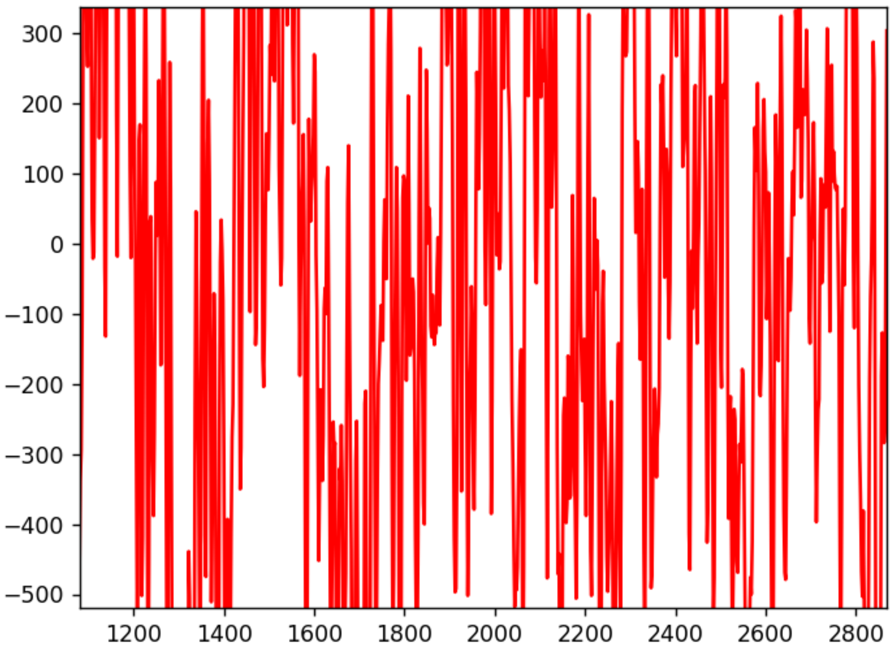

Figure 4.15: Coughing sound.

After the data processing is completed, the patient's health status is identified, and based on this result, the system can predict the reasons that led to this result, based on prior knowledge of the reasons that affect the health of respiratory patients, which were mentioned in the first chapter. For example, the effect of smoke or Dust increases the severity of the disease, which indicates a problem with the ventilation device in the room and others .

1. Coughing with high pollution (Figure 4.16)

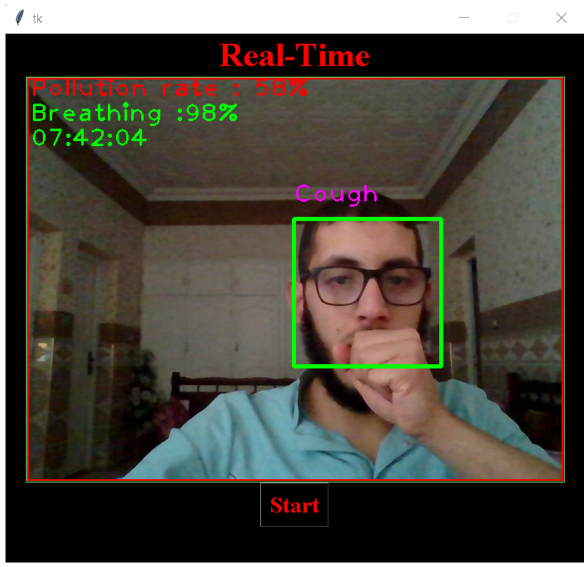

Figure 4.16: Case 1.

2. Oxygen drops to a medium state (Figure 4.17)

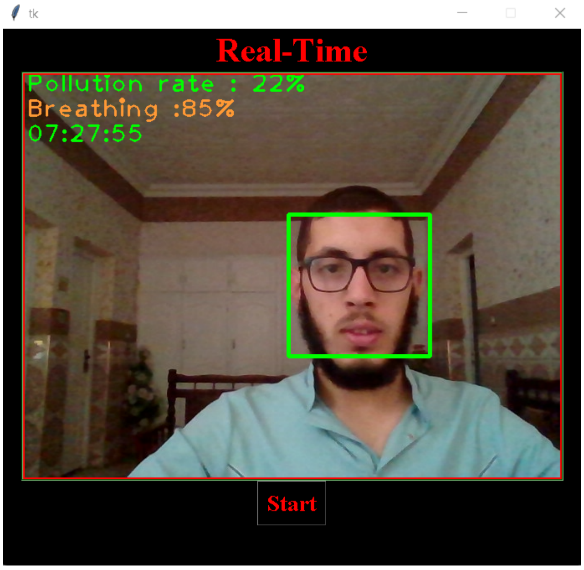

Figure 4.17: Case 2.

