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Smart Bracelet to Monitor Hospital Patients

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Declaration of Authorship

I, SAOUDI Mohamed Nafae, declare that this thesis titled, Smart Bracelet to Monitor Hospital Patients and the work presented in it are my own. I confirm that:

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- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
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Signed: SAOUDI Mohamed Nafae

Date: 22-06-2023

Knowledge is my capital, reason is my religion's root, longing is my mount, remembrance of God is my companion, trust is my treasure, knowledge is my weapon, patience is my mantle, contentment is my booty, poverty is my honor, asceticism is my profession, honesty is my intercessor, obedience is my love, jihad is my morality and the joy of my eye.

Ali bin Abi Talib

Abstract

Smart Bracelet to Monitor Hospital Patients

by SAOUDI Mohamed Nafae

The development of information technology has led to the emergence of smart healthcare as a promising research field. Where providing health data and accurate location in real time is one of the most important challenges. This research focuses on creating a smart bracelet based on Internet of Things technologies. This latter responsible of collecting data from patients inside a hospital then forward it to a server. While the collected data is exploited to create a machine learning model for predict patients recovering or death within the next 28 days. In this study, we aim at two important items, the first is to include a new technology in constructing this bracelet, which enables us to track the patient's current location with high accuracy on 3D axes (i.e., Latitude, longitude, altitude), and the second is to predicting patient recovering or death efficiency and with high accuracy using machine learning algorithms. To evaluate the the performance of machine learning models in predicting patient mortality or recovering, a comparative analysis is performed, which demonstrates the potential of smart bracelets and machine learning technologies in providing valuable insights to healthcare professionals and improving patient outcomes. The realization of this project is supported by mobile and desktop applications to ensure ease and simplicity of use. Overall, this research contributes to the field of smart healthcare by demonstrating the effects of enhancing patient monitoring and facilitating timely interventions to improve patient care and reduce mortality rates.

Keywords: Internet of Things (IoT), Internet of Medical Things (IoMT), Smart Medical Bracelet (SMB), Artificial Intelligence (AI)

تَــــــلْـخِـيــــص

Smart Bracelet to Monitor Hospital Patients

من طرف الطالب:سعودي محمد نافع

أدى تطور تكنولوجيا المعلومات إلى ظهور الرعاية الصـــحية الذكية كمجال بحثي واعد. حيث يعتبر توفير البيانات الصـــحية والموقع الدقيق في الوقت الحقيقي من أهم التحديات. يركز هذا البحث على إنشاء سوار ذكي يعتمد على تقنيات إنترنت الأشياء. هذا الأخير مســؤول عن جمع البيانات من المرضـــى داخل المســتشــفى ثم إعادة توجيهها إلى الخادم. بينما يتم اســـتغلال البيانات التي تم جمعها لإنشـــاء نموذج تعلم آلي للتنبؤ بتعافي المرضـــى أو وفاتهم خلال الـــــ 28 يومًا القادمة. في هذه الدراسـة ، نهدف إلى عنصـرين مهمين ، الأول هو تضـــمين تقنية جديدة في بناء هذا الســوار ، والذي يمكننا من تتبع موقع المريض الحالي بدقة عالية على محاور ثلاثية الأبعاد (أي خط العرض وخط الطول والارتفاع) ، والثاني هو التنبؤ بكفاءة تعافي المريض أو الوفاة وبدقة عالية باســـتخدام خوارزميات التعلم الآلي. لتقييم أداء نماذج التعلم الآلي في التنبؤ بوفيات المرضى أو التعافي ، يتم إجراء تحليل مقارن يوضـــح إمكانات الأســـاور الذكية وتقنيات التعلم الآلي في توفير رؤى قيمة لأخصـــائي الرعاية الصـــحية وتحســـين نتائج المرضـــى. يتم دعم تحقيق هذا المشــروع من خلال تطبيقات الهاتف المحمول وســطح المكتب لضــمان ســهولة وبســاطة الاستخدام. بشكل عام ، يساهم هذا البحث في مجال الرعاية الصحية الذكية من خلال إظهار آثار تعزيز مراقبة المرضى وتسهيل التدخلات في الوقت المناسب لتحسين رعاية المرضى وتقليل معدلات الوفيات.

Résumé

Le développement des technologies de l'information a conduit à l'émergence des soins de santé intelligents en tant que domaine de recherche prometteur. Où fournir des données de santé et une localisation précise en temps réel est l'un des défis les plus importants. Cette recherche porte sur la création et le développement d'un bracelet intelligent basé sur les technologies de l'Internet des objets. Ce dernier est chargé de collecter les données des patients à l'intérieur d'un hôpital puis de les transmettre à un serveur. Alors que les données collectées sont exploitées pour créer un modèle Machine Learning permettant de prédire la réponse au traitement ou la mort des patients dans les 28 prochains jours. Dans cette étude, nous visons deux éléments importants, le premier est d'inclure une nouvelle technologie dans la construction de ce bracelet, qui nous permet de suivre l'emplacement actuel du patient avec une grande précision sur des axes 3D (c'est-à-dire la latitude, la longitude, l'altitude), et la seconde consiste à prédire l'efficacité de la récupération ou de la mort des patients et avec une grande précision à l'aide d'algorithmes d'apprentissage automatique. Pour évaluer les performances des modèles d'apprentissage automatique dans la prédiction de la mortalité ou de la convalescence des patients, une analyse comparative est effectuée, qui démontre le potentiel des bracelets intelligents et des technologies de Machine Learning pour fournir des informations précieuses aux professionnels de la santé et améliorer les résultats pour les patients. La réalisation de ce projet est soutenue par des applications mobiles et de bureau pour assurer la facilité et la simplicité d'utilisation. Dans l'ensemble, cette recherche contribue au domaine des soins de santé intelligents en démontrant les effets de l'amélioration de la surveillance des patients et en facilitant les interventions en temps opportun pour améliorer les soins aux patients et réduire les taux de mortalité.

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اهداء

اتقدم بهذا العمل المتواضع الى

والديا الاعزاء حفضهما الله و رعاهما تقديرا و عرفانا لتربيتهما و مساعدتهما الدائمة و تشجيعهما لي خلال حياتي و مسيرتي الدراسية

و الى اخي الغالي مهدي حفظه الله

و اختي الصغيرة لبنى رعاها الله

و الى استاذتي الغالية وافية

و استاذتي المشرفة يسرى بن عيسى

و الى ابن خالتي محمد

و الى أصدقائي

"حسام و نزار و مهدي و لقمان....."

و الى عائلتي الثانية نادي مكارم بسكرة لكرة السلة .

و بدون نسيان اقربائي و كل من ساعدني ومن اكن لهم الاحترام و التقدير.

نافع

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General Introduction

General Context

Internet of Things (IoT) can be defined as a world of interconnected things that are capable of sensing, actuating, and communicating among themselves and with the environment (i.e., smart things or smart objects). In addition, IoT provides the ability to share information and autonomously respond to real/physical world events by triggering processes and creating services with or without direct human intervention [9]. Thus, IoT is defined as a network between devices or things through any internet connection method (wire, wireless, WiFi, GPRS, 3G, etc.). IoT applications grow in many applications like transportation, medical, shopping, smart home, smart cities etc [10]. A new positive vision for the healthcare sector is established by "Health 4.0." Innovative technologies, like the Internet of Health Things (IoHT), medical Cyber-Physical Systems (medical CPS), health cloud, health fog, big data analytic, sensors, and intelligent algorithms, are effectively combined and used [11]. The objective of Health 4.0 is to provide patients with valuable and accessible healthcare services for boosting the efficacy and efficiency of the healthcare sector. Health 4.0 modifies the healthcare business model to improve communication between healthcare customers (the patients), stakeholders, and infrastructure [12]. Health 4.0 is an adaptation of Industry 4.0 ideas [13]. Which would successfully raise patient happiness, lower mortality rates, increase average life expectancy, and improve the quality, flexibility, productivity, cost-effectiveness, and dependability of healthcare services [14]. Generally, this healthcare system is built on two pillars: Physical components (Patient, Smart Bracelet) and virtual components (Database, Treatment and Monitoring System, and other Self-contained Systems). For this context, several devices need to be connected, and a huge amount of data will be generated. One of the most challenging tasks is how we choice the right sensors and devices? how much time these devices takes for collecting data set? what is the accuracy of this data? How much energy these devices consume to collect and transmit this data? how to display it? and what can we do with the collected data? At the same time, real-time collecting and controlling data is very useful for patient remote follow-up and first aid. Also, it is very important for detecting diseases that the patient may encounter in the future. Moreover, the diagnosis with the help of the Internet of Things and artificial intelligence has advantages that improve the health care industry in several ways.

Depending on the desired problem, data collection and hardware combination techniques are used for various purposes such as: maximum data acquisition, maximum accuracy, synchronization, low power, and alerts. The most common criticisms for choosing the most appropriate technologies and devices are: for the first stage, determine the domain and location of the problem itself (its objectives and consequences). For the second step, define how to collect, transmit, and store the data. While the third step is how to displayed and exploited the data?.

Problem Statement

The development of a smart bracelet capable of monitoring and tracking patients, combined with machine learning-based health status assessment, 3D location tracking, and the creation of mobile and desktop applications, holds great potential for revolutionizing healthcare. By integrating advanced technologies, this innovative solution aims to enhance patient care by providing real-time health data, accurate health status predictions, precise location information, and user-friendly monitoring applications. However, several challenges need to be addressed to ensure the successful implementation and usability of such a comprehensive system.

One critical challenge in patient monitoring is accurately assessing health status. Traditional methods often rely on subjective observations or periodic check-ups, which may not capture subtle changes in a patient's condition in a timely manner. By incorporating machine learning models, the smart bracelet can analyze various health parameters and provide real-time assessments, enabling early detection of deteriorating health conditions and prompt intervention.

Another problem to address is the precise tracking of patients' 3D location. In healthcare settings, knowing the exact location of a patient can be crucial for emergency response, efficient care coordination, and preventing wandering in cases involving elderly or mentally impaired patients. The smart bracelet should leverage location-tracking technologies, such as GPS or indoor positioning systems, to ensure accurate and reliable real-time location data.

Furthermore, the development of user-friendly mobile and desktop applications for monitoring and tracking is essential. These applications should provide intuitive interfaces, seamless data synchronization, and comprehensive visualization of the collected health and location data. Ensuring compatibility across different platforms and user-friendly features will facilitate the adoption and engagement of both healthcare professionals and patients.

Moreover, data security and privacy must be prioritized throughout the entire system. As sensitive health information is transmitted and stored, robust security measures should be implemented to protect against unauthorized access and data breaches.

Contributions

To overcome the above problems, we have proposed several contributions to this letter:

- The first proposed contribution(Bracelet): Developing a technological component represented by a bracelet that uses Internet of Things (IoT) technology. This bracelet is designed to sense a maximum number of a patient's vital signs and current location on 3D axes, while addressing issues with cost, size, accuracy, and availability. Through the use of IoT technology, the bracelet can be connected wirelessly to various storage and processing devices capable of transmitting vital signs and location data in real time. This allows for continuous monitoring of a patient's vital signs, which can help detect any abnormalities or changes that may require medical attention. It is important to collect accurate readings to ensure proper diagnosis and treatment for the patient.

- The second proposed contribution(Communication/Applications): This combined contribution proposes a comprehensive system for monitoring patient vital signs and location in real-time. It incorporates the use of communication technologies like Bluetooth, Wi-Fi, or cellular networks to transfer data from a wearable bracelet to servers for processing and storage. Advanced algorithms and machine learning techniques are employed to analyze the data and identify abnormalities or patterns. Two tools are developed: one for computers, allowing medical professionals to monitor the patient's location and vital signs, and one for smartphones, enabling remote monitoring by family members or caregivers. These tools provide real-time data and notifications, facilitating prompt action when needed. Overall, this system integrates communication, data processing, storage, and user-friendly applications for effective monitoring of patients.

- The proposed Third contribution(machine learning model): Aims to exploit artificial intelligence models with the help of a computer that can classify the patient's desire into two categories, the first is the improvement of the patient's condition, and the second is the expectation of his death within a period of 28 days from a data set that includes clinical data from the MiMIC II database, all data related to patient care collected from the care unit concentrated in the United States. Three main tasks are proposed and implemented.

Task 1 is to improve data quality by solving the unbalanced category and missing values problem.

Task 2 is to exploit genetic algorithm and random forest algorithm as feature extractor using machine learning.

Task 3 relates to the development of automatic identification of patient status using and training of machine learning tools.

The results of the experiments will shed light on the impact of choosing one model over another in order to be adopted in the future in prediction processes.

Thesis Structure

The rest of this thesis is organized as follows:

Chapter 1 presents the basic concepts related to this dissertation such as: Internet of Things, AI, patient vital signs, and the recent related work to healthcare 4.0.

Chapter 2 starts by giving an overview of the principles of artificial intelligence and its relationship with the environment and nature of work with its models and types. After that, this chapter provides details and comparisons about the architecture of the sensors and devices used in the proposed smart bracelets and data collection.

Chapter 3 focuses on designing the general structure of system flow, diagrams and scenarios that explain the basic elements and their role in the integration and harmony of the system, whether it is hardware, human or software, where it starts from how to sense then pass through transmission, storage and processing.

Chapter 4 starts with an overview of the advantages of the software and mobile application, then we give details about the platforms and services used, implementation and some algorithms in this prototype. It presents the experimental analysis and the proposed system. Also, presents a study in real special place with real data, takes some of marks, observation, giving captures of materials, and program.

Chapter 5 Concludes the whole thesis by giving an overview of the problems treated, the suggested solutions. Also, we discuss the achieved results and then, we finalize with prescriptive and future work and limits.

Chapter 1

IoMT in Healthcare: Preliminaries and Basic Concepts

1.1 Introduction

This chapter presents the main concepts and domains related to this thesis, such as the Internet of Things (IoT) and its different categories (Sec. 1.2), the Internet of Medical Things (IoMT) and its different structure (Sec. 1.3). Also, a hospitalized patient chronic disease and their related concepts are introduced in Section 1.4. Moreover, A localization on 3D plan (on different axis (X, Y, Z)), a bio-marks patient, statistics, and advantages of using computer in medical domain are presented in Sections 5,6, and 7. At the end of this chapter, we provide an overview of the effect of assisting inpatients.

1.2 Internet of Things

The Internet of Things (IoT) has adjusted how data are used to be collected and expanded the vision of the Internet further. The IoT becomes a huge source of information by moving beyond connected computers within the internet to include every object that is able to receive or transfer digital data . [10]

IoT is defined as" things with identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts" or" interconnected objects playing an active role in what could be called the Future Internet" by the European Commission Information Society . [15] The "things" in the Internet of Things (IoT) can range from a smartwatch to a cruise control system equipped with sensors (such as position, switches to turn on/off other devices (TV), and so forth) (e.g. temperature, light, motion, location, etc.). Therefore, The communication medium (Bluetooth, RFID, 4G, etc.), which facilitates communication with other machines or humans, and the computer resources are the other elements of the IoT ecosystem . [11]

Moreover, low price and accuracy may significantly improve the decision-making abilities of IoT customers [16]. Due to the broad deployment of IoT technology, enterprises may now improve work processes and increase productivity by collecting and reporting environmental data. Prior research indicates that IoT will be the next significant destination for investment by a range of enterprises and startups [4].

As an IoT opportunities, the healthcare environment will soon be revolutionized, which will be useful in hospital tele-monitoring and more crucially at home. Remote patient monitoring offers huge promise for not only increasing healthcare quality but also reducing healthcare costs by recognizing and preventing a change of patient state, bio-marks , and potentially harmful situations [17].

Our healthcare services are now more expensive than ever, and the majority of patients are required to stay in the hospital for the course of their treatment. These issues can be overcome by utilizing technologies that allow patients to be monitored remotely [18]. By collecting and transmitting real-time health data from patients to caregivers, IoT technology will not only reduce the cost of healthcare services but also will permit the treatment of health problems before they become critical [19].

1.2.1 IoT Architecture

IoT architecture consists of various technology layers as mentioned below:

- Smart device/sensor layer: is the lowest layer The main task of the sensing layer is to monitoring changes in the physical state of linked objects. The primary elements of this layer are the sensors. The sensor is in charge of detecting and finding things, collecting and transferring data to the cloud layer for storage. It also measures the physical environment, including temperature, air quality, speed, humidity, pressure, flow, movement, voltage, and others [20].

- Communication Layer: The layer of communication is responsible for the interaction of the IoT architecture layers. The data collected in the sensing layer are transferred directly to the cloud or the service and application layer. This layer comprises routers, switches, and gateways connected to devices that cannot connect to the cloud directly. Protocols connect different IoT devices to send data to upper [21].

- Cloud Layer : It is sometimes referred to the IoT system processing unit. The cloud layer receives the data gathered from sensors and devices. Its features include data processing, analysis, and storage. The cloud often uses a data center as a central server to handle the data produced by the network edge [22].

- Management Layer: It is responsible for operating and monitoring all other layers with the features of the cloud management tools, which are normally implemented.

- Services and Applications Layer: is the highest layer offers a range of services and applications, including security, data collecting, data analysis, and visualization. They are determined by the use scenarios and the functionality that end users want [20].

1.2.2 IoT Characteristics

IoT is a complex network that represents the convergence of many real-world domains, where each domain has its own characteristics. Here is the major ones:

- Sensing: is the characteristic that can be utilized in a various IoT applications such as smart mobile devices, healthcare, climate monitoring, etc. Since that sensors allow measurement, in a context aware manner, of environmental parameters, and enable device communication with the physical world and surrounding people [20].

- Connectivity: different technologies are used to build connectivity between IoT devices or the Internet, enable service accessibility, exchange global information, and communication among different infrastructures [23].

- Intelligence: IoT devices facilitate data sensing and collecting. They may also incorporate different algorithms that can enable smart data analysis and take decisions accordingly [24].

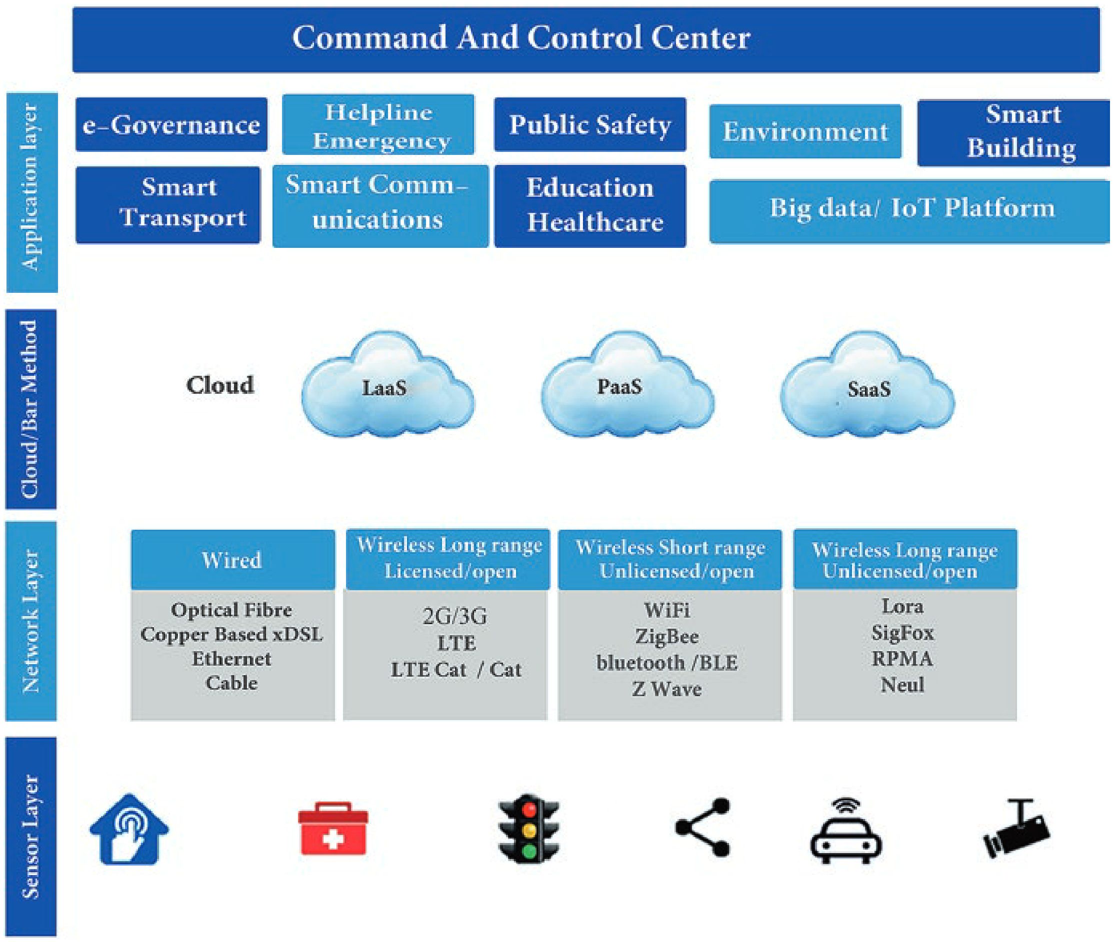


FIGURE 1.1: IoT architecture [1]

- Heterogeneity: various hardware platforms and operating systems are involved in enabling IoT. This complex ecosystem must allow an interconnection among heterogeneous devices and services in a way to provide seamless data exchange [20].
- Dynamic changes: IoT networks are characterized by the dynamic changes in topology since they can connect or disconnect according to their battery level or mobility. Moreover, the growing number of IoT devices and their usage makes the network topology more dynamic [25].
- Scale: a tremendous amount of data is generated by a huge number of IoT devices. This makes network management and data analysis more challenging and requires scalable IoT schemes and solutions [20].
- Addressing: billions of IoT devices can interconnect and collaborate for different tasks, create, and exchange content between each other. Each IoT device should have a unique and persistent address [25].
- Security Privacy: most of the data is generated and collected by IoT devices and analyzed for monitoring purposes and decisions. Thus,

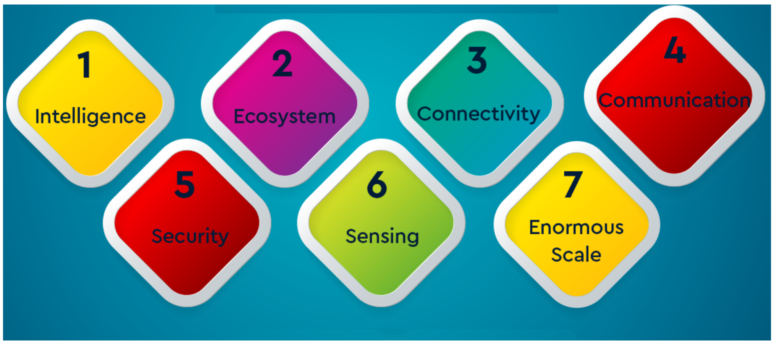


FIGURE 1.2: IoT Characteristics [1]

the network layer should treat the content by its name rather than its network address or the availability of the original producer. IoT based smart applications must adopt serious security mechanisms to ensure data security, privacy, access control, reliability, and confidentiality, regardless of the used channel type. Hence, keeping this data safe and reducing the risk, requires developing different trust models among content providers and consumers [26].

- Mobility: IoT based applications may cause some reliability issues, due to the patient mobility in healthcare systems, or vehicle mobility in smart transportation systems. Thus, providing at anytime anywhere connectivity and content availability in IoT requires serious design choices especially in a highly dynamic mobile environment [20].
- Resource Constraints: most of IoT devices are considered as resource constrained with limitations in power, memory, computing capabilities, and bandwidth. Therefore, providing IoT applications that deal with these constraints is required to satisfy the user experiences and provide continuous service availability during high mobility and network outage [27].

1.2.3 IoT Communication Models

IoT devices tend to cooperate, exchange, and process data between each other. These devices are able to communicate with their domain gateway, or with the Internet. Hence, we can broadly classify IoT communication models into the following classes:

- Device to Device Communication Model: two or more IoT devices may directly connect and communicate with each other instead of going through an intermediate service (e.g; smartwatch communicates directly with a mobile phone). This communication model is using by various protocols such as Bluetooth and ZigBee [28].
- Device to Gateway Communication Model: this model is also known as Device to Application Layer Model, where an IoT device connects with an associated service or gateway that acts as an intermediary between the IoT network and the Internet [29].

- Device to Internet Communication Model: in this model, IoT devices can directly connect to an Internet cloud service (e.g., Application Service Provider) to exchange data and receive control messages. Through the cloud service, users are able to obtain remote access to sensor devices using smartphone applications, also to export their desirable data from cloud services [30].

1.2.4 IoT Protocols

IoT protocols are divided on two: IoT network protocols and IoT data protocols as showing below (see Fig. 1.3)

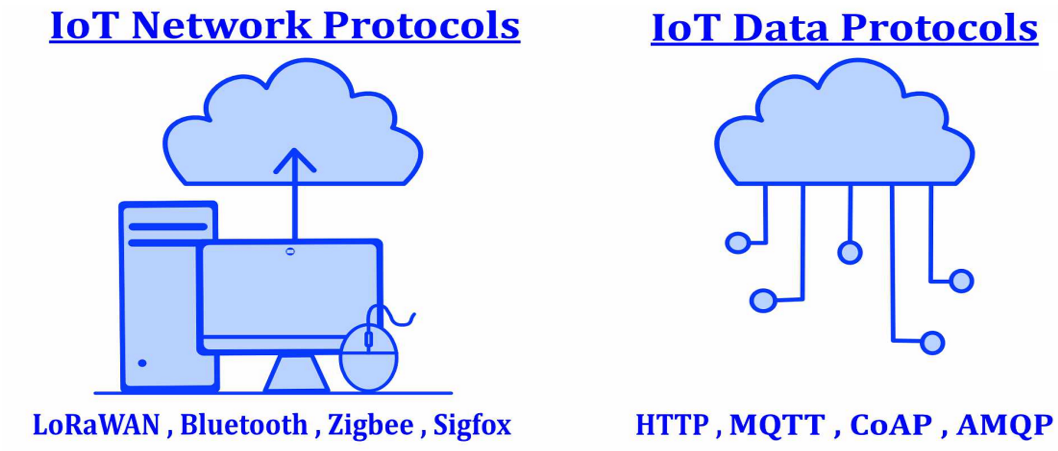


FIGURE 1.3: IoT Protocols [2]

IoT Network Protocols

IoT network protocols are used to connect devices over the network. These are the set of communication protocols typically used over the Internet. Using IoT network protocols, end-to-end data communication within the scope of the network is allowed. Following are the mostly used IoT Network protocols:

- WiFi (short for wireless fidelity) refers to a technology that uses radio waves to provide wireless high-speed internet and network connections between devices. WiFi technology is based on the IEEE 802.11 family of standards, which provides a set of protocols for wireless local area networks (WLANs). With WiFi, users can access the internet and share data without having to use cables or physical connections [31].

- Cellular networks (GSM,GPRS,3G, 4G, and 5G) provide high bandwidth and reliable broadband communication for voice calls or video streaming but with high operational costs and power consumption. Cellular networks cannot be used with most IoT devices due to their frequency, range, and security challenges. GPS systems and cellular networks can help track road traffic in real-time as cellular networks can transfer high quantities of data over the network.

- RFID (Radio-frequency identification) uses radio waves to transfer small data packets over the network within small areas. It is easy to embed an RFID chip in IoT devices. RFID readers can then read the tags and give information about the product that is attached to tags [32].
- LoRaWan (Long Range Wide Area Network): is a long-range low power protocol that provides signal detection below the noise level. LoRaWan connects battery operated things wirelessly to the Internet in either private or global networks. This communication protocol is mainly used by smart cities, where there are millions of devices that function with less power and memory [31].
- Bluetooth: Bluetooth is one of the most widely used protocols for short-range communication. It is a standard IoT protocol for wireless data transmission. This communication protocol is secure and perfect for short-range, low-power, low-cost, and wireless transmission between electronic devices. BLE (Bluetooth Low Energy) is a low-energy version of Bluetooth protocol that reduces the power consumption and plays an important role in connecting IoT devices [33].
- ZigBee: is an IoT protocol that allows smart objects to work together. It is commonly used in home automation. More famous for industrial settings, ZigBee is used with apps that support low-rate data transfer between short distances [31].

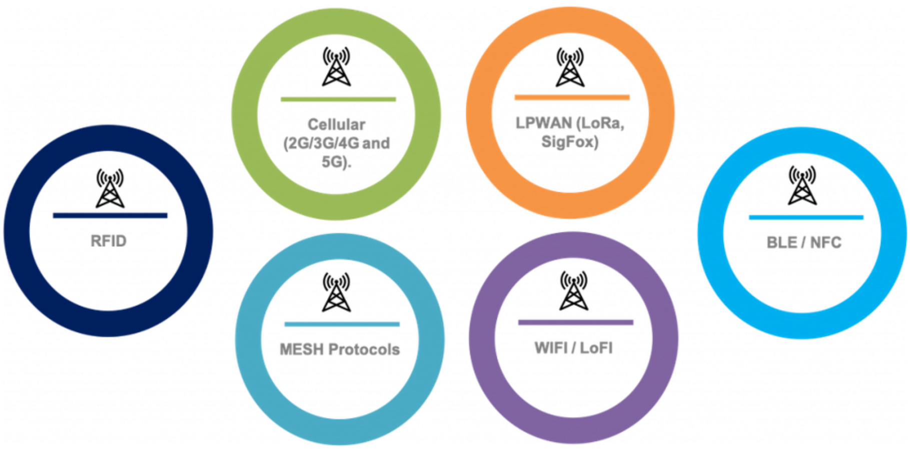


FIGURE 1.4: IoT Network Protocols [2]

IoT Data Protocols

IoT Data Protocols are used to connect low power IoT devices. These protocols provide point-to-point communication with the hardware at the user side without any Internet connection. Connectivity in IoT data protocols is through a wired or a cellular network. Some of the IoT data protocols are:

- HTTP (Hypertext Transfer Protocol): is the best example of IoT data protocol. This protocol has formed the foundation of data communication over the web. It is the most common protocol that is used for IoT devices when there is a lot of data to be published with maximum of security. However, the HTTP protocol is not preferred because of its cost, battery-lifetime, energy saving [34].

- Message Queue Telemetry Transport (MQTT): One of the most preferred protocols for IoT devices. MQTT collects data from various electronic devices and supports remote device monitoring. It is a subscribe/publish protocol that runs over Transmission Control Protocol (TCP), which means it supports event-driven message exchange through wireless networks. MQTT is mainly used in devices which are economical and requires less power and memory. For instance, fire detectors, car sensors, smart watches, and apps for text-based messaging. [35]

- Constrained Application Protocol (CoAP): is an internet-utility protocol for restricted gadgets. Using this protocol, the client can send a request to the server which can send back the response to the client via HTTP. For light-weight implementation, it makes use of UDP (User Datagram Protocol) and reduces space usage. The protocol uses binary data format EXL (Efficient XML Interchanges) [36].

- Advanced Message Queuing Protocol (AMQP): is a software layer protocol for message-oriented middleware environment that provides routing and queuing. It is used for reliable point-to-point connection and supports the seamless and secure exchange of data between the connected devices and the cloud. AMQP consists of three separate components namely Exchange, Message Queue, and Binding. All these three components ensure a secure and successful exchange and storage of messages. It also helps in establishing the relationship of one message with the other [35].

- Machine-to-Machine (M2M) Communication Protocol : is an open industry protocol built to provide remote application management of IoT devices. M2M communication protocols are cost-effective and use public networks. It creates an environment where two machines communicate and exchange data. This protocol supports the self-monitoring of machines and allows the systems to adapt according to the changing environment [36].

- Extensible Messaging and Presence Protocol (XMPP): is uniquely designed. It uses a push mechanism to exchange messages in real-time.

XMPP is flexible and can be integrated with the changes seamlessly. XMPP is developed using open XML (Extensible Markup Language) and it is working as a presence indicator showing the availability status of the servers or devices transmitting or receiving messages [36].

1.2.5 IoT Specific Domains

IoT is involved in different applications which have a common vision, but still have different characteristics. In order to reap the benefits of merged IoT technology, it is important to address these characteristics of each application domain. In the following, we present a review of different IoT applications [37].

- Smart Transportation Systems:

  Information and communications technology(ICT) has enhanced intelligent transportation systems . Nowadays, the idea of a "smart city" which combines ICT and IoT has emerged to increase the effectiveness of local operations and services [38].

- Smart Grid Systems:

  is mainly the integration of advanced electrical information with the IoT, and it can connect with users and utilities. Compared to conventional transmission and distribution systems, it operates more quickly and intelligently. Building automation is a well-known concept of autonomous and intelligent actions needed in any structure or store. i.e., control of the door, pressure, and temperature [39].

- Smart Home Systems: The IoT concept of a smart home uses a low energy wireless IoT elements with simple installation and implementation of sensors to create a smart home without a necessity to reconstruct a household [40].

- Smart City Systems: It presents a picture of the city where service providers interact with residents using information technology to build better urban organizations and systems that can enhance quality of life. The creation of smart cities is based on the growing IoT concept. Value creation requires an integrated cloud-oriented architecture of networks, software, sensors, user interfaces, and data analytic [41].

- Smart Healthcare Systems: combines a new generation of information technologies, such as IoT, big data, cloud computing, and artificial intelligence, to reform the conventional medical system in a proactive strategy and improve healthcare in terms of efficiency, convenience, and personalizing with the intention of highlighting the concept of smart healthcare [42].

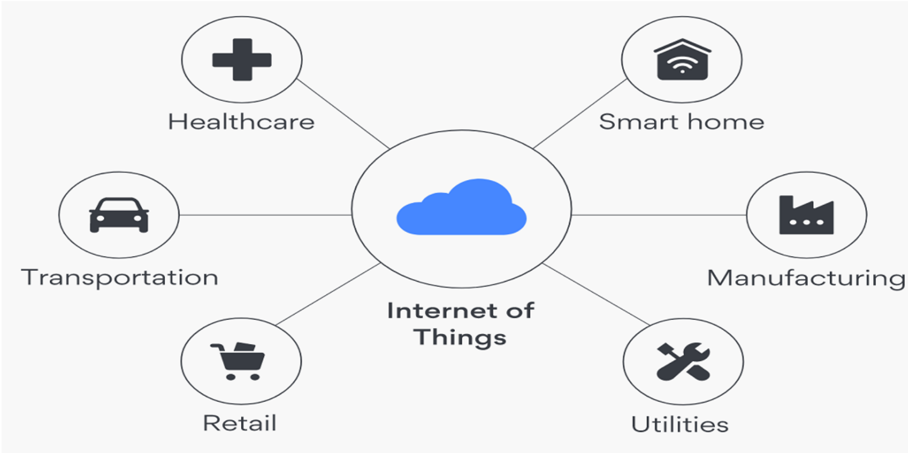


FIGURE 1.5: Specific Domain of IoT [1]

1.2.6 Advantages / Disadvantages of IoT

Advantages

IoT provides various advantages in our daily lives.

1. Minimizing the human effort: IoT devices communicate and interact with each other, they provide automation of the tasks which helps us to improve the quality of a business services and reduce the need for human intervention.

2. Save time: As we discussed above it reduce the human effort, so it saves a lot of our time also. Time Saving is the primary advantages of IoT platform.

3. Enhanced data collection: In IoT Information is very easy accessible, even if we are away from our location, and it is updated very fast in real-time. So these devices can access any information from any place at any time on any device.

4. Improved security: As we know in IoT If we have a system that is interconnected, it can assist in the smarter control of cities and homes through mobile phones. It enhances security and offers us personal protection.

5. Efficient resource utilization: with the help of IoT one can increase and monitor resource utilization by knowing the functionality and how each device works.

6. Reduce the use of other electronic equipment: E-devices are directly connected and can communicate with a computer, such as a mobile, resulting in efficient use of electricity. Hence, there will be no unimportant use of electrical equipment.

Disadvantages

As the Internet of things provides advantages, it also has a significant set of drawbacks. Some disadvantages of IoT are given below:

1. Security issues: Since IoT systems communicate and connect over networks, they offer little control despite of any security measures, and it can invite various kinds of network attacks.

2. Privacy concern: The IoT system provides personal data in detail without the user's active participation.

3. Unemployment: Due to IoT unskilled or even the skilled ones are at very high risk of losing their jobs, which leads to high unemployment rates. Robots, smart surveillance cameras, smart washing machines, smart ironing systems, and other facilities are also replacing the workers who was earlier doing these works.

4. System complexity: The developing, maintaining, designing, and enabling the extensive technology of IoT system is quite complex process.

5. System corruption: It may be possible that every connected device will become corrupted if there is bug in it.

6. International standardization: for IoT there is no international standard of compatibility, which is difficult for devices from various manufacturers to communicate with each other.

7. Internet dependency: heavily rely on the internet and cannot function effectively without the internet.

8. Mental and physical activity: It can make people ignorant because they solely rely on smart devices instead of doing work by themselves, this cause them to become inactive and lethargic. [43]

1.3 Internet of Medical Things (IoMT)

healthcare is poised for a transformation through IoT. The term Internet of Medical Things (IoMT), a healthcare application of the IoT technology, comprises a network of connected devices that sense vital data in real time.

1.3.1 IoMT Structure and Technologies

Three levels make up the macro-level IoT architecture: Local Patient Systems and Control(including sensors), Device Connectivity and Data Layer, and data analytic and solutions(firmware, and end medical controls):

Following is a discussion of each component's structural and functional aspects:

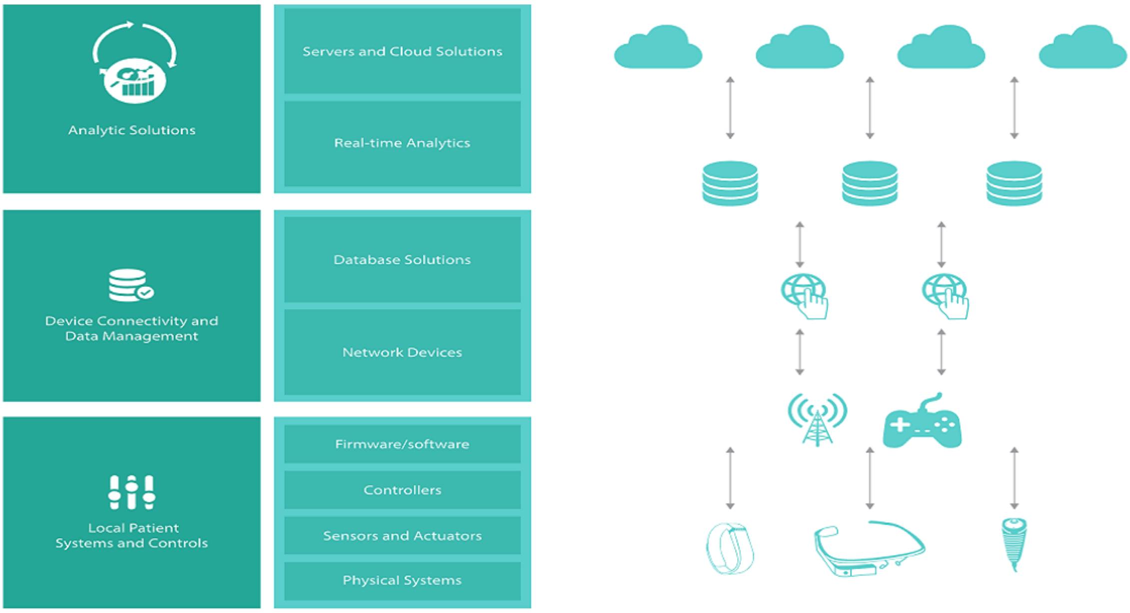


FIGURE 1.6: IoMT Structure and Technologies [3]

Local Patient Systems and Control

These devices often have network connections for data sharing with other machines or centralized servers, sensors to detect operational parameters, converters to create digital inputs, controllers to make choices in real time based on inputs from the converters. Wearable monitoring, implants, and portable diagnostic tools for doctors are a few examples of such technologies [44].

- Sensor and Smart Patient Devices :

  The traditional sensing device uses potentiometric, accelerometric, and electrochemical principles to monitor several physiological data. The medical equipment and solutions contain these sensors. The multi-sensing platform, which combines two or more sensors in next-generation, customized self-tracking devices [44].

- Micro-controllers and Gateways:

  Data is converted from analog to digital representation using conventional controllers. These technologies include converters that take sensor data, process and analyze it, turn it into bio-metric data, then communicate it via a wireless network. These gadgets' main benefit is that they minimize manual mistakes brought on by human interaction [44].

Device Connectivity and Data Layer

The layer's main goal is to collect data from network devices and store it in pre-established data storage. This layer's technologies are not specific to any one solution (such as patient monitoring). Network technologies control data transfer and link medical equipment to distant places. WiFi, Bluetooth

Low Energy (BLE), ZigBee, cellular, NFC, and satellite are the different categories of these communication technologies. Bluetooth® and Bluetooth Low Energy (BLE) (for personal area networks, or PANs) and WiFi (for local area networks, or LAN's), used in clinics and hospitals, are some examples of wired and wireless technology applications [44].

Analytic and Solutions Layer

No matter what kinds of healthcare solutions are enabled, the central/remote server receives data from various devices connected to the network and their essential parts. Real-time operational data is analyzed by the server's built-in algorithms to produce insights and conclusions. This data-driven attentiveness aids in illness prediction, preventative measure implementation, and diagnostic capabilities. Healthcare solutions like remote patient monitoring, interventions, and chronic illness management are made possible by the aggregate and thorough examination of data from many sources like implants and smart devices [44].