3. Oxygen reduced to critical state (Figure 4.18)

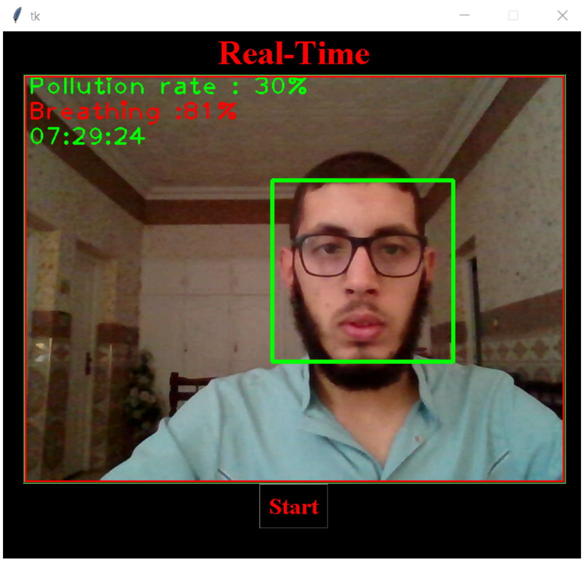

Figure 4.18: Case 3.

4. The patient is in normal condition (Figure 4.19)

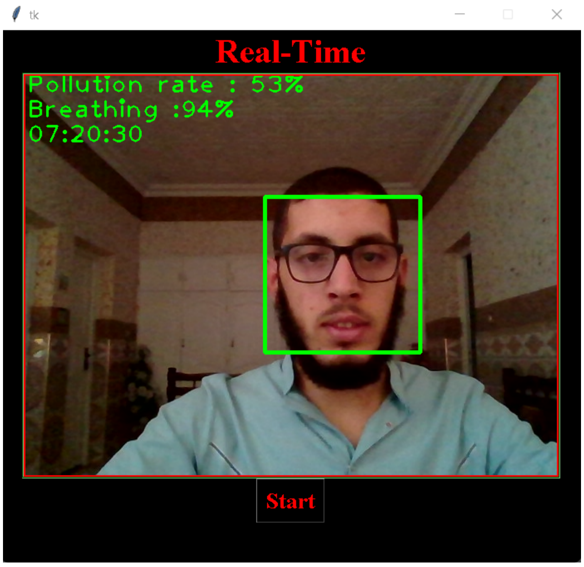

Figure 4.19: Case 4.

4.4 Conclusion

At the conclusion of this chapter, we have completed the practical part of the work, in which we touched on the tools and means that allowed us to carry out the work, and we also touched on how the patient monitoring system works and the desired results from it.

General conclusion

In conclusion, we say that this work was accomplished with the aim of monitoring the patient through video and audio processing in real time, that is, checking the presence of cough or not, using some vital information of the patient such as an oxygen meter, as well as measuring the level of contamination.

At the end of this work, we came up with a system that allows us to differentiate between a patient who is coughing and a patient in the normal situation, by analyzing the video on the one hand and analyzing the sound on the other hand, and then comparing the results with the reasons that lead to the deterioration of the patient's health.

Although the system knows the patient's cough or not, and the possibility of his health deteriorating, but these results are inaccurate (due to the lack of deep learning data), which leads to wrong prediction of the results. He overlooks the fact that there are other cases that he cannot analyze and many more.

In the future inshalah, we will increase the accuracy of the system's work in order to avoid medical errors, by increasing the efficiency of the work of the deep learning algorithm. We will also connect several devices through Raspberry Pi and transfer information to the cloud to facilitate the process of dealing with it as well as storing it, in addition to the in-depth study of various cases. Medical through consulting a doctor specializing in the field of chronic lung diseases, to enable the system to be able to accurately predict the health status of the patient, and inform the competent authorities.

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