1.3.2 Impact of Industry 4.0 on IoMT Technology

Medical equipment and equipment improvements are part of Industry 4.0. It enables a computerized emergency clinic and a comprehensive evaluation framework that meet the specific demands of the patient/clinic while saving time and money [45]. High-quality healthcare technology created by Industry 4.0 may be customized to meet unique needs. Automatizing is being accepted in this change to create new opportunities in the healthcare sector [46]. It generates a new virtual environment with the help of the integrated operating system (IOS) and connected IoT. It makes information interchange possible through new parts, programming, sensors, robotics, and other data-driven developments [45]. Additionally, a new term called *Healthcare 4.0* has evolved from Industry 4.0 to meet diverse requirements in the healthcare domain. The IoMT or Healthcare 4.0 is a network of connected sensors, wearable technology, medical equipment, and clinical frameworks. It enables various human services applications to lower the cost of social insurance, deliver suitable clinical replies, and focus medical care [47]. IoMT is modernizing the human services sector by offering personalized medical care and standardizing the sharing of clinical information. It is being driven by advances in sensor systems, mobile phones, big data analysis, distributed computing, and remote communication. With the introduction of Industry 4.0 and the integration of the automatic sector with IoMT, Healthcare 4.0 has a significant influence [48].

The future of medicine is being molded by the digital pillars of Industry 4.0, including sensors, artificial intelligence, augmented reality, and virtual reality [46]. The Healthcare 4.0 paradigm's implanted sensors make it possible to continuously monitor vital indicators such the ECG, heart rate, blood sugar level, temperature, and breathing [47]. Smart intensive care units (ICUs), smart thermal scanners, medical asset management, and smart tablet dispensers are all made possible by the integration of medical embedded devices, equipment, and the internet [47]. These medical devices have certain benefits, but they also pose serious privacy and security risks [45].

1.4 Chronic Diseases and a Hospitalized Patient

1.4.1 Chronic Diseases

Definition

A disease that persists for a long time. A chronic disease is one lasting 3 months or more, by the definition of [49]. National Center for Health Statistics. Chronic diseases generally cannot be prevented by vaccines or cured by medication, nor do they just disappear. Health damaging behaviors are major contributors to the leading chronic diseases. Chronic diseases tend to become more common with age. The leading chronic diseases include arthritis, cardiovascular disease such as heart attacks and stroke, cancer such as breast and colon cancer, diabetes, epilepsy and seizures, obesity, and oral health problems. Each of these conditions plague older adults in all nations.

Chronic Disease	Necessary Vital Signs to Monitor
Hypertension	Blood pressure
Diabetes	Blood glucose, blood pressure, and weight
Chronic obstructive pulmonary disease (COPD)	Oxygen saturation, respiratory rate, and heart rate
Heart failure	Blood pressure, heart rate, and weight
Coronary artery disease (CAD)	Blood pressure, heart rate, and electrocardiogram (ECG)
Chronic kidney disease (CKD)	Blood pressure, urine output, and serum creatinine
Asthma	Peak expiratory flow rate, oxygen saturation , and respiratory rate
Osteoporosis	Bone density
Arthritis	Joint pain, stiffness, and swelling
Dementia	Cognitive function and mood

TABLE 1.1: Example Effects of chronic diseases [8]

Effects of chronic diseases

- Reducing the quality of individuals' life.
- The nation's loss of manpower as a result of premature deaths and disability caused by diseases.

- The costs of health care for chronic diseases put pressure on the budgets of countries, especially with the exacerbation of the disease and the development of its complications.
- It leads to a lot of social, health, psychological and economic problems

1.4.2 A hospitalized patient

He is the patient, whether he suffers from a chronic disease or not, but his condition requires staying in the hospital for several days to follow up on his treatment or to follow up on his condition, whether it is stable or not. Currently, traditional methods are used to follow up on their condition represented by summoning a relative to stay with him or hiring people to accompany them in return for money. However, all these methods have several obstacles and drawbacks. Among them is the patient's discomfort, which negatively affects his treatment condition, and the mistakes made by the companions, interventions, naps, forgetfulness, neglect, and so on. Several studies on this type of patients confirmed that there is an effect on the patient's response to treatment and its speed, and between not staying in bed all day and remaining, in other words allocating a period in which the patient move in the hospital,if conditions met with only remote monitoring.

1.5 A Basic Concepts of Geometry and Location

1.5.1 Euclidean geometry

is geometry in its classical sense.As it models the space of the physical world, it is used in many scientific areas, such as mechanics, astronomy, crystallography, and many technical fields, such as engineering, architecture, geodesy ,aerodynamics, and navigation. The mandatory educational curriculum of the majority of nations includes the study of Euclidean concepts such as points, lines, planes, angles, triangles, congruence, similarity, solid figures, circles, and analytic geometry [50].

1.5.2 Location

A location is the place where a particular point or object exists. Location is an important term in geography, and is usually considered more precise than "place.

A place's absolute location is its exact place on Earth, often given in terms of latitude and longitude.

For example, the LINFI Building is located at 5.74 degrees north (latitude), 34.84 degrees west (longitude). It sits at the face of faculty of science technology in university Mohamed khider , Biskra, Algeria. That is the building's absolute location.

Location can sometimes be expressed in relative terms. Relative location is a description of how a place is related to other places. For example, the

LINFI laboratory Building is 0.5 kilometers north of Wholesale market for vegetables and fruits in el alia, Biskra. It is also about 15 blocks from The theater. These are just two of the building's relative locations.

Directions like north, south, east, and west help describe where one place is in relation to another. and in the third space we have another axis called z ,it mean the altitude from the sea level. both of longitude ,latitude ,altitude can help me for get the exact or with max of accuracy position (location) of thing.

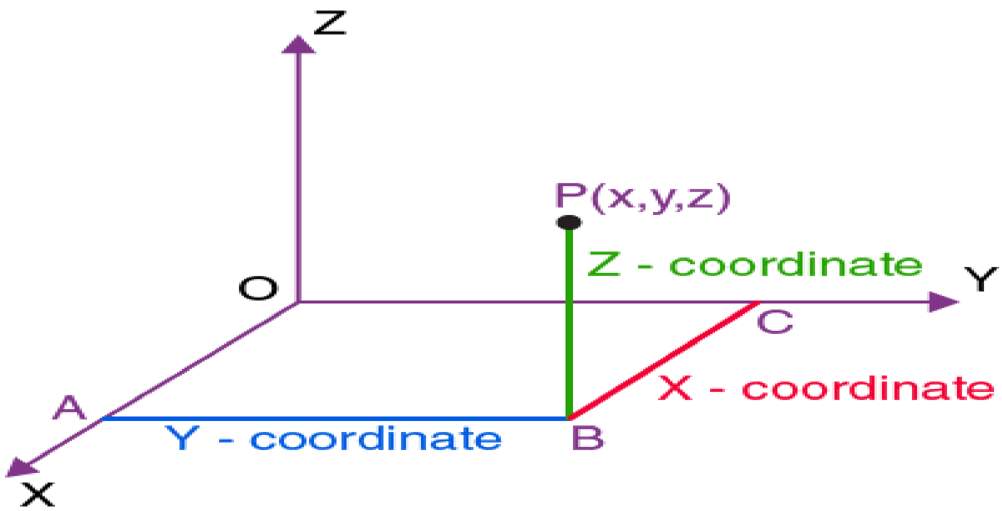


FIGURE 1.7: Cartesian Coordinate System [4]

1.6 Monitoring and tracking systems

A tracking and monitoring system is a technology-based solution that is designed to keep track of and provide real-time information on the location, status, and performance of a particular object, process, or system. The system typically uses sensors, GPS, or other data collection tools to capture relevant data and transmit it to a central location where it can be analyzed and acted upon.

1.6.1 Monitoring Systems

Temperature Monitoring systems:

The normal body temperature of a person varies depending on gender, recent activity, food and fluid consumption, time of day, and, in women, the stage of the menstrual cycle. Normal body temperature can range from 36.5 degrees C, or Celsius 37.2 degrees C for a healthy adult. A person's body temperature can be taken in any of the following ways: • Orally • Axillary • By ear • By skin Body temperature may be abnormal due to fever (high temperature) or hypothermia (low temperature). A fever is indicated when body temperature rises about one degree or more over the normal temperature of 37 degrees , . Hypothermia is defined as a drop in body temperature below 35 degrees. There are several technologies currently used to obtain human body temperature, including Contact-based temperature sensors [51], Infrared temperature sensors [52], Wearable temperature sensors [53], and Thermal cameras [54].

Contact-based temperature sensors provide high accuracy [55] and consume less power than other sensors, but they require good placement and installation [55]. Thermal cameras sensors are less accurate [56] but perform well indoors and consume more power than other sensors. Infrared temperature sensors provide very accurate temperature data without contact [57], but they require special installation, their price is high, and they have not been available since the Corona pandemic [57].

Systems	Technologies	Related Works	Features				Advantages - Limitation
			Accuracy and validity	services availability	Power	Hardware cost	
Monitoring Systems (Temperature)	Contact-based temperature sensors	work [51]	High	Contact	Low	Low	+ Provide accurate temperature readings - Require physical contact with object - Can be affected by the thermal properties of the object - Can be affected by the environment
	Infrared temperature sensors	work [52]	Low	Non-Contact	Moderate	High	+ Non-contact temperature measurement + Can measure temperature from a distance - Can be affected by the emissivity of the object - Can be affected by environmental factors
	Wearable temperature sensors	work [53]	High	Contact	Low	Low	+Can provide real-time temperature data +Can be used in various applications - May not provide as accurate temperature readings - Can be affected by the position on the body
	Thermal cameras	work [54]	High	Non-Contact	High	High	+Provide a visual representation of temperature distribution - Can be affected by environmental factors - Require specialized training to interpret images

TABLE 1.2: Related Work in Temperature Monitoring systems

Heart Rate Monitoring systems

The pulse rate is a measurement of the heart rate, or the number of times the heart beats per minute. As the heart pushes blood through the arteries, the arteries expand and contract with the flow of the blood. Taking a pulse not only measures the heart rate, but also can indicate the following:

1. Heart rhythm
2. Strength of the pulse

The normal pulse for healthy adults ranges from 60 to 100 beats per minute. The pulse rate may fluctuate and increase with exercise, illness.

There are many techniques currently used to obtain information about blood pressure in the human body, including Photo plethysmography (PPG) sensors in [58], Electrocardiography (ECG or EKG) sensors in [59],Ballistocardiography (BCG) sensors in [60], Doppler ultrasound sensors in [61], Piezoelectric sensors in [62].

The PPG sensor is non-invasive, small and portable [63], consumes less power than other sensors, is easy to use, but has limited spatial resolution [64]. ECG or EKG and BCG sensors are more accurate and work well [65], can be affected by motion problems, require multiple electrodes and consume more power than other sensors [66]. Dopplerultrasound and Piezoelectric sensors provide very accurate real-time data with high frequency response [67], but they can be affected by temperature [67].

Other characteristics of previous works can be summarized in the following tables.

Systems	Technologies	Related Works	Features				Advantages - Limitation
			Accuracy and validity	services availability	Power	Hardware cost	
Monitoring Systems (Heart Rate)	Photo plethysmography (PPG) sensors	work [58]	High	Semi-Contact	Low	Low	+easy to use +low power consumption -Non-surgical -Limited to measuring peripheral blood flow
	Electrocardiography (ECG or EKG) sensors	work [59]	High	Contact	High	High	+Highly accurate +surgical -requires electrodes to be attached to skin
	Ballistocardiography (BCG) sensors	work [60]	High	Contact	High	High	+Measures mechanical activity of heart + surgical -requires patient tolie still on a platform
	Dopplerultrasound sensors	work [61]	Low	Non-Contact	Low	Low	+can measure blood flow velocity -Non-surgical -Limited to measuring blood flow in larger vessels
	Piezoelectric sensors	work [62]	Moderate	Non-Contact	High	Low	+measures small movements -Non-invasive -Limited to measuring mechanical activity

TABLE 1.3: Related Work in Heart Rate Monitoring systems

O2 level Monitoring systems

SpO2 stands for peripheral capillary oxygen saturation. It is a measure of the amount of oxygen-saturated hemoglobin in the blood, expressed as a percentage. A normal SpO2 level is between 95-100, meaning that the blood is carrying a healthy amount of oxygen to the body's tissues. a SpO2 level of 92 or lower is considered low and may indicate Hypoxemia, which is a lack of oxygen in the blood. Hypoxemia can be caused by a range of factors, including lung disease, heart disease, anemia, and high altitudes. Recently, many modern and old technologies have been used to obtain information about the level of oxygen in the human body, especially in the time of the Covid-19 pandemic, including pulse oximetry sensors in action 1 [68] by passing light through tissues and measuring the amount of oxygenated hemoglobin The blood is deoxygenated. , and electrochemical sensors in action 2 [69], with a gas concentration by measuring the current produced by a chemical reaction between the gas and the reactive electrode. The infrared spectral sensor in [70], concentrates a gas by detecting the absorption of infrared light at specific wavelengths by the gas.

All the types sensors mentioned are of high accuracy and are available [71], but they differ in the way they work and the nature of the material to be tested and therefore the location and installation of them. We find, for example, in work 1 that he talked about accuracy and energy consumption, and neglected the appropriate place to put it, and that the measurement is done by touching the sensor skin as well. For the second work, he talked about accuracy and neglected how or where to place the sensor so that it does not hinder daily work, and also with regard to the price which is rather expensive. Other characteristics of the previous works can be summarized in the following tables:

Systems	Technologies	Related Works	Features				Advantages - Limitation
			Accuracy and validity	services availability	Power	Hardware cost	
Monitoring Systems (O2 Level)	Pulse oximetry sensors	work [68]	High	Contact	Low	Low	+measures oxygen saturation -Non-invasive -Limited to measuring oxygen saturation
	Electrochemical sensors	work [69]	High	Non-Contact	High	High	+Portable +can measure various analytes in blood -May require frequent calibration and maintenance.
	Infrared spectroscopy sensors	work [70]	High	Non-Contact	High	High	+can measure multiple analytes. -Expensive and complex instrumentation -limited availability

TABLE 1.4: Related Work in O2 Level Monitoring systems

1.6.2 Tracking Systems

Indoor Tracking patient systems

There are several technologies currently used for getting indoor/outdoor position using the signal strength of nearby networks or devices or things to estimate the user's location, as presented in [72] [73] [74] [75], while GPS NEO-6M Sensors use satellite signals to determine the user's position as presented in work [76].

The work [77] presents Google GPS API which provides data location using a combination of GPS, Wi-Fi,and cellular networks.

In [78], the authors present Barometric Sensors which uses the air Pressure of zone to estimate the user's altitude.

To compare and contrast the different technologies, we use a table in below to highlight the similarities and differences between each technology. For example, GPS NEO-6M Sensors provide high accuracy and can work both indoors and outdoors [79], but they require a clear line of sight to the sky [80] and consume more power than Wi-Fi Positioning Sensors. Wi-Fi Positioning Sensors are less accurate but work well indoors [81] and consume less power than GPS NEO-6M Sensors. Google GPS API provides accurate location [79] but requires an internet connection and may raise privacy concerns.

Several studies have evaluated the performance of different tracking position technologies, but there are still gaps in the research. For example, some studies have focused on the accuracy of GPS and Wi-Fi-based technologies in indoor environments, while others have investigated the impact of power consumption on the user's experience. Further research is needed to address these gaps.

Systems	Technologies	Related Works	Features					Advantages - Limitation
			Accuracy and validity	services availability		Power	Hardware cost	
				indoor	outdoor			
Tracking Systems	Wi-Fi	work [72]	Low	yes	No	High	Moderate	+High-speed connectivity +Supports multiple devices -Range is limited -Susceptible to interference
	RFID	work [82] [73]	Low	yes	No	Low	High	+ Does not require line of sight +Can be used in harsh environments -specific reader technology
	GPS	work [76]	High	No	No	High	High	+Provides accurate location information +Works globally -Requires line of sight to satellites -Can be affected by interference -Battery life can be limited
	Barometric	work [78]	High	Yes	Yes	Low	Low	+Can be used for altitude measurement +Can be used for weather forecasting +Can be used for indoor navigation -Accuracy can be affected by changes in weather -Can be affected by environmental factors
	Bluetooth	work [74]	Low	Yes	No	Low	Low	+Low power consumption + Can be used for short-range communication +Widely available in devices - Range is limited - Can be affected by interference - Limited data transfer rate
	Ultrasounds	work [75]	High	Yes	No	Low	Low	+ Can be used for distance measurement +Can be used in noisy environments - Range is limited - Accuracy can be affected by environmental factors - Requires specialized hardware
	Google Map api	work [77]	High	Yes	Yes	Moderate	Free	+ Provides accurate location information +Can be used for indoor navigation +Works globally - Requires internet connectivity - Limited to outdoor navigation

TABLE 1.5: Related Work in Tracking Systems

1.7 Conclusion

This chapter introduced the main themes of our thesis: IoMT, machine learning and location, and sensors. The digitization of the medical sector has led to an exponential growth of data (big data) that comes from various sources. The healthcare industry needs to work on collection, transportation, storage, detection, diagnosis, prediction and prevention to improve outcomes. To achieve this, we use the best technologies and transmission protocols, the latest and safest storage methods, and artificial intelligence (machine learning) technologies that examine large data sets and reveal hidden information. Chapter 2: Introductions, basic concepts, and patterns for discovering knowledge from data, plus personalized medicine, all in real time. The next chapter aims to present the first contribution to this thesis, which aims to build a device to collect information, send it, store it, and display it after processing. This work, which is about integrating and transferring technologies used in industrial fields to the medical field.

Chapter 2

Prevailing Machine Learning

2.1 Introduction

This century has marked developments in the area of microelectronics, sensors, material science, Internet of Things (IoT), and many others which have led to significant developments in the area of agriculture, military, medi -cine, space, industrial production, and even day-to-day routine activities. Medical technology among all these has seen drastic changes in terms of technology for the patient's treatment. Intelligent health monitoring systems are regarded as the need of hour for accurate and responsive monitoring of a patient's health in diverse situations like , pregnant women, heart patients, and cancer patients. Current advancements in biosensor technology have led to the development of various health monitoring systems, but these systems have some limitations in terms of cost, accuracy, and portability. The objective of this these is to propose an Intelligent IoMT-based health monitoring system, i.e., smart bracelet and monitoring system. it is working prototype for monitoring real-time vital statistics of patients in terms of body oxygen level, pulse rate/heart rate, and body temperature and sends the live data to doctors via local server.

2.2 Machine learning

Machine learning is a branch of Artificial Intelligence (AI) that emerged from pattern recognition to examine the data model and integrate it into patterns that people could understand and use [83]. A machine learning algorithm is a computing process that utilizes input data to accomplish a goal without being explicitly written to achieve that goal . [84] According to these definitions of ML, the main role of ML is to make the computer learn from various instances of the surrounding environment to accomplish specific tasks [84].

it focused on constructing algorithms that make predictions based on data without programming it to perform the task. ML aims to identify a function $f : X- > Y$ that maps the input X into output Y [85]. Functions f are chosen from different function classes, dependent on the type of learning algorithm used. Machine learning algorithms can be classified mainly into three categories by the type of datasets used as experience.

Machine learning is broadly classified as supervised, unsupervised, reinforcement learning. A supervised learning model has two major tasks: classification and regression. Classification is about predicting a nominal class label, whereas regression is about predicting the numeric value for the class label.

2.2.1 Machine learning categories

Machine learning categories involve supervised learning, unsupervised learning and reinforcement learning. Other learning systems combine two categories, such as semi-supervised learning that use labelled and unlabeled data. More details in the followings sections.

Supervised learning

Supervised learning systems make use of labeled datasets, where x represents a data point and y the corresponding true prediction for x. This training set of input-output pairs is used to find a deterministic function that maps any input to an output, predicting future input-output observations while minimizing errors as much as possible [86]. Supervised learning problems can be further grouped into regression and classification problems:

- **Classification:** a classification problem is when the output variable is a category, such as "disease" and "no disease». Classes can be called as targets/labels or categories.
- **Regression:** a regression problem is when the output variable is a real value, such as "dollars" or "weight". Some popular examples of supervised learning algorithms are: – Linear regression – Random forest – Support vector machines – Decision Tree – Neural network (Multiple layer perception) – K-Nearest Neighbors – Naive Bayes

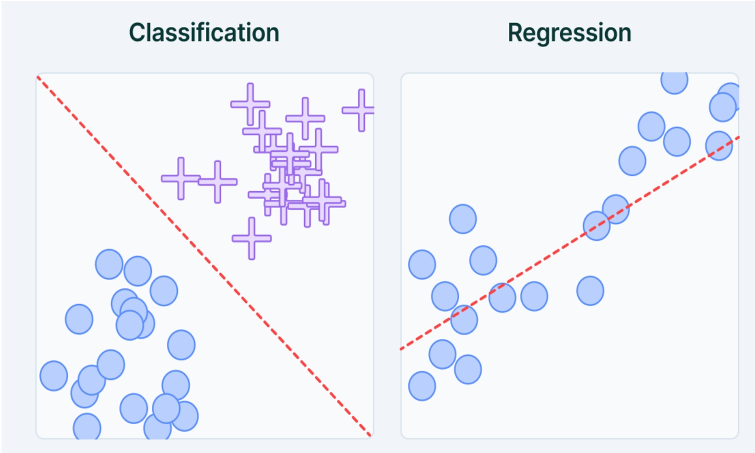


FIGURE 2.1: Supervised learning (Classification and Regression) [4]

Unsupervised learning

Unsupervised learning systems use unlabeled datasets to train the system. The objective of unsupervised learning is to derive structure from unlabeled data by investigating the similarity between pairs of objects, and is usually associated with density estimation or data clustering 2.2. Unsupervised learning problems can be further grouped into clustering and association problems. Unlabeled datasets are used in unsupervised learning systems to train the algorithm. Unsupervised learning, which is typically connected with density estimation or data clustering [87], aims to extract structure from unlabeled data by examining the similarity between pairs of objects. Clustering and association difficulties are subcategories of unsupervised learning issues.

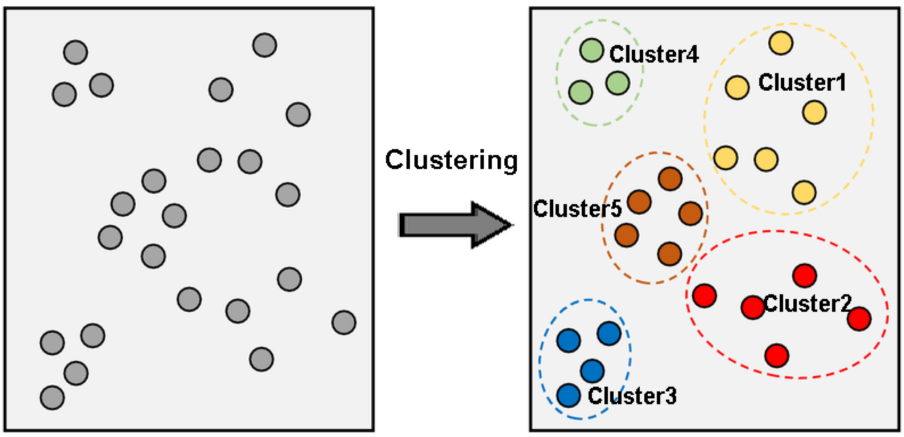


FIGURE 2.2: Unsupervised learning(Clustering) [5]

Clustering: is a way of grouping the data points into different clusters, consisting of similar data points. The objects with the possible similarities remain in a group that has less or no similarities with another group. It does it by finding some similar patterns in the unlabeled dataset such as shape, size, color, behavior, etc., and divides them as per the presence and absence of those similar patterns.

Association: checks for the dependency of one data item on another data item and maps accordingly so that it can be more profitable [88]. It tries to find some interesting relations or associations among the variables of dataset. It is based on different rules to discover the interesting relations between variables in the database. Some popular examples of unsupervised learning algorithms are:

– k-means for clustering problems.

– Apriori algorithm for association rule learning problems

Reinforcement learning

Reinforcement learning systems do not experience a fixed dataset, but a feedback loop between the system and its experiences [89].state-action-reward triples are observed as the data. The objective of reinforcement learning is mapping situations to actions with the goal of maximizing rewards.

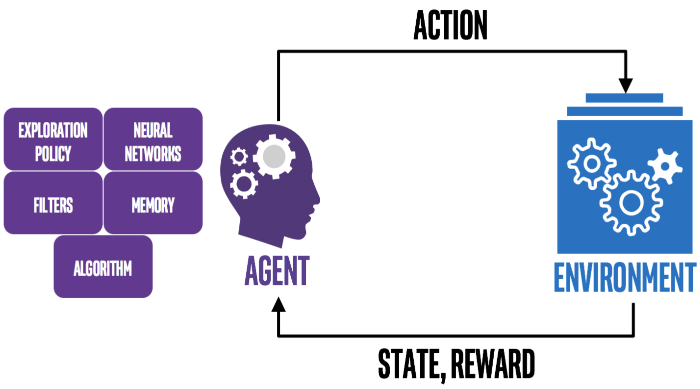


FIGURE 2.3: Reinforcement learning [4]

2.2.2 Machine learning process

Machine Learning is a data-driven process that starts by pre-processing the collected data until the model construction spits out predictions and insights. The method of performing machine learning usually requires many steps that are explained in the following sections:

Data pre-processing

Data preprocessing is the first and crucial step while creating a machine learning model. It is a process of preparing the raw data and making it suitable for a machine learning model. A typical healthcare data preprocessing procedure usually includes the following steps depending on the source and format of the data :

- **Data cleaning:** is the method of detecting, correcting or removing wrong or inaccurate records from images, table, or database and identifying incorrect, incomplete, irrelevant or inaccurate parts of the data and then replacing, modifying, or deleting the row data. [90]

- **Missing value interpolation:** In health analytic, missing data may be unavoidable due to a variety of reasons, for example, faulty equipment, and/or imprecise or lost measurements; moreover, the errors of the caregivers, for instance, physicians or nurses who forget and/or improperly record the information may also lead to missing information. Yet, the most serious problems of missing values are the resulting consequences, thereby effectively slowing down the analytic processing due to lower efficiencies, and/or the potential to compromise the information extracted from the data, there by leading to faulty conclusions. Essentially, three strategies may be applied to deal with missing data. -The first is missing data ignoring techniques that simply delete the cases that comprise the missing data [91]. In cases where the size of the data is small (as with the current study), deleting any information is not ideal. -The second approach would be to deploy missing data modeling techniques. The strategy here is to define a model from the existing data and then generate inferences based on the distribution of the data [91]. -The third strategy is to employ the missing data imputation techniques. These techniques complete the missing data in the dataset with a potential value [92]. Examples of such techniques include: Mean regression, K-NNs, and multiple imputations.

- **Data synchronization:** Data synchronization ensures secure, accurate, compliant data. It assures harmony between each source of data and its different endpoints. As data comes in, it is cleaned, checked for errors, consistency and duplication before being used [93]. Data must always be consistent throughout the data record. If data is modified in any way, changes must upgrade through every system in real-time to avoid mistakes, prevent privacy breaches, and ensure that the most up-to-date data is the only information available. Data synchronization ensures that all records are consistent, all the time.

- **Data normalization:** This step is usually needed to adapt to differences in the data recording process. For example, a daily heart rate may represent a daily average heart rate or a measurement during a specific time range. Moreover, a normalization step is usually performed to transform the original feature into a similar format by adopting and mapping standardized terminologies and code sets. A normalization process should sometimes be carried out to convert the original numerical values to nominal ones for a specific algorithm [94]. It is deserving of mentioning that the discretionary process may cause information loss and impact data quality.

- **Imbalanced data problem:** Imbalanced data typically refers to a problem with classification problems where the classes are not represented equally. The imbalance of medical data, as characterized by the non-uniformity of the class distribution among the classes, seriously affects the accuracy of medical diagnosis classification. Data imbalance exists widely in real-world datasets, especially those in the medical field. To resolve this challenge, a widely implemented technique for dealing with highly unbalanced datasets is resembling:

1. Under-sampling: is resampling consists of eliminating samples from the majority class which can cause waste of information.

2. Over-sampling is to duplicate random samples from the minority class, which can affect over-fitting [95].

3. Generate synthetic samples: is to sample the attributes from instances in the minority class randomly. We could sample them empirically within a dataset or use a method like Naive Bayes to sample each attribute independently when run in reverse. If data is different and no linear relationships between the attributes may not be preserved. There are systematic algorithms that generate synthetic samples. The most popular of such algorithms is called SMOTE or the Synthetic Minority Over-sampling Technique [96]. As its name suggests, SMOTE is an oversampling method. It works by creating synthetic samples from the minor class instead of creating copies. The algorithm selects two or more similar instances (using a distance measure) and perturbing an instance one attribute at a time by a random amount within the difference to the neighboring instances

Feature selection

Appropriate feature identification has become an essential task to apply data mining algorithms effectively in real-world scenarios. Therefore, many feature selections methods have been proposed to obtain the relevant features or feature subsets in the literature to achieve their classification and clustering objectives. There are three main approaches for feature selection:

- **Filter methods:** The filter approach incorporates an independent measure for evaluating features subsets without involving a learning algorithm. This approach is efficient and fast to compute (computationally efficient). However, filter methods can miss features that are not useful by themselves but can be very useful when combined with others.

- **Wrapper methods:** The filter and wrapper approaches can only be distinguished by the evaluation criteria. Different wrapper algorithms can be generated by varying the subset generation and subset evaluation measure (using dependent criterion). The wrapper approach selects an optimal subset that is best suited to a learning algorithm. Therefore, the performance of the wrapper approach is usually better .

- **Embedded methods:**This approach combines with the learning algorithm at a lower computational cost than the wrapper approach. It also captures feature dependencies. It considers relations between one input features and the output feature and searches locally for features that allow better local discrimination. It uses the independent criteria to decide the optimal subsets for a known cardinality. The learning algorithm is used to select the optimal subset among the optimal subsets across different cardinality .

Approach	Technique	Advantages	Disadvantages	Suitable Models
Filter	Chi-Square Test	Simple, fast, and computationally inexpensive	Ignores feature interactions, may select redundant features	Naive Bayes, Logistic Regression
	Information Gain	Simple, fast, and computationally inexpensive	Ignores feature interactions, may select redundant features	Decision Trees, Random Forests
	Correlation-based Feature Selection	Handles linear correlations well, computationally efficient	Ignores non-linear correlations, may miss important features	Linear Regression, Logistic Regression
Wrapper	Recursive Feature Elimination	Considers feature interactions, less prone to overfitting	Computationally expensive, may miss important features	SVM, Random Forests, Gradient Boosting
	Genetic Algorithm	Handles feature interactions and non-linear relationships well, can find global optima	Computationally expensive, may not scale well with high-dimensional data	SVM, Random Forests, Neural Networks
Embedded	Lasso Regression	Performs feature selection and regularization simultaneously	May struggle with correlated features, requires training data	Linear Regression, Logistic Regression
	Ridge Regression	Performs feature selection and regularization simultaneously	May struggle with correlated features, requires training data	Linear Regression, Logistic Regression

TABLE 2.1: Feature selections methods(Filter/Wrapper/Embedded) [4]

Choosing a model

There are various existing models developed by data scientists which can used for different purposes. These models are designed with different goals in mind. For instance, some models are more suited to dealing with texts, while another model may be better provided to handle images. We need to make the choice that meets our expected outcome. The options for machine learning models can be explored across three broad categories.

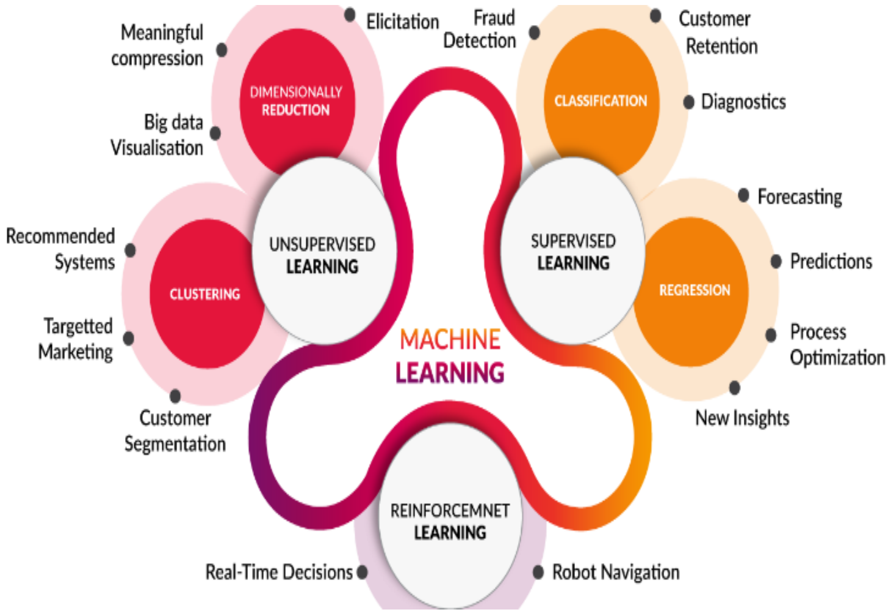


FIGURE 2.4: Machine learning techniques [6]

Model evaluation

Evaluating a model is a crucial step throughout the development of the model. Evaluation metrics have a correlation with machine learning tasks. Figure illustrates various evaluation metrics based on the type of tasks(classification, regression, etc.) all have different metrics. In this section, we are going to shed light on the evaluation metrics used for classification.

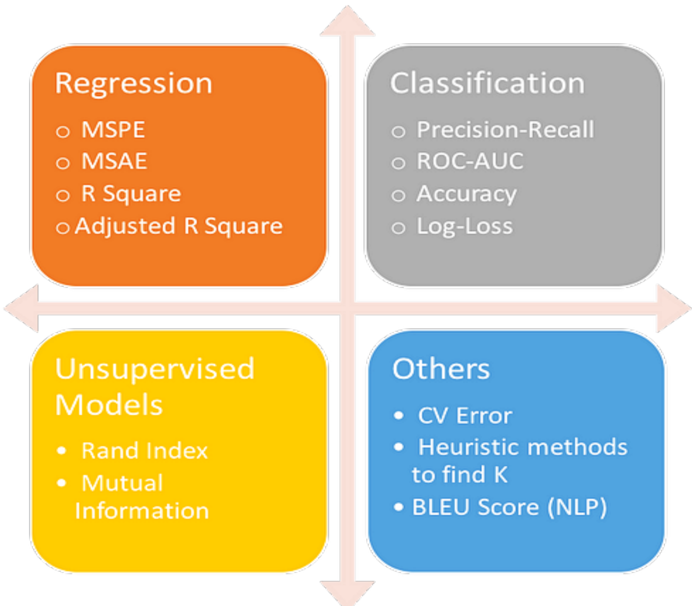


FIGURE 2.5: Machine learning Models evaluation [7]

- Accuracy: is the proportion of correct predictions made by a model over the total number of predictions made.

$$Accuracy = (TP + TN)/(TP + TN + FP + FN) \tag{2.1}$$

- Precision: is the proportion of true positive predictions made by a model over the total number of positive predictions made.

$$Precision = TP/(TP + FP) \tag{2.2}$$

- F1-score: is a combination of precision and sensitivity. Therefore, a high value of F-measure shows a high value of both precision and sensitivity []

$$F1 - score = 2 \times (precision \times Sensitivity)/(precision + Sensitivity) \tag{2.3}$$

- Sensitivity: is the proportion of true positive predictions made by a model over the total number of actual positive instances in the dataset.

$$Sensitivity = TP/(TP + FN). \tag{2.4}$$

- Specificity: is the proportion of true negative predictions made by a model over the total number of actual negative instances in the dataset.

$$Specificity = TN/(TN + FP) \tag{2.5}$$

- ROC (Receiver Operating Characteristic) curve: ROC curve is a graphical representation of the performance of a binary classification model. It plots the true positive rate (TPR) against the false positive rate (FPR) at various classification thresholds.

$$TPR = TP/(TP + FN) and FPR = FP/(FP + TN) \tag{2.6}$$

- AUC/ (Area Under the Curve): is a metric used for binary classification problems to evaluate how well the model is able to distinguish between positive and negative classes. It represents the area under the receiver operating characteristic (ROC) curve.

$$AUC = integral of (TPR) d(FPR) \tag{2.7}$$

where TP is true positives, TN is true negatives, FP is false positives,FN is false negatives,TPR is true positive rate and FPR is false positive rate..

2.3 The development board for Monitoring and tracking systems

We first start by searching for the most important electronic boards for open development and for the most important products and leading companies in this field, and we came to three products or boards ESP8266 Board [97], Arduino Board [98], Raspberry Pi4 [99] and after obtaining the Datasheet (manual) for their use, we create an in-depth comparison for the smallest important details that serve

Feature	ESP8266	Arduino	Raspberry Pi 4
Processing Power	32-bit Tensilica XtensaLX106 CPU	8-bit AVR microcontroller	Quad-core ARM Cortex-A72 CPU
Processor Speed	80-160MHz	16MHz - 32MHz (depending on the board)	1.5GHz (overclockable to 2GHz)
Connectivity	Built-in WiFi	Built-in WiFi	Built-in WiFi, Ethernet, Bluetooth
GPIO Pins	17	Up to 20 digital I/O pins and 6 analog input pins	40
Power Consumption	Low	Moderate	High
Programming	Arduino IDE, Lua	Arduino IDE, C++	Python, C, and other
Language	scripting language	scripting language	high-level languages
Operating System	None	None	Linux and other OSs
Analog Input	1 (10-bit resolution)	Up to 6 (10-bit resolution)	4 (12-bit resolution)
PWM Output	1	Up to 6	2 (Hardware PWM)
ADC	Built-in ADC with 1 channel	Optional ADC module	2 channels (12-bit resolution)
DAC	None	Optional DAC module	2 channels (12-bit resolution)
Operating Voltage	3.3V	5V (compatible with 3.3V)	5V
Storage	4MB built-in flash memory (expandable with SPI flash chips)	32KB Flash (Uno) up to 256KB Flash (Mega) Optional SD card reader	MicroSD card reader up to 16GB eMMC Flash storage (depending on model)
USB Ports	1 micro USB port (for power and programming)	1 micro USB port (for programming and power)	2 USB 3.0 ports, 2 USB 2.0 ports and 1 USB-C port
Audio	None	None	HDMI and 3.5mm audio jack
Wireless Protocols	Wi-Fi b/g/n	None	Wi-Fi b/g/n/ac, Bluetooth 5.0
Memory	80KB RAM and 4MB Flash	2KB RAM	2GB or 4GB LPDDR4-3200 SDRAM,
GPIO Voltage	3.3V (not 5V tolerant)	5V (tolerant to 3.3V)	3.3V (not 5V tolerant)
Size	Small (25.4 x 50.8 mm)	Small to medium (Uno: 53.3 x68.6 mm, Mega: 101.6 x 53.3 mm)	Medium (88 x 58 x 19.5 mm)
cost	7*to*12 (958-1643 DZ)	24*to*50 (3286-6845 DZ)	109*to*195 (14836.1-26541.99 DZ)

TABLE 2.2: Comparison between development board

After examining the various characteristics of these panels shown in the table above, we generally concluded that there are differences that may or may not matter, depending on the field of use, but especially in our field, we concluded that using ESP8266 Board is the most appropriate and best solution in terms of price, energy consumption, accuracy, and Other privileges.

2.4 The development devices for Monitoring and tracking systems

2.4.1 Monitoring sensors

After completing the search for the most important electronic boards for development, we went to the stage of searching for sensors and the most important products and leading companies in this field, and we concluded that there are many products or sensors, including similar ones and different ones according to several criteria, and after obtaining the manual for their use, we divided them First, according to the nature and type of information to be monitored and collected, then we created an in-depth comparison of the most important details that serve us in this experiment, summarized in the following tables:

Temperature Sensors:

We start first with the Body temperature sensors, where we found that there are two types, the first is for the environment, and the other is for topical or for medical use.And when searching for the type intended for topical use, we found several types, from which we selected the best and most famous three LM35 sensor [100],Ds18B20 sensor [101],Maz30102 sensor [102] and we reviewed the evidence for their use, and we concluded this comparative table shown below:

Feature	**LM35**	**DS18B20**	**MAX30102**
Temperature Range	-55°C to +150°C	-55°C to +125°C	-40°C to +85°C
Accuracy	+/- 0.5°C (typical)	+/- 0.5°C(typical)	+/- 0.1°C (typical)
Response Time	~400ms (to reach 63% of final reading)	750ms to 2s (depending on resolution)	<2s
Output Type	Analog	Digital	Digital
Communication Protocol	N/A	1-Wire	I2C
Power Consumption	60 µA (typical)	1 mA (typical)	1.6 mA (typical)
Cost	Relatively inexpensive (usually under $2 273 DZ)	Moderately priced (usually under $5 684 DZ)	Moderately priced (usually under $10 1369 DZ)
Additional Features	N/A	Can operate on long cables (up to 10m)	Can also measure heart rate an d blood oxygen saturation

TABLE 2.3: Comparison between Temperature sensors

After examining the various characteristics of these sensors shown in the table above, we generally concluded that there are differences that may or may not matter, depending on the field of use, but especially in our field, we concluded that using DS18B20 sensor is the most appropriate and best solution in terms of price, energy consumption, accuracy, and size. Availability and other benefits

Heart Rate Sensors:

Then we went to the third element represented by heart rate sensors, where we found that there are several types in terms of technology or measurement method, including: optical heart rate sensors (PPG), electrocardiogram sensors (ECG) and radar heart rate sensors...and When searching for the type intended for daily and medical use, we found several versions and products, from which we selected the best and most famous three Max30100 sensors [103],Max30102 sensors [102],SEN-11574 sensors [104] and we reviewed the manual for their use, and we concluded this comparative table shown below:

Features	**MAX30102**	**MAX30100**	**SEN-11574**
Dimensions	5.6mm x 3.3mm	3.3mm x 6.7mm	18mm x 15mm x 5mm
Operating Temperature	-40°C to +85°C	-40°C to +85°C	-40°C to +85°C
Heart Rate Monitoring	Yes	Yes	Yes
SpO2 Monitoring	Yes	Yes	Yes
Motion Artifact Removal	Yes	Yes	Yes
LED Current Range	0.2mA - 50mA	4.4mA - 44mA	0.2mA - 50mA
LED Pulse Width	1600ns	1600ns	200ns - 1600ns
Supply Current	1.8mA @ 100sps	600µA @ 100sps	50mA @ 100sps
Ambient Light Rejection	moderate	low	High
Power Supply	1.8-2.0V	2.7-5.5V	3.3V
LED Wavelength	Red/IR	Red/IR	Red/IR
Sampling Rate	Up to 320Hz	Up to 1000Hz	Up to 1600Hz
Communication	I2C/SPI	I2C	I2C/SPI
Price	3*to*5(409-681Dz)	3*to*5(409-681Dz)	20*to*25(2738-3422Dz)

TABLE 2.4: Comparison between Heart Rate sensors

After examining the various characteristics of these sensors shown in the table above, we generally concluded that there are differences that may or may not matter, depending on the field of use, but especially in our field, we concluded that using **MAX30102 sensor** is the most appropriate and best solution in terms of price, energy consumption, accuracy, and size. Availability and other features.

Air Pressure sensors:

Then we went to the second element represented in the air pressure sensors (atmospheric), where we found that there are several types in terms of technology or measurement method, including: thermal pressure sensors, piezoelectric pressure sensors and pressure sensors for micro-electromechanical systems (MEMS) ... and when searching for The type intended for use in closed places and populated buildings, we found several versions and products, from which we selected the best and most famous three BMP280 [105],BMP180 [106],BM1383AGLV [107] and we reviewed the manual for their use, and we concluded this comparative table shown below:

Feature	**BMP280**	**BMP180**	**BM1383AGLV**
Measurement Range	Temperature: -40°C to 85°C	Temperature: -40°C to 85°C	Temperature: -40°C to 85°C
	Pressure: 300 hPa to 1100 hPa	Pressure: 300 hPa to 1100 hPa	Pressure: 300 hPa to 1200 hPa
	(9000 m to -500 m altitude)	(9000 m to -500 m altitude)	(9000 m to -500 m altitude)
Accuracy	Temperature: ±0.01°C	Temperature: ±0.1°C	Temperature: ±0.5°C
	Pressure: ±0.18Pa	Pressure: ±1 Pa	Pressure: ±0.08 Pa
	(equivalent to ±1 m)	(equivalent to ±1 m)	(equivalent to ±3.2 m)
Power Consumption	2.7 µA (at 1 Hz sampling rate)	0.5 µA (at 1 Hz sampling rate)	1.2 µA (at 1 Hz sampling rate)
Interface	I2C, SPI	I2C	I2C, SPI
Operating Voltage	1.7V to 3.6V	1.8V to 3.6V	1.7V to 3.6V
Size	2.5 x 2.5 x 0.93 mm	3.6 x 3.8 x 0.93 mm	3 x 3 x 1 mm
Other Features	Altitude measurement (based on pressure)	None	None
Sampling Rate	Up to 75Hz	Up to 50Hz	Up to 200Hz
Measurement Mode	Normal, Forced, Standby	Ultra-Low-Power, Standard, High	Normal, Fast, Forced
Data Output Rate	Up to 200Hz	Up to 128Hz	Up to 200Hz
Filter	Digital filter with adjustable bandwidth	None	Digital filter with adjustable bandwidth
Standby Time	0.5ms to 1000ms	N/A	0.5ms to 1000ms
Response Time	1s (Normal), 125ms (Fast), 20ms (Forced)	1s (Ultra-Low-Power), 5ms (Standard), 8ms (High)	2ms (Normal), 0.6ms (Fast), 0.1ms (Forced)
Calibration	Factory-calibrated with calibration coefficients stored in on-chip non-volatile memory	Factory-calibrated with calibration coefficients stored in on-chip non-volatile memory	Factory-calibrated with calibration coefficients stored in on-chip non-volatile memory
Cost	$2to5$ (136.36-681.78Dz)	$1to3$ (136.36-409.07Dz)	$1to2$ (136.36-272.71.07Dz)

TABLE 2.5: Comparison between air Pressure sensors

Overall, the BMP180 and BM1383AGLV are generally less expensive than the BMP280, although the price difference may not be significant for small-scale projects. The cost of the sensor is just one factor to consider when choosing a sensor, and it is important to evaluate the trade-offs between cost, performance, and features when making a decision.

We came to the valid perception that there are differences between these sensors that may or may not matter, depending on the field of application. However, specifically in our field, we found that using the **BMP280 sensor** is the most appropriate solution is that it is available on one of the most important characteristics, which is giving the height relative(Altitude) to sea level, depending on the prevailing atmospheric pressure in the region, and the best in terms of price, energy consumption, accuracy, size, availability, and other privileges.

2.4.2 Tracking and Location devices(sensors)

Then we moved on to the last and most important in this research represented by the positioning devices, where we found that there are several types in terms of the technology used in communication or the method of collecting information, including: GPS (Global Positioning System) [108] GLONASS (Global Navigation Satellite System) [109] Galileo Navigation System [110] BeiDou Navigation Satellite System [111] Wi-Fi Positioning System [112] Bluetooth Low Energy (BLE) Beacons [113] Inertial Measurement Units (IMUs) [114] Google GPS API integrated sensors [115] When searching for the type intended for indoor use and suitable for our environment and the nature of our buildings, we found several versions and products, from which we chose the best and most famous three, and we reviewed them, and we finished with this comparative table shown below:

Feature	Wi-Fi Positioning Sensors	GPS NEO-6M Sensors	Google GPS API
Accuracy	Moderate to High	High	High
Indoor/Outdoor Use	Indoor	Outdoor/Indoor(Depending on the nature of the building)	Both
Availability	Requires Wi-Fi Access Points	Requires Clear Line of Sight to Satellites	Requires Internet Connection
Power Consumption	Low	Moderate	Low
Cost	Low	Moderate to High	Free
Integration with Devices	Easy	Requires Additional Hardware	Software API
Granularity of Location Data	Depends on Density of Wi-Fi Access Points	Precise Coordinates	Precise Coordinates
Time to First Fix	Fast	Slow	Fast
Robustness to Interference	Vulnerable	Resistant	Resistant
Data Usage	Minimal	Minimal	Moderate
Continuity of Service	Dependent on Wi-Fi Access Points	Continuous Service	Dependent on Internet Connection
Geographical Coverage	Limited to areas with Wi-Fi Access Points	Global	Global
User Privacy	User's location data may be shared with third-party Wi-Fi providers	User's location data is generally not shared	User's location data is shared with Google
Multi-platform Support	Supported on most platforms	Supported on most platforms	Supported on most platforms
Ease of Use	Requires knowledge of network and algorithm development.	Requires knowledge of GPS and microcontrollers	Requires knowledge of software development
Integration with Other Sensors	Can be integrated with other sensors such as accelerometers and temperature sensors for more advanced applications.	Can be integrated with other sensors, but requires additional hardware and programming	Can be integrated with other sensors through software development
Data Security	Wi-Fi signals can be intercepted and location data compromised	GPS signals can be jammed or spoofed, leading to inaccurate location data	Google has data security measures in place to protect user data
Real-Time Updating	Real-time location updates may be delayed due to signal strength and network connectivity	Real-time location updates may be delayed due to satellite signal strength and network connectivity	Real-time location updates may be delayed due to network connectivity and server response times

TABLE 2.6: Comparison between Tracking and Location sensors

As shown in the table, Wi-Fi positioning sensors have moderate to high accuracy and are suitable for indoor use, whereas GPS sensors have high accuracy and are suitable for both indoor and outdoor use. Google GPS API provides high accuracy, but requires an internet connection to access. Wi-Fi positioning sensors have low power consumption and cost, but their accuracy depends on the density of Wi-Fi access points. GPS sensors have higher power consumption and cost, but provide precise location data regardless of the density of access points. Google GPS API is free but requires an internet connection and a software API to access location data.

Wi-Fi positioning sensors have a fast time to first fix, which means they can provide a location fix quickly after being turned on. GPS sensors, on the other hand, have a slower time to first fix, as they require a clear line of sight to satellites. Wi-Fi positioning sensors are vulnerable to interference and signal blocking, whereas GPS sensors are resistant to these issues. Data usage is minimal for both Wi-Fi positioning sensors and GPS sensors, but can be moderate to high for Google GPS API, depending on how often location updates are requested. Continuity of service is dependent on Wi-Fi access points for Wi-Fi positioning sensors, continuous for GPS sensors, and dependent on an internet connection for Google GPS API. Geographical coverage is limited for Wi-Fi positioning sensors, as they only work in areas with Wi-Fi access points. GPS sensors have global coverage, while Google GPS API also provides global coverage.

After examining the various characteristics of these sensors shown in the table above and Discuss it, we generally concluded that there are differences that may or may not matter, depending on the field of use, but especially in our field, we concluded that the use of **Google MAP API**.It is the most appropriate solution because it has one of the most important characteristics, which is giving the location with high accuracy depending on the availability of an Internet connection, whether it is internally or via mobile networks externally, and the best in terms of price, energy consumption, accuracy, availability and other privileges.

2.5 Conclusion

In conclusion, this chapter highlights the importance of IoT and data accuracy in healthcare. The application of IoT and computing technologies, specifically in the healthcare sector, presents both opportunities and challenges. While IoMT has the potential to improve patient care and well-being, its implementation requires addressing issues such as real-time response, data security, scalability, data management, and availability. The specific problem addressed in the chapter is real-time patient monitoring and accurate location tracking in critical healthcare domains. Combining IoMT and computing is a significant challenge that necessitates addressing data accuracy, security, scalability, and other key concerns. Overall, the chapter emphasizes the significance of IoT and data accuracy in healthcare while acknowledging the complexities involved in their integration.

Chapter 3

SMB: Smart Medical Bracelet Design

3.1 Introduction

In this chapter, we will explore the concept of a smart bracelet that harnesses the power of IoT technology to provide users with a seamless and personalized experience. We will discuss design considerations, technical specifications, and potential use cases for our smart bracelet. We have divided it into parts, where we find in the first part the definition of the devices used, followed by the second scenario of concepts (description using the UML model) and finally the proposed procedures and algorithms. Ultimately, our goal is to create a device that is not only functional and efficient, but also aesthetically pleasing and comfortable to wear. Where readers will have a comprehensive understanding of the process of designing a smart bracelet in the era of the IoT, and will be equipped with the knowledge and skills necessary to develop their own innovative wearable devices.

3.2 SMB Functions

This section explains the proposed system architecture and its functions using UML model.

3.2.1 General Architecture

The general conceptual model of the system we have been working on is shown in Figure 3.1, which is made up of a three-section.

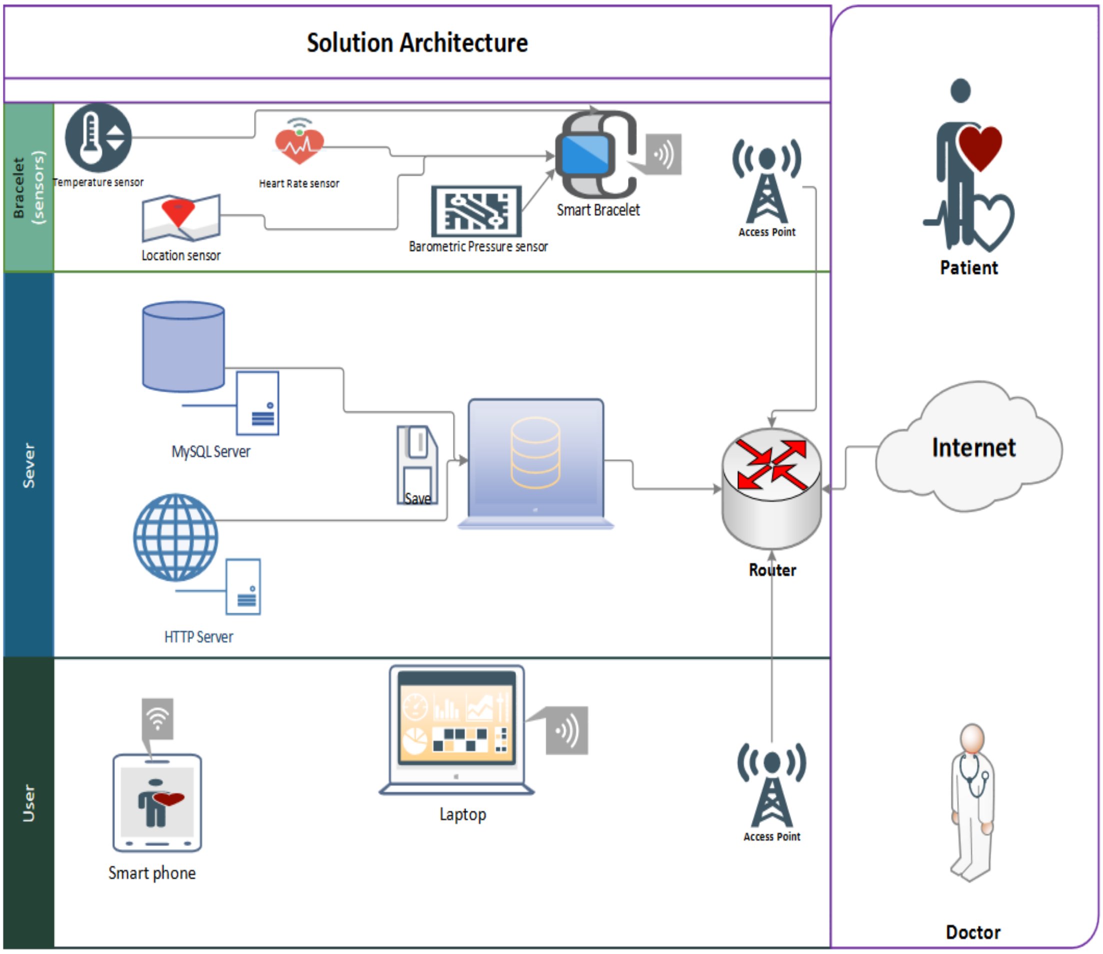


FIGURE 3.1: Proposed General Architecture

- The first part consists of a set of medical sensors included in one bracelet (e.g., heart rate sensor, O2 level sensor, temperature body sensor, ...etc) that we place in the human body or attach them on his hand. The sensed data using these sensors will be forwarded to a base station. where each sensor picks up values and sends them to a base station. Therefore, the publisher here represents the local server which is in contact with the users at the other end via local network.

- The second part consists of a base station (Server) that receives the collected data from the bracelet, promotes patient database with more information about each patient.

- The third part is a subscriber (User), in which each doctor/nurse will be the supervisor/observer of one or more patients. So, they can consult patients' sensed data using the stored computer database, cure patients according to their updated situation in real-time, offer immediate intervention, predict the coming urgent situation. With the possibility of rounding the time.

3.2.2 System Visualization and Construction

System User Details

This section summarizes system user roles which consists of three basic elements, as shown in Figure 3.2 below.

- Patient: is the sample on which the study will be carried out. He can wear the bracelet alone or with the help of a nurse to make sure that it is working. Then it will be automatically linked to the previously programmed local network. After that, the bracelet starts collecting, sensing and capturing the current health data of this patient through the sensors embedded inside it, as well as providing his current location. At the end, the sensed data will be processed and sent to the main station via the same network (Wi-Fi).

- Nurse/doctor: Here we find that they have common requirements. At the beginning, one of the display devices must be used, either a smart phone or a computer, the local network of the hospital is connected, after which the account is logged in using the user name and password, we find a set of available tasks that are represented on operations related to patient information, such as viewing patient current health information and his current location. In addition to a distinctive feature, which is the ability to receive real-time alerts in the event that the patient's condition suddenly deteriorates, and the possibility of exploiting the service of predicting emergency cases for the patient. While the nurse handles the other tasks related to the bracelets such as: i) adding new bracelets, i.e., including them in the network and the system, and assigning them to patients, ii) modifying the settings of a bracelet and to whom it is assigned, such as its number, name, surname, and information related to patient's condition, as will as she can delete a bracelet.

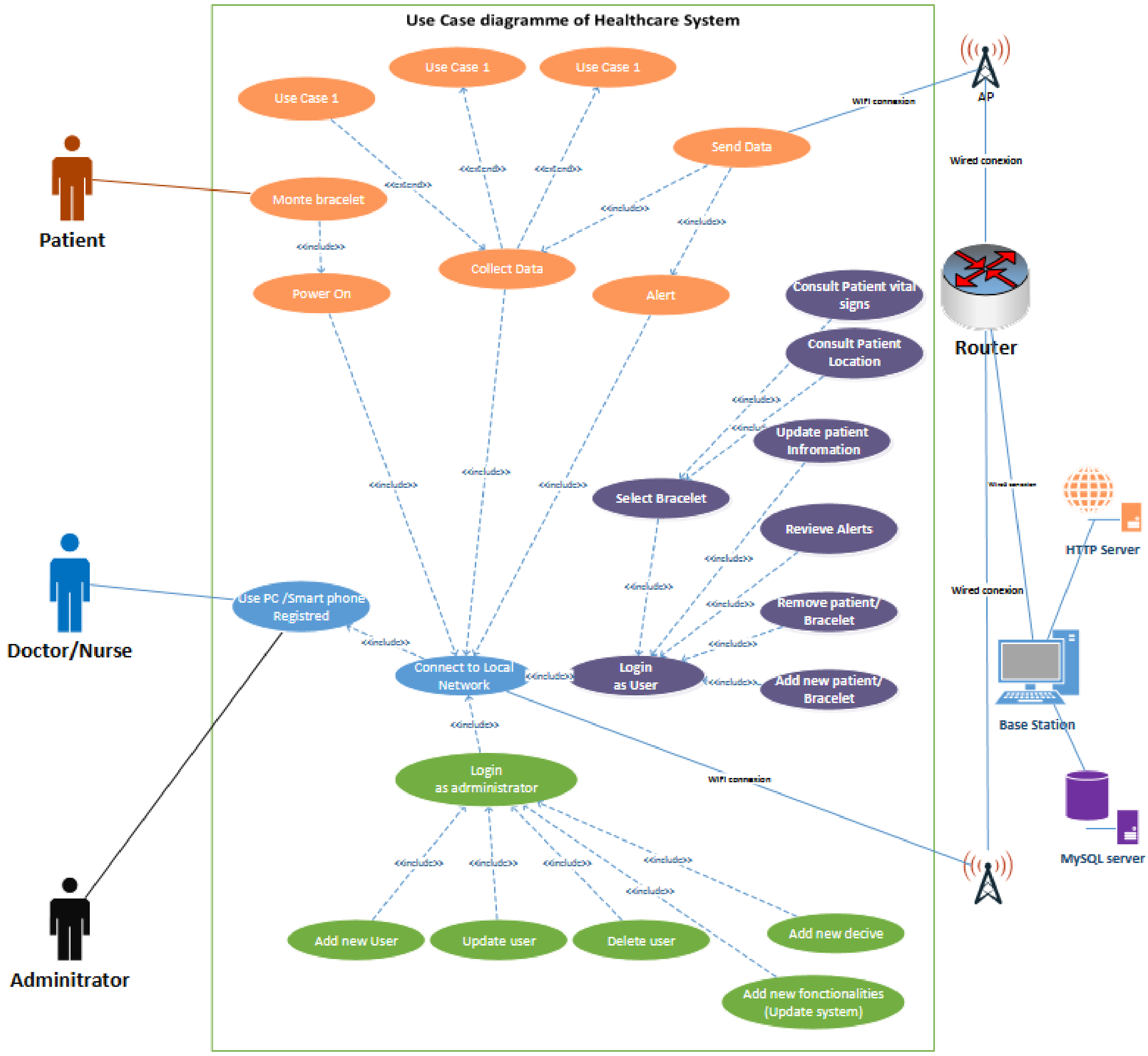


FIGURE 3.2: Use Case Diagram

- admin: has other characteristics related to the system in general, such as adding or modifying user information, deleting it, or adding a device, and it also has the ability to update the system if necessary.

System Operation Dynamic Aspects

This section presents the dynamic aspects of system operation using UML Activity Diagram. As shown in Figure 3.3, system scheme is divided on three elements, each of them plays a role in system function according to a specific sequence of actions.

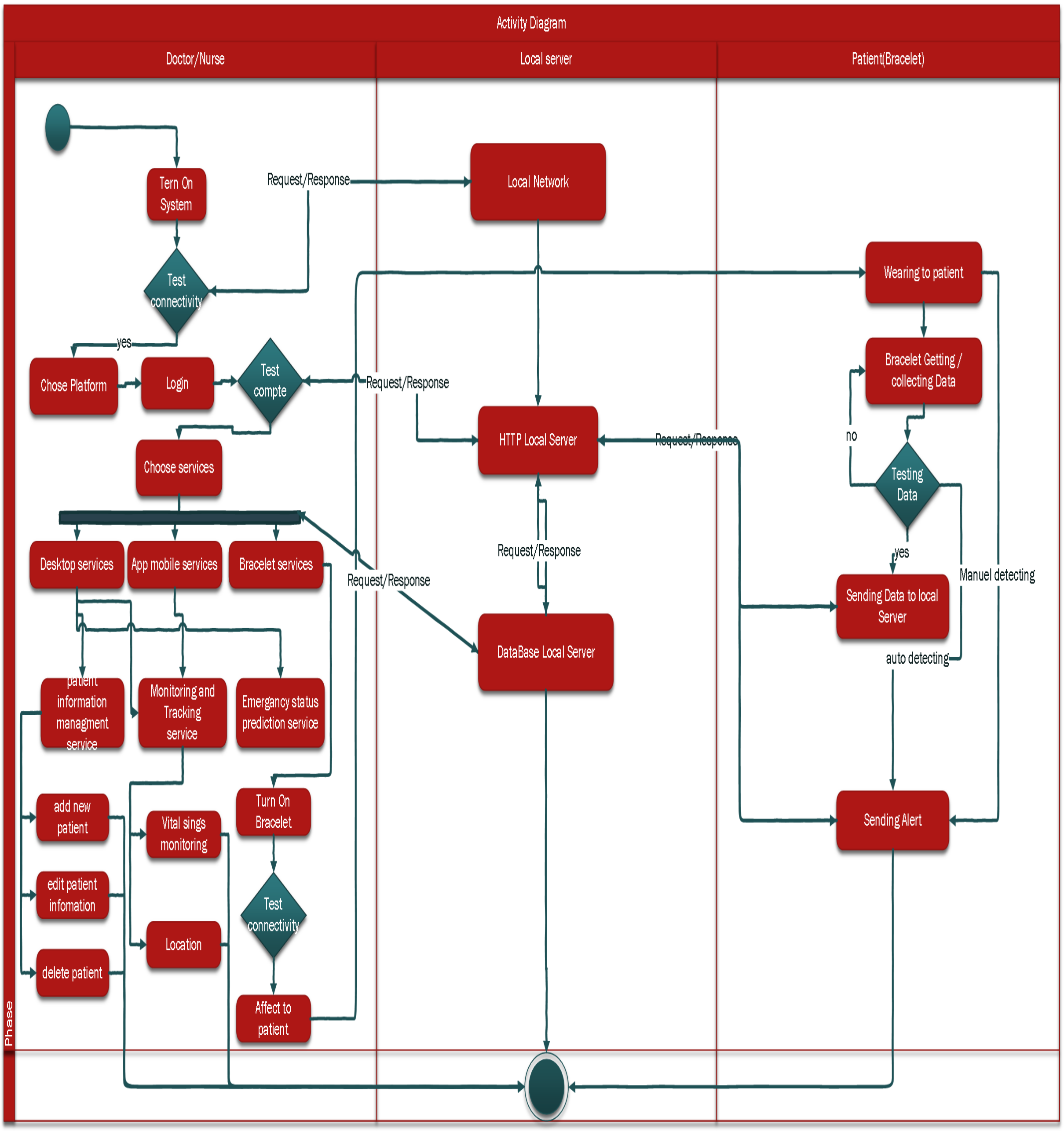


FIGURE 3.3: Activity diagram

System Interaction

This section visualizes the interactive behavior of the system which is not trivial task using UML Sequence Diagram, see Figure 3.4.

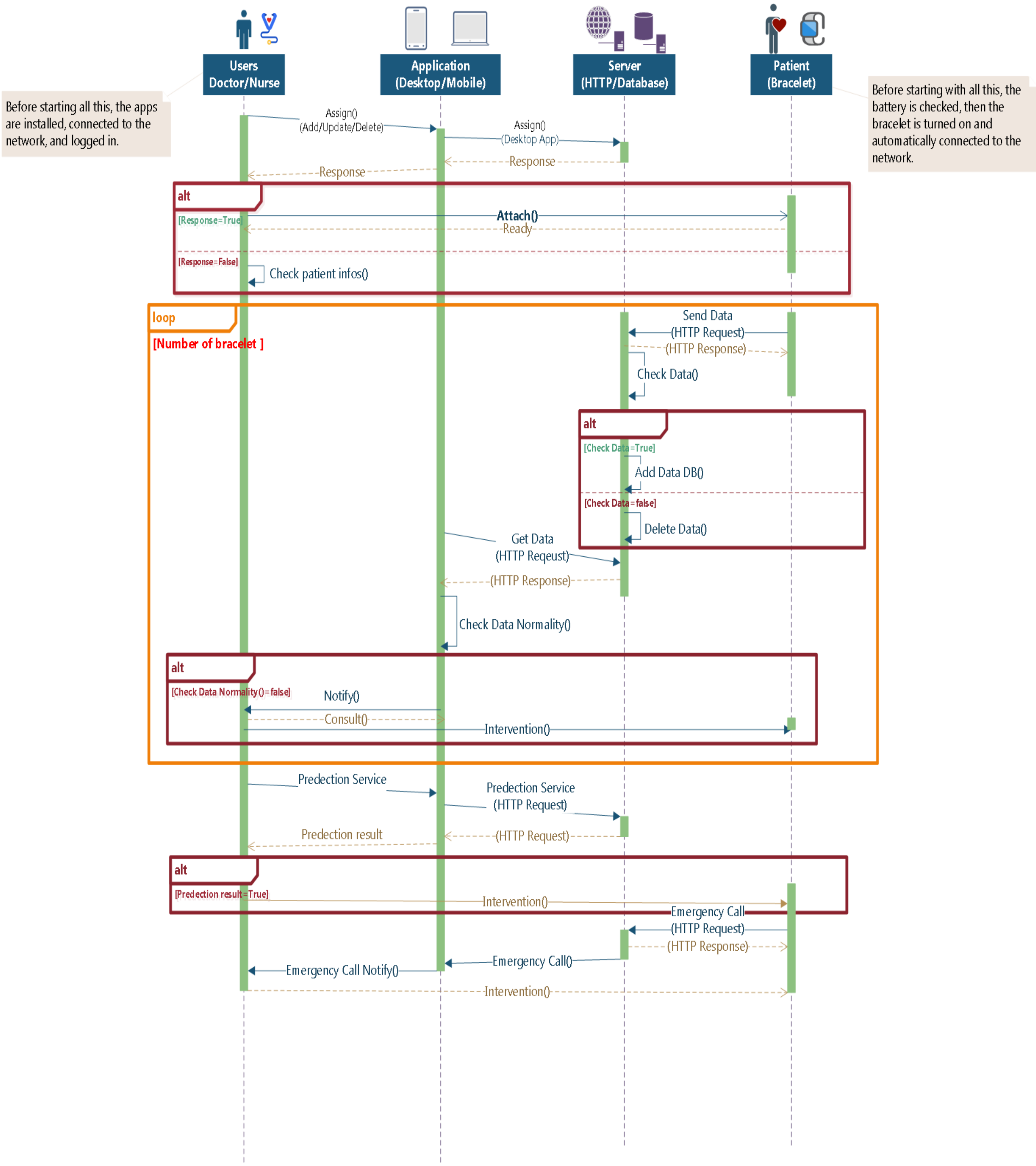


FIGURE 3.4: Sequence diagram

Our system consists of four pillars of integrated tasks, which are subject to a sequence based on the exchange of various information and tasks, shown in the above diagram, where we find:

The user: who is represented by a member of the medical staff (doctor/nurse), where we find that he has two functions. The first is to assign the bracelet to the patient via a computer application, and this is of course after logging in correctly and ensuring the integrity of the patient's information entered previously or currently. Secondly, which is attaching the bracelet on the patient's wrist and fixing it well, of course, after making sure that it is ready on the electrical sides and connected to the network. In case of encountering any problem in the previous steps, it is re-checked or contacted maintenance.

After the success of all the previous steps, the system will start working automatically, as the bracelet senses the values of the vital indicators of the patient at the present time, collects them, and checks their reasonableness. If the values are valid, it creates an HTTP request to the local server, Apache, containing these values, and sends it to the local server of the MySQL databases through the local WiFi network connected to it, and it also responds with an HTTP response message attached to a number indicating the status of the message (success / failure / ...etc) By means of a code that was previously discussed in the part explaining the HTTP protocol, and if the data is wrong, it deletes it, taking into account that it is not repeated and alerting to that.

We then move to the phone and computer applications, where each of them sends an HTTP request to access the information stored on the local server of the MySQL databases. Upon request, he examines it and compares it with the normal values of a healthy person, and any values outside these fields. He displays two audio and visual alerts showing the type of abnormal vital indicator, as well as the exact current location of the patient, as we mentioned earlier. Based on these alerts, a quick intervention is made to aid the patient if necessary. This scenario, which we discussed, concerns one bracelet, and the rest are followed by the same steps, and it is repeated according to a time determined by the default battery life and the needs of medical professionals.

We move to another part of the patient's calls, in the event that the patient wants to send a distress call, he presses the button designated for that, and from it an HTTP request message containing the call is generated and sent to the server, in turn he sends it to the two applications, which in turn show an audio and visual alert that differs from the alerts It does not stop unless it is seen and intervened to aid the patient.

Finally, we explain the part related to the prediction service provided by the server, which works with two features, the first is automatic, which depends on the current data of the patient, and when predicting the existence of an unusual condition, it sends alerts accompanied by information about the patient, his condition and location. The other is manual, i.e. opening a window dedicated to that. Addressing it previously, filling out the data, and activating the service that is returned as a result of either positive or negative, and which has to adopt decisions regarding the quality of services provided to the patient.

System Blueprints

This section models the objects that make up the system, displays the relationships between the objects, and describes what those objects do and the services that they provide as shown in Figure 3.5.

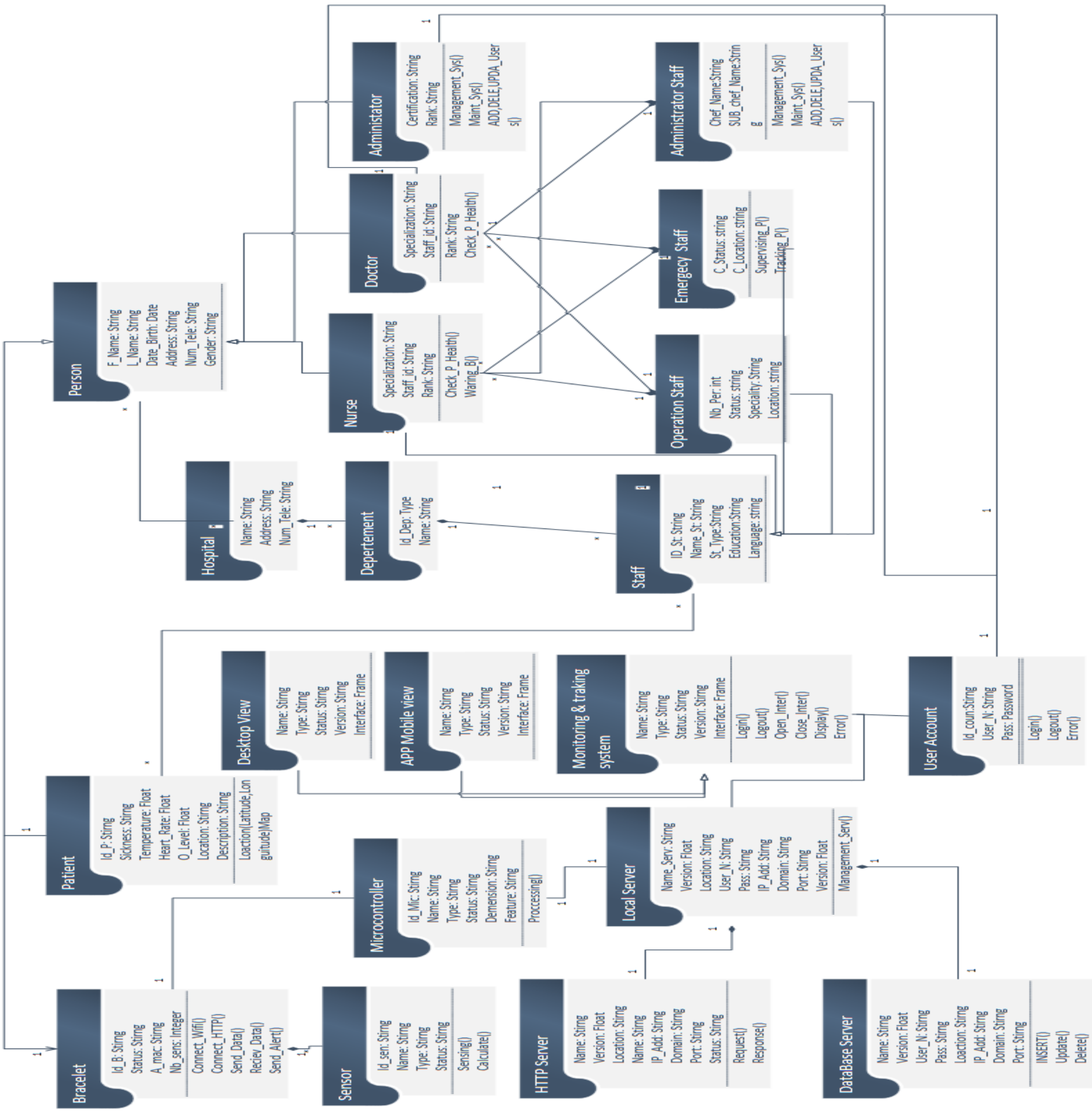


FIGURE 3.5: Class diagram [4]

3.2.3 System Model Scenario

In this section, we proposed two scenarios to summarize system functions, The first one shows the normal situation and summarizes its course, while the second one shows the emergency situation and procedures accompanying it.

- **Normal case:** we simulated the work environment, so we tried to make it as close to reality as possible in the following figure

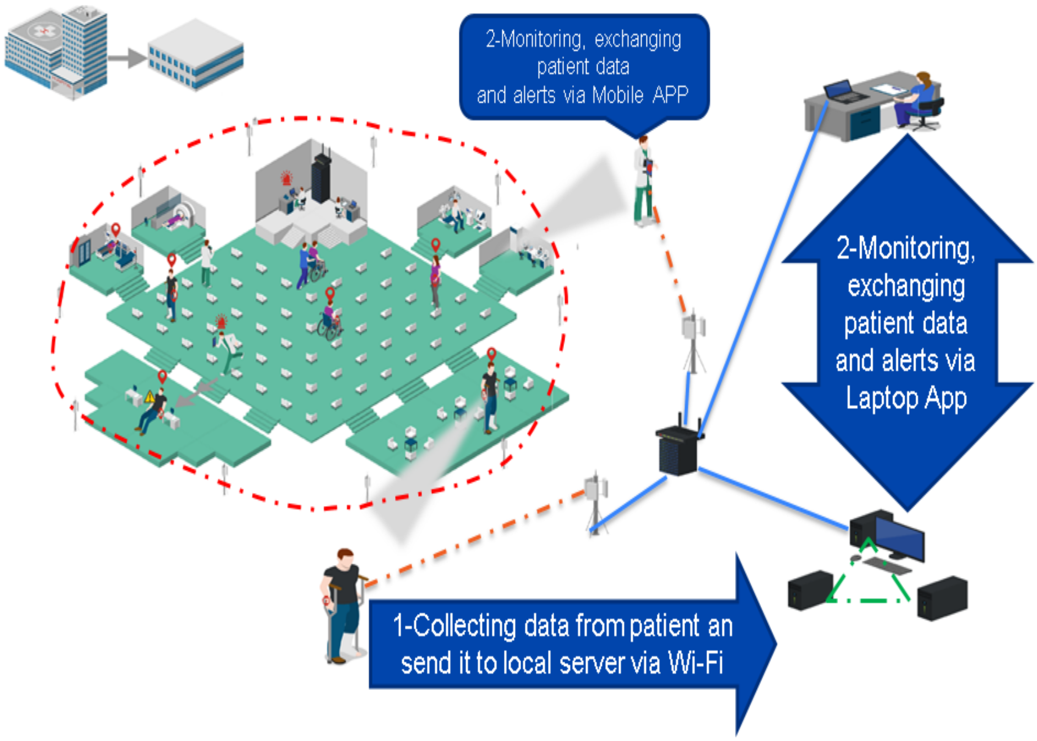


FIGURE 3.6: First scenario(normal case)

The first scenario represents the normal case for both the patient and the medical staff, where we find that the patient wears the bracelet that is connected to the local network of the hospital and can roam and move around the hospital in specific places, after making sure that his condition allows that. While the patient is moving, the sensors embedded within the bracelet sense his vital signs, determine his exact location, and ensure the reasonableness values, then send them to the local server every pre-specified time period via WiFi.

On the opposite side, the medical staff monitors the values of the vital signs sent by each bracelet and then checks them. The current location of the patient can be tracked on the hospital map. All these tasks will be performed either through a smartphone or computer. There is another additional feature that enables us to predict the patient's condition within a maximum period of 28 days if he is recovering or going to die within the next 28 days.

- **Emergency case:**

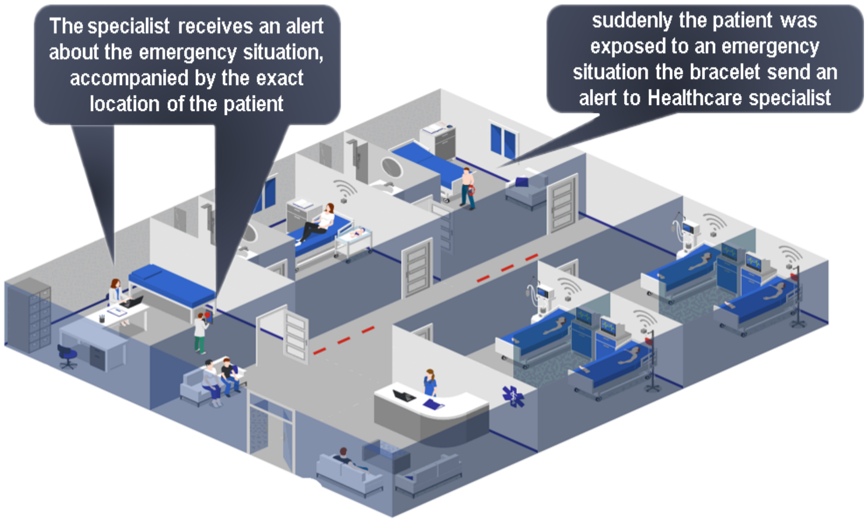


FIGURE 3.7: Second scenario(Emergency case)

The second scenario represents the emergency situation of patient and medical staff, where we find that the patient wears the bracelet that is connected to the local network, so he can hang around inside the hospital after making sure that he is in good conditions. During the movement of the patient, suddenly he exposes to a health problem, then the bracelet sends an urgent alert to doctor/nurse contains patient vital signs and exact location on 3D axes for alerting the existence of an emergency that requires rapid intervention.

On the opposite side, the medical staff receives an audio alert (notification) attached to a report showing the abnormal vital component of the bracelet owner with the number, as well as the exact location, including the floor and the room. By observing the values of the vital indicators sent by the bracelet and then examining them, the medical staff speeds up to provide immediate intervention for the patient, taking into account the provided information by his bracelet. All these tasks will be performed either through a smartphone or computer.

3.3 SMB Compositions

In this section, we explain the implementation of the bracelet node side. First, we need:

1. NodeMcu(Esp8266)
2. Pulse Heart sensor (Max30102)
3. Body Temperature sensor (DS18B20)
4. Barometric Pressure sensor (BMP280)

5. GPS Module (GPS-Neo-6M) (Optional)

6. Push Button 4 Pin

7. Jumper wire

8. Power supply (Battery charger TP4056, Lithium Battery, Regulator 5V to 3.3V)

Components Description

1. **NodeMcu(Esp8266):** MCU stands for Micro-controller Unit - which means it is a computer on a single chip. A micro-controller contains one or more CPU's (processor cores) along with memory and programmable input/output peripherals project and built on the Espressif Non-OS SDK for ESP8266. also is an open-source firmware and development kit that helps you to prototype or build IoT products. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The firmware uses the Lua scripting language. It is based on the eLua project and built on the Espressif Non-OS SDK for ESP8266. The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and micro-controller capabilities, which makes it an ideal platform for IoT (Internet of Things) applications. It provides an onboard USB-to-serial converter for easy programming and debugging, as well as a range of GPIO pins, PWM, IIC, 1-Wire, for connecting various sensors and actuators. for more information about NodeMcu we invited you to read this datasheet [?] [2].

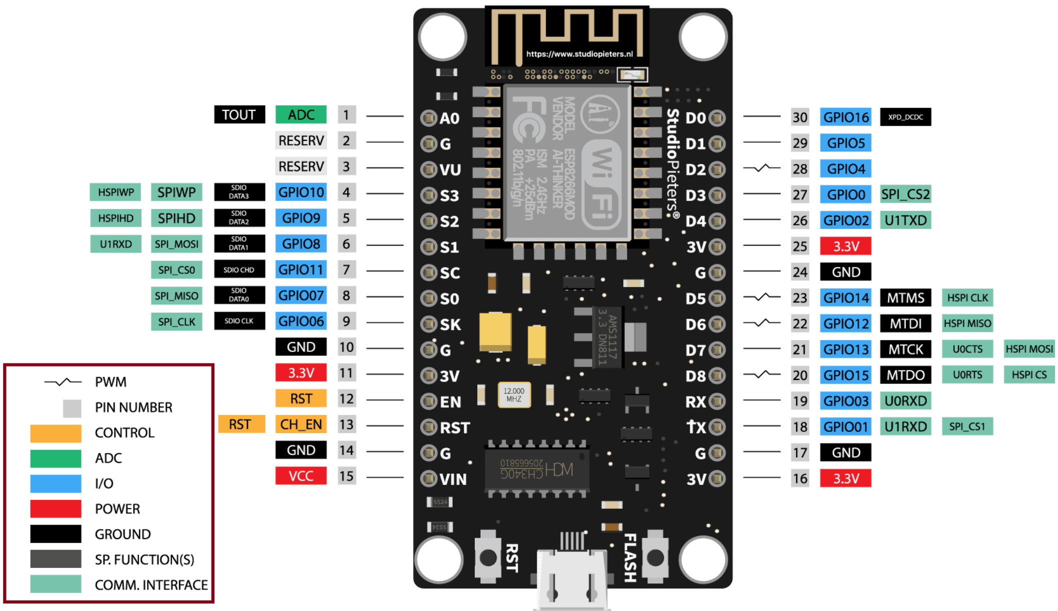


FIGURE 3.8: NodeMcu(Esp8266) [4]

2. **Pulse Heart sensor (Max30102):** The MAX30102 sensor is a highly integrated optical sensor module, offers high sensitivity, low power consumption. that is designed for use in wearable devices and healthcare applications. It combines two LED's, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart rate signals. The sensor utilizes two LED's, a red LED and an infrared LED, which are used to shine light through the skin and detect the amount of light that is absorbed by oxygenated and deoxygenated blood. The photodetector then measures the intensity of the light that is transmitted through the skin and converts it into an analog electrical signal. The signal is then processed by the onboard analog front-end and digital signal processing circuits, which remove the noise and extract the pulse oximetry and heart rate signals.

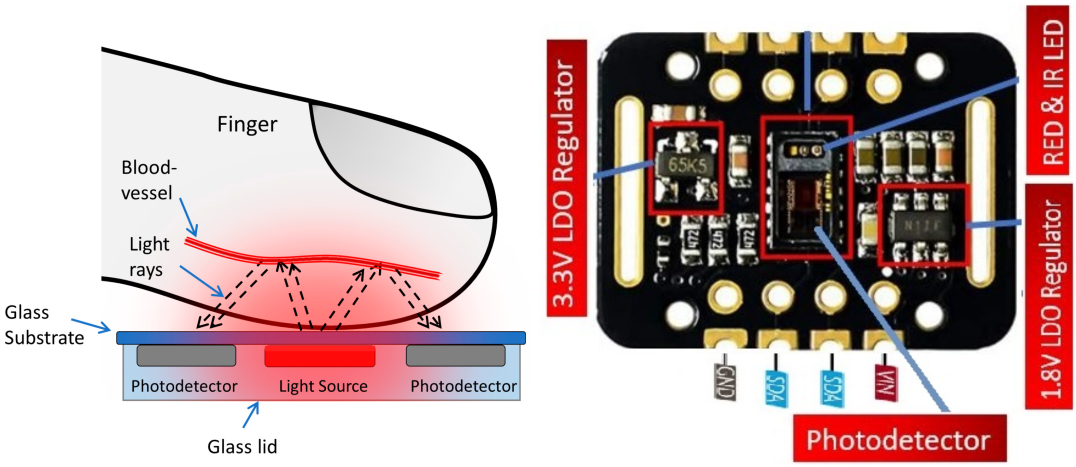


FIGURE 3.9: Pulse Heart sensor (Max30102) [4]

3. **DS18B20 temperature sensor:** is a digital temperature sensor that uses a one-wire interface to communicate with microcontrollers such as ESP8266. It is a low-cost, high-precision sensor that can measure the temperature of the surrounding environment or an object with an accuracy of ±0.5°C over the range of -10°C to +85°C. The sensor has a wide temperature measurement range of -55°C to +125°C and a resolution of up to 12 bits, providing a temperature resolution of 0.0625°C. The DS18B20 sensor is housed in a small waterproof stainless steel package, which makes it suitable for use in harsh environments. The one-wire interface simplifies the wiring and allows multiple sensors to be connected to a single micro-controller.

4. **BMP280 barometric sensor :** sensor is a barometric pressure and temperature sensor form Bosch that is used to measure atmospheric pressure and ambient temperature with high accuracy and low power consumption. It is a small, low-cost, and easy-to-use. The BMP280 sensor utilizes MEMS (Micro-Electro-Mechanical Systems) technology to measure pressure and temperature. It can measure pressure in the range of 300 to 1100 hPa with an accuracy of ±1 hPa and temperature in the

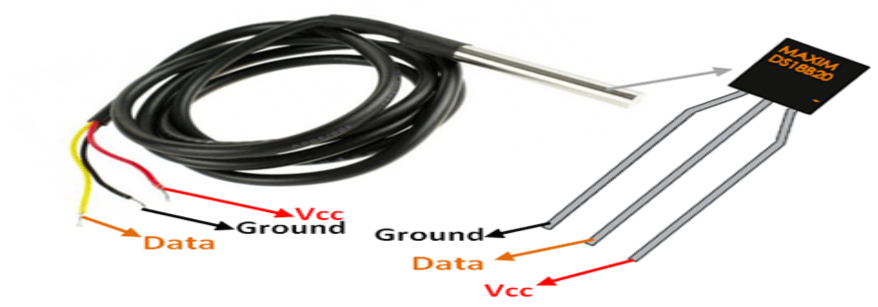


FIGURE 3.10: DS18B20 temperature sensor [4]

range of -40°C to +85°C with an accuracy of ±1°C. The sensor has a resolution of up to 20 bits for pressure and 16 bits for temperature, which provides high precision and sensitivity. The BMP280 sensor communicates with microcontrollers through I2C and SPI interfaces, which makes it easy to integrate with popular development platforms such as NodeMcu. It also has a low power consumption mode, which makes it suitable for battery-powered applications such as weather stations, altimeters.

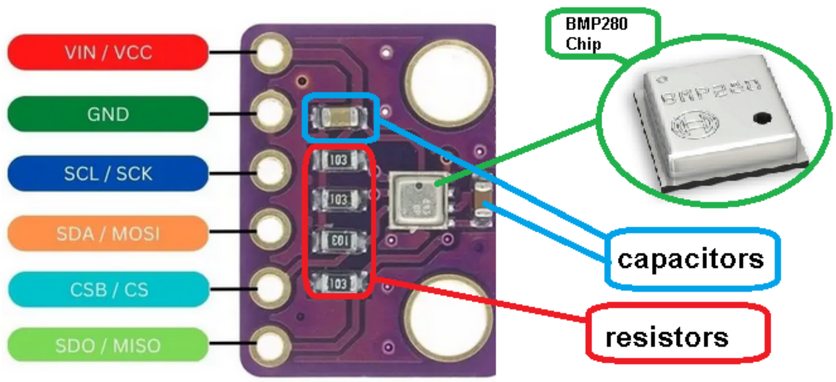


FIGURE 3.11: BMP280 Barometric sensor [4]

5. **Global Positioning System module (GPS-Neo-6M) :** is a device that receives signals from GPS satellites to determine its position and time. The module consists of a GPS receiver, an antenna, and associated electronics, including a micro-controller and memory. The GPS receiver collects data from multiple GPS satellites to determine the user's latitude, longitude, altitude, and speed. The antenna is used to receive the signals from the satellites, and the micro-controller processes the data to provide the user with accurate location and time information. The GPS-Neo-6M is a commonly outdoor used GPS module that offers high accuracy and fast time-to-first-fix performance, making it suitable for a wide range of applications, including navigation, tracking, and timing.

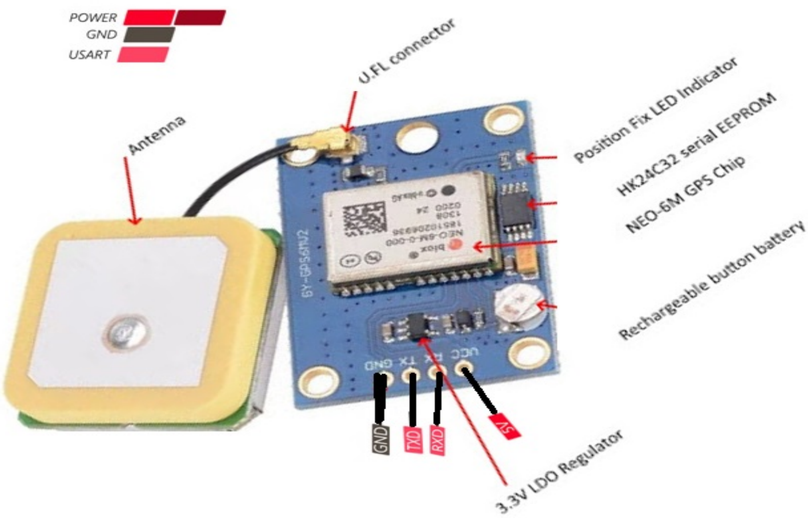


FIGURE 3.12: GPS module (GPS-Neo-6M) [4]

6. **Push button 4-pin :** is a type of switch that is commonly used in electronic circuits and devices to initiate or stop a specific function or process, it consists of a button that is mounted on a base and has four pins for electrical connection. The four pins of the push button are typically labeled as NO (Normally Open), NC (Normally Closed), C (Common), and GND (Ground). When the button is not pressed, the NO pin is open, and the NC pin is closed. When the button is pressed, the NO pin is closed, and the NC pin is open. The C pin is connected to one of the NO or NC pins depending on the desired function of the button. The GND pin is connected to the ground of the circuit or device. When the push button is pressed, it completes an electrical circuit, allowing the current to flow from the power source through the button and to the load or device. When the button is released, the circuit is opened, and the current stops flowing.

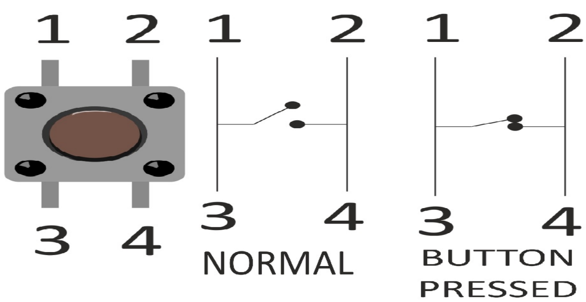


FIGURE 3.13: A push button 4-pin [4]

7. **Jumper Wire:** A jumper wire is an electrical wire with a connector at each end that is used to connect two points on a circuit board or between different electronic components. Jumper wires are often used to enable temporary or permanent connections between two points, bypass damaged components, or modify circuits. They are typically made

of flexible insulated wire and come in various lengths, gauges, and colors to make it easy to identify and differentiate them.

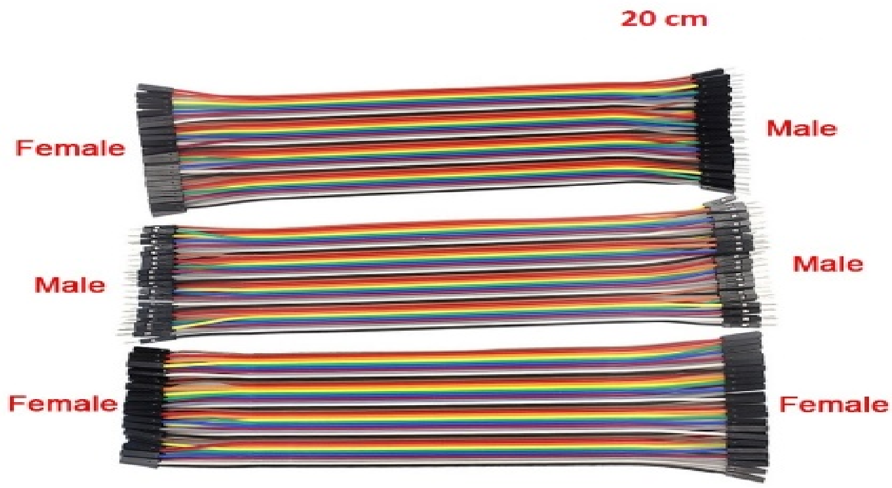


FIGURE 3.14: Jumper Wire [4]

8. **Power supply:** The TP4056 is a popular lithium-ion battery charging module, is designed to charge single-cell lithium-ion or lithium polymer batteries with a maximum charging current of 1A.

   The TP4056 module has an integrated microchip that manages the charging process and provides various safety features, such as overcharging protection, over-discharging protection, and short circuit protection. It also has LED indicators that show the charging status of the battery, making it easy to monitor the charging process. It can be powered by a USB port or an external power source and is capable of charging a wide range of battery capacities.

9. **Lithium Battery:** is a type of rechargeable battery that uses lithium ions as the primary material for its electrolyte. These batteries are widely used in portable electronic devices, due to their high energy density, low self-discharge rate, and long cycle life.

   Lithium-ion batteries consist of one or more electrochemical cells that contain a positive electrode (cathode), a negative electrode (anode), and an electrolyte that facilitates the flow of ions between the two electrodes. During charging, lithium ions move from the cathode to the anode, where they are stored. During discharging, the ions move from the anode to the cathode, generating an electrical current that can power a device. Lithium-ion batteries are favored over other rechargeable batteries because they have a high energy density. They also have a low self-discharge rate, which means they can hold a charge for a longer

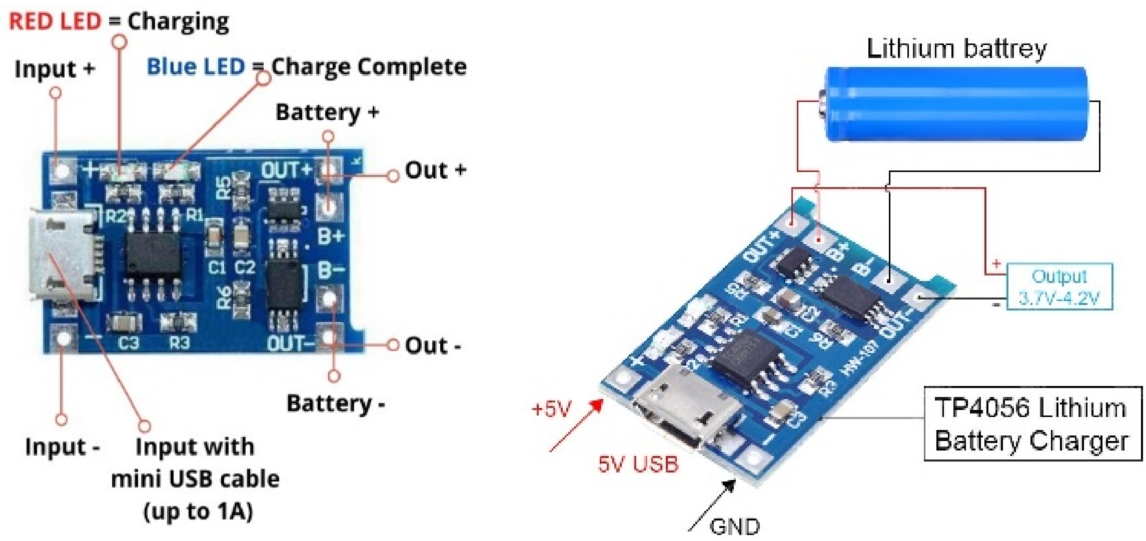


FIGURE 3.15: Power supply/The TP4056 [4]

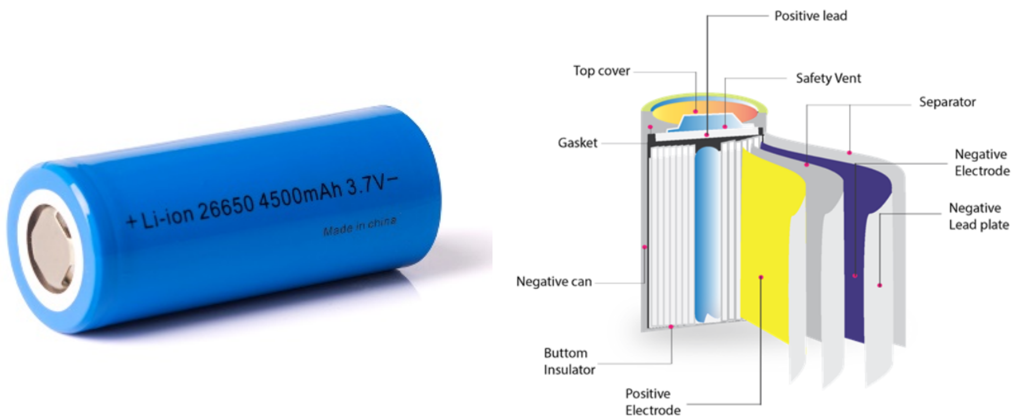


FIGURE 3.16: Power supply/Lithium Battery [4]

period of time. Lithium-ion batteries are also known for their long cycle life, which refers to the number of charge-discharge cycles they can endure before their performance degrades significantly.

10. **Google Maps API (Application Programming Interface)** is a web service provided by Google that enables developers to embed and customize Google Maps functionality in their own web-based applications, It allows developers to access various features and functions of Google Maps, such as displaying maps, creating markers, and adding custom overlays. The Google Maps API provides a range of tools and features, including:

    - Mapping services - Provides access to the base maps, imagery, and other geographic data.
    - Geocoding services - Converts addresses and place names into geographic coordinates.

- Directions services - Provides turn-by-turn directions between two or more locations.
- Street View services - Allows developers to add Street View imagery to their applications.
- Places services - Provides information about nearby places, such as restaurants, hotels, and gas stations.
- Distance Matrix services - Calculates travel distances and times between multiple points.

FIGURE 3.17: Google Maps API [4]

Developers can use the Google Maps API to create customized maps that display specific geographic data, such as real-time traffic information, weather data, and business listings. They can also integrate the API with other web-based tools and services to create interactive and dynamic applications. Google Maps API is widely used in various industries, such as transportation, logistics, tourism, and real estate.

3.4 Machine Learning Classifier for Death Prediction

3.4.1 Data description

This dataset used in this study was derived from MIMIC II Waveform Database, the publicly-accessible critical care database. It contains summary clinical data and outcomes for 1,776 patient's dataset. involving some missing values. Table III.1 shows the MIMIC II Waveform dataset attributes with their definitions and type.

Name	Description
icu_los_day	length of stay in ICU (days, numeric)
hospital_los_day	length of stay in hospital (days, numeric)
age	age at baseline (years, numeric)
gender_num	patient gender (1 = male; 0=female)
weight_first	first weight, (kg, numeric)
bmi	patient BMI, (numeric)
sapsi_first	first SAPS I score (numeric)
sofa_first	first SOFA score (numeric)
service_num	service as a numeric (binary: 0 = MICU or FICU, 1 = SICU)
day_icu_intime_num	day of week of ICU admission (numeric, corresponds with day_icu_intime)
hour_icu_intime	hour of ICU admission (numeric, hour of admission using 24hr clock)
day_28_flg	death within 28 days (binary: 1 = yes, 0 = no)

Name	Description
mort_day_censored	day post ICU admission of censoring or death (days, numeric)
censor_flg	censored or death (binary: 0 = death, 1= censored)
sepsis_flg	sepsis present (binary:0= no, 1= yes – absent (0) for all)
chf_flg	Congestive heart failure (binary: 0 = no, 1 = yes)
afib_flg	Atrial fibrillation (binary: 0 = no, 1 = yes)
renal_flg	Chronic renal disease (binary: 0 = no, 1 = yes)
liver_flg	Liver Disease (binary: 0 = no, 1 = yes)
copd_flg	Chronic obstructive pulmonary disease (binary: 0 = no, 1 = yes)
cad_flg	Coronary artery disease (binary: 0 = no, 1 = yes)
stroke_flg	Stroke (binary: 0 = no, 1 = yes)
mal_flg	Malignancy (binary: 0 = no, 1 = yes)
resp_flg	Respiratory disease (non-COPD) (binary: 0 = no, 1 = yes)
map_1st	Mean arterial pressure (mmHg, numeric)
hr_1st	Heart Rate (numeric)
temp_1st	Temperature (F, numeric)
spo2_1st	S_pO_2 (%, numeric)
abg_count	arterial blood gas count (number of tests, numeric)
wbc_first	first White blood cell count (K/uL)

3.4.2 Data preprocessing

In order to achieve more accurate results, data pre-processing is an important step in changing raw heart disease dataset into a clean and understandable format for analysis. The following sub-sections discuss techniques applied to improve the quality of our dataset.

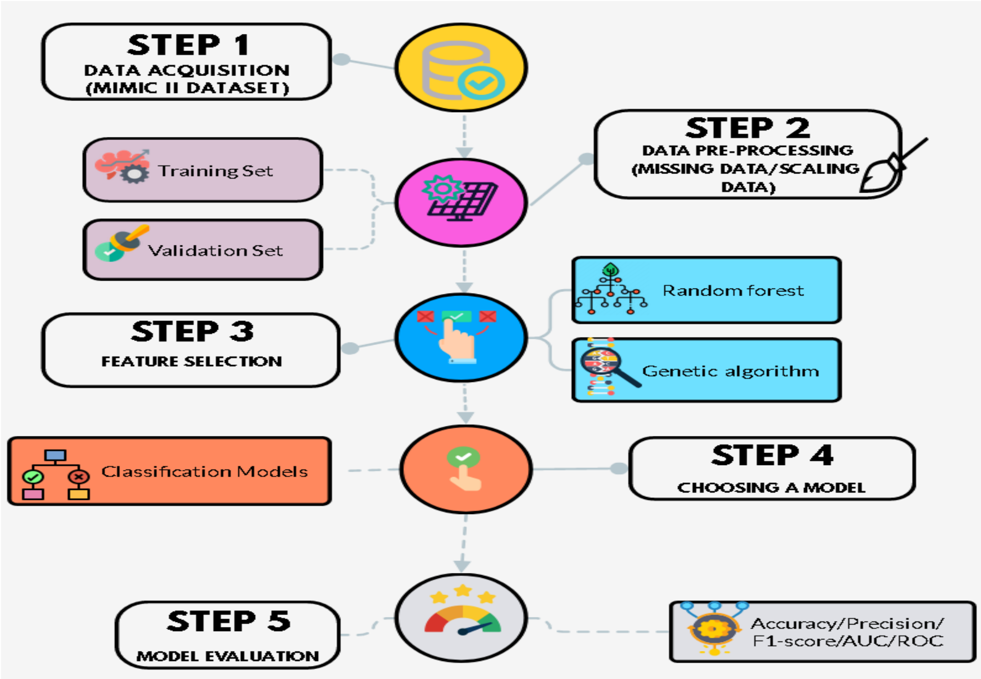


FIGURE 3.18: Flowcharts

Missing data

In this contribution, we are going to apply the Mode Imputation techniques/KNN algo, which is an algorithm that is useful for matching a point with its closest k neighbors in a multidimensional space [116]. It can be used for data that are ordinal, continuous, categorical, and discrete which makes it particularly useful for dealing with all types of missing values.

Scaling data

In this step, data columns are re-scaled to a range of [0 to 1] and float to integer in age for two causes. The first is one is to simplify the complexity of digital computing. The second one is to get rid of attributes in the largest numeric range while controlling attributes in the smallest numeric range [117].

3.4.3 Feature selection

Feature selection process is very significant to find most relevant attributes to the classification and then to the diagnosis. It has many advantages:

(1) To make the model simpler to interpret.

(2) To decrease the variance of the model, and therefore over-fitting.

(3) To decrease the computational time and cost.

(4) And finally, the most important one, is to increase the performance of the model [118].

In the literature, there is three main types of feature selection: filter, wrapper, and embedded methods. In this contribution we will choose the second one, which is wrapper methods as implemented by algorithms that have their own built-in feature selection methods.

use genetic algorithm to search for the optimal feature subset [119], and then use random forest algorithm to evaluate the performance of the selected subset. Use genetic algorithm operators such as selection, crossover and mutation to produce a new generation of feature subsets.

Random Forests (RF) are often used as evaluated feature selection in data science. The reason is tree-based strategies used by RF can logically orders by how well they improve the clarity of the node [120]. at the start of the trees, we find nodes with the highest decrease in impurity, while nodes with the minimum decrease in impurity occur at the end of trees. Thus, by pruning trees below a particular node, we can create a subset of the most important features.

By combining the strengths of genetic algorithm and random forest algorithm, this approach can effectively search for the optimal feature subset while also providing a reliable evaluation of the selected subset. [121]

3.4.4 Imbalanced Data

In this part, after examining the database, we noticed that there is an imbalance between the two categories, and we found that category 0 prevails over category 1.

3.4.5 Choosing Model

In this part, we explain the most important models that were chosen

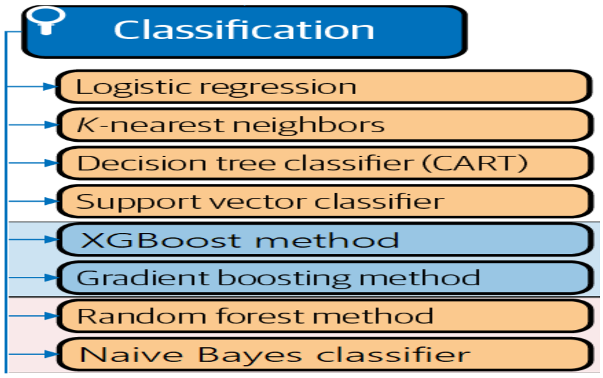


FIGURE 3.19: Selected Models

and explain why they were chosen over others in the following table:

Model Name	Theory
Gradient Boosting	Gradient Boosting is an ensemble learning method that combines multiple weak prediction models, typically decision trees. It focuses on minimizing the loss function by iteratively adding models that address the shortcomings of the previous models.
Random Forest	Random Forest is also an ensemble learning method that combines multiple decision trees. It introduces randomness by using bootstrapping and random feature selection during the construction of individual trees to improve generalization and reduce overfitting.
Naive Bayes	Naive Bayes is a probabilistic classifier based on Bayes' theorem. It assumes that all features are independent of each other, which is a naive assumption but leads to efficient and fast classification. It is commonly used for text classification and spam filtering.
Decision Trees	Decision Trees are a non-parametric supervised learning method that learns a hierarchy of if-else conditions from the data. It splits the data based on features and their thresholds to make predictions. Decision Trees are interpretable and can handle both categorical and numerical features.
k-Nearest Neighbors	k-Nearest Neighbors is a non-parametric lazy learning method that classifies data points based on their proximity to k nearest neighbors in the training set. It does not make any assumptions about the underlying data distribution and can handle multi-class classification problems.
Logistic Regression	Logistic Regression is a linear classification model that uses the logistic function to model the probability of a binary outcome. It is interpretable and works well when the relationship between features and the target variable is linear.
Support Vector Machine	Support Vector Machine is a supervised learning algorithm that finds the optimal hyperplane in a high-dimensional space to separate different classes. It aims to maximize the margin between classes and can handle both linear and non-linear classification problems using kernel functions.
XGBoost	XGBoost is an optimized gradient boosting algorithm that uses a combination of gradient boosting and regularization techniques. It focuses on both model accuracy and computational efficiency, providing better performance compared to traditional gradient boosting. It has gained popularity in various machine learning competitions.

3.4.6 Evaluating Model

In this last part, which is the most important, we discuss the models that we chose and applied the study to, and the most important criteria used in evaluating these models. First, we load the above database and divide it into 4 sub-datasets, namely:

X-train: A dataset used to train models. It is an entry and contains the pre-selected features from the feature selection step. Y-train: A dataset that is used to train the models and to train their predictions from the inputs.

X-test: A dataset used to test models and is an input and contains predefined elements from the feature selection phase, which are new elements to the model.

Y-test: A set of data used to evaluate the results predicted by the models and considered to be valid outputs compared to the expected outputs of the model.

In this research, we tried to collect the maximum number of effective models used in classifications and prediction, where we find: Gradient Boosting, Random Forest, Naive Bayes, Decision Trees, k-Nearest Neighbours, Logistic Regression, Support Vector Machine, XGBoost

After the models are trained and tested, we move on to the evaluation criteria to choose the best model, which should include excellent values that cover most of these criteria. The first criterion is accuracy, and it should be as high as possible. The second criterion is pressure, and it should be as high as possible. The third criterion is the TP and FP values, and they should also be as high as possible. TN FN should be as low as possible. The AUC should also be as high as possible. All of these criteria have been explained in previous sections and the results presented in the last chapter.

3.5 Conclusion

In conclusion, the chapter on the conception of a smart bracelet and classification machine learning model presents an overview of the design and development of a wearable device and the application of machine learning techniques for prediction.

The chapter introduces the concept of a smart bracelet, which is a wearable device equipped with various sensors to collect data related to user activities, health parameters, and environmental factors. The smart bracelet aims to provide personalized and real-time monitoring of user health and well-being.

Furthermore, the chapter discusses the integration of machine learning models into the smart bracelet system. Machine learning algorithms can analyze the collected data and make predictions or provide valuable insights. These models can be trained to detect patterns, classify activities, predict health conditions, or provide recommendations based on user behavior and environmental factors.

Overall, the chapter emphasizes the potential of combining wearable technology with machine learning algorithms to enhance health monitoring and provide personalized assistance. The smart bracelet and predictive machine learning models have the potential to revolutionize healthcare and empower individuals to take proactive steps towards maintaining their well-being.

Chapter 4

Realisation

4.1 Introduction

This chapter is devoted to the realization of the bracelet and the development of the applications and will present the implementation of the system, the development tools, the sensors used, and some screenshots of the applications made (PC/Android).

4.2 Programming Tools and Languages

First of all, the project is realized on Intel(R) Core(TM) i5-5300U CPU @ 2.30GHz, with 8 GB of memory. We are implementing the project on Windows 10/7 and Ubuntu 22.04. The main tools and languages that we used for the realization of our system are the following:

4.2.1 Programming Languages:

Java; Python; C; PHP; SQL;

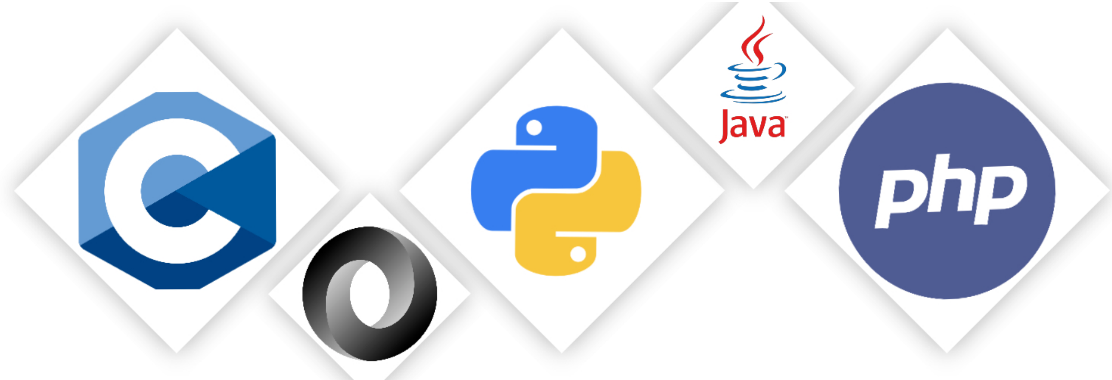


FIGURE 4.1: Class diagram [4]

- Java: Java is a high-level, object-oriented programming language that was developed by Sun Microsystems (now owned by Oracle Corporation) in the mid-1990s. Java is designed to be platform-independent, meaning that Java programs can run on any computer or device that has a Java Virtual Machine (JVM) installed [122].

- Python: Python is a high-level, interpreted programming language that was first released in 1991. Python is known for its simplicity, readability, and ease of use. It is commonly used for web development, scientific computing, data analysis, artificial intelligence, and automation [123].

- C: C is a high-level programming language that was developed in the early 1970s. It is a general-purpose programming language that is used for system programming, embedded systems, and developing applications where high performance and low-level hardware access are required [124].

- PHP: PHP (Hypertext Preprocessor) is a server-side scripting language that is used for web development. PHP is designed to be embedded into HTML pages and can be used to create dynamic web pages, process form data, authenticate users, and interact with databases [125].

- SQL: SQL (Structured Query Language) is a programming language that is used for managing relational databases. SQL is used to create, modify, and delete databases, tables, and records, and to query data from databases. It is commonly used in web development, data analysis, and data science [126].

4.2.2 Programming Tools

NetBeans [1]; PyCharm, google colab; notepad++; Xampp; apache server; MySQL server, Netcat;

1

FIGURE 4.2: Programming Tools NetBeans/ PyCharm/ google colab/ notepad++/ Xampp/ apache server/ MySQL server/ Netcat/ Arduino IDE

- NetBeans: is an open-source integrated development environment (IDE) that supports development in multiple programming languages such as Java, C, C++, HTML, CSS, and JavaScript [127].
- PyCharm: is an integrated development environment (IDE) used in computer programming, specifically for the Python language. It provides code analysis, graphical debugging, and supports web development with Django [128].
- Google Colaboratory: or Colab for short, is a cloud-based platform that allows users to write, execute, and share Python code in a Jupyter notebook environment. It is free and runs on Google's cloud infrastructure [129].
- Notepad++: is a free source code editor and Notepad replacement that supports several programming languages. It runs on the Microsoft Windows operating system and is designed to be lightweight and fast.
- XAMPP: XAMPP is a free and open-source cross-platform web server solution stack package developed by Apache Friends. It includes Apache HTTP server, MariaDB database server, and interpreters for scripting languages such as PHP, Perl, and Python [130].
- Apache Server: The Apache HTTP Server, commonly referred to simply as Apache, is a free and open-source cross-platform web server software. It is one of the most widely used web servers in the world and supports several programming languages such as PHP, Perl, and Python [131].
- MySQL Server: is an open-source relational database management system (RDBMS) that uses Structured Query Language (SQL) to manage

and manipulate data. It is widely used in web applications to store and retrieve data [132].

- Netcat; Netcat is a command-line tool used for reading and writing data across network connections using TCP or UDP protocols. It can be used for port scanning, transferring files, and debugging network protocols [133].

- PhpMyAdmin: is a free and open-source web-based application that provides a graphical user interface (GUI) for managing MySQL and MariaDB databases. It allows users to easily manage their databases, create tables, run queries, and perform other database-related tasks. • A popular book on PhpMyAdmin is "Mastering PhpMyAdmin 3.3.x for Effective MySQL Management" by Marc Delisle. This book provides comprehensive coverage of phpMyAdmin and its features, including installation, configuration, and use. It also includes practical examples and tips for using phpMyAdmin effectively.

- Android Studio: is an integrated development environment (IDE) used for developing Android applications. It provides a comprehensive suite of tools for developing, debugging, and deploying applications for Android devices [134] [135].

- Fritzing IDE: is an open-source software tool used for designing electronic circuits, prototyping and developing printed circuit boards (PCBs). It provides a user-friendly interface that allows users to create and customize circuits, and to generate a schematic diagram, a PCB layout, and a bill of materials for their projects [136].

- Arduino IDE: is an open-source software development environment used to write and upload code to Arduino boards. It includes a code editor, a compiler, and a serial monitor, making it easy to program and debug Arduino-based projects [137].

- SolidWorks: is a popular computer-aided design (CAD) software used for creating 3D models, assemblies, and drawings. It is widely used in engineering, product design, and manufacturing industries for creating accurate and detailed models of products and mechanical components [138].

4.3 Bracelet Realisation

In this section, we introduce the bracelet that was issued as *SMB*, and we first tried to provide the necessary electronic components and connect them in the way that was dealt within Chapter 1/Sec. 1.2, all of this kind is represented in the following document. In general, we find that linking is divided into two classes

Class 1 Electrical feeding: It is appointed by a rechargeable lithium battery with a constant current of 3.7 volts, connected by two leads, the first positive VCC and the second negative GND connected to a voltage regulator for charging and discharging. We also mention that all sensors and the control board are fed in the same format. Class 2 Data transmission: It is done by two threads, one called Serial Clock pin (SCL) that pulses the Controller board at regular intervals, and a Serial Data pin (SDA) through which data is sent between the two devices.

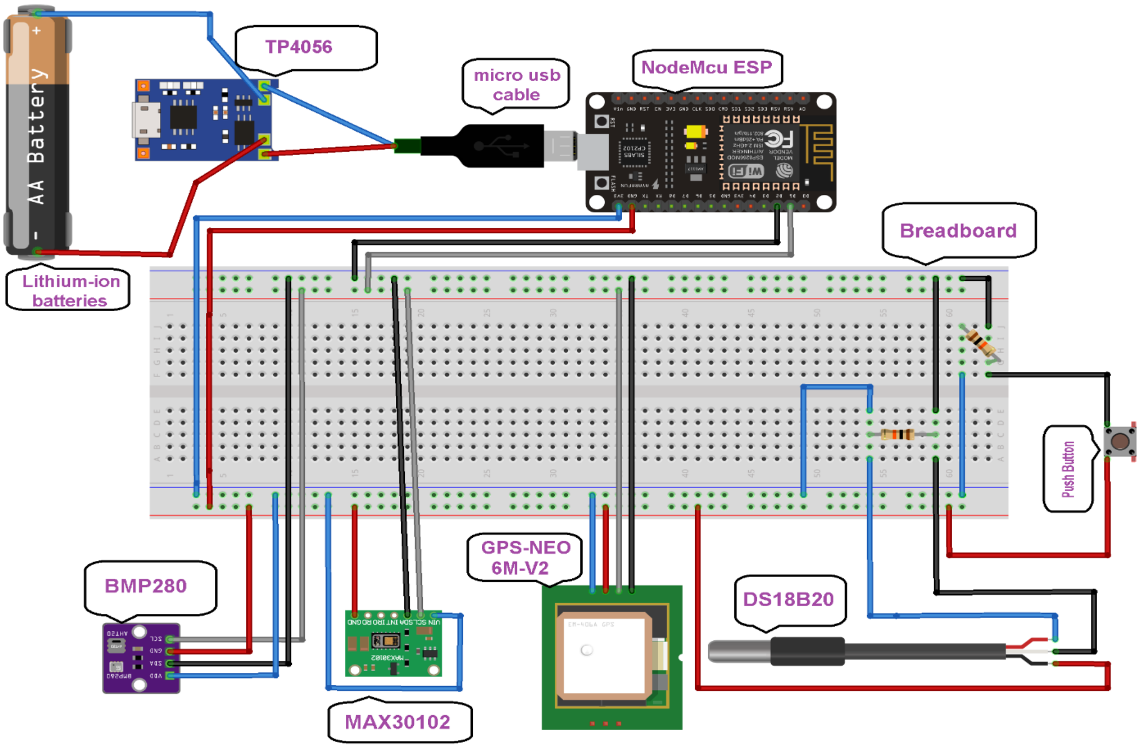


FIGURE 4.3: Connect circuit components

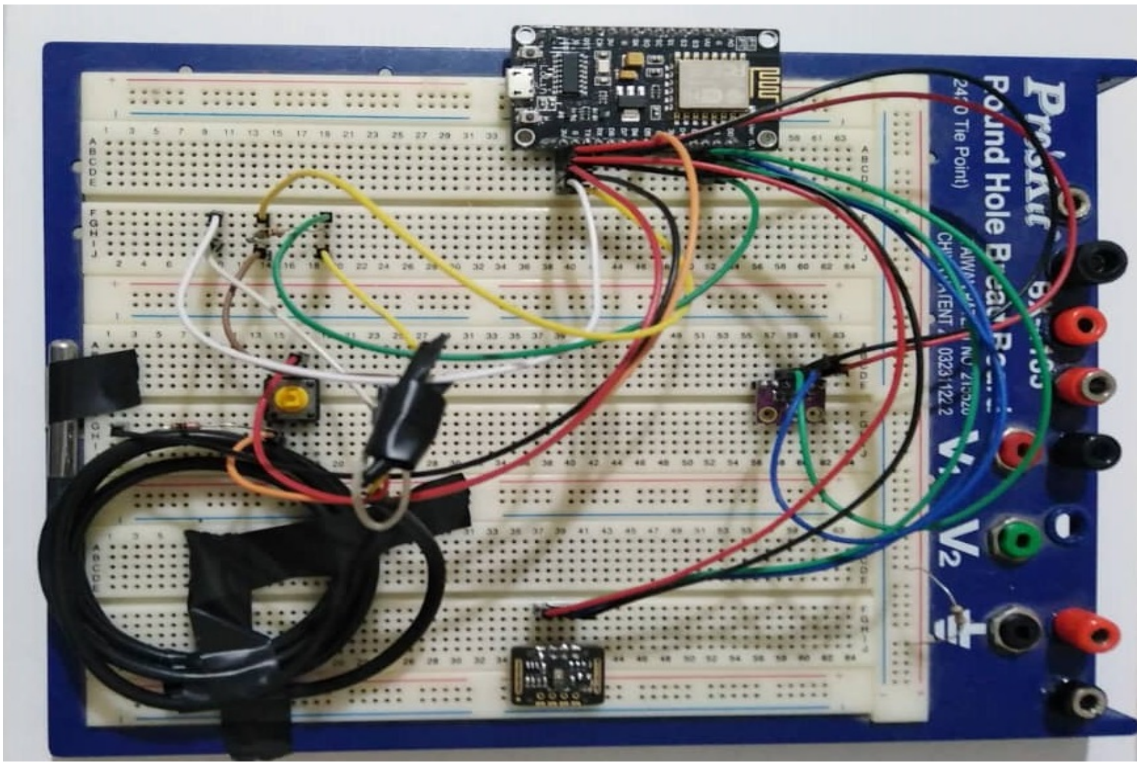


FIGURE 4.4: Connect circuit components(Real)

After completing the connection of the various elements, depending on its manual, we went to the part related to programming and setting up the work environment and communicating with it. We relied on the Arduino IDE program, and the following document explains parts of the programming process.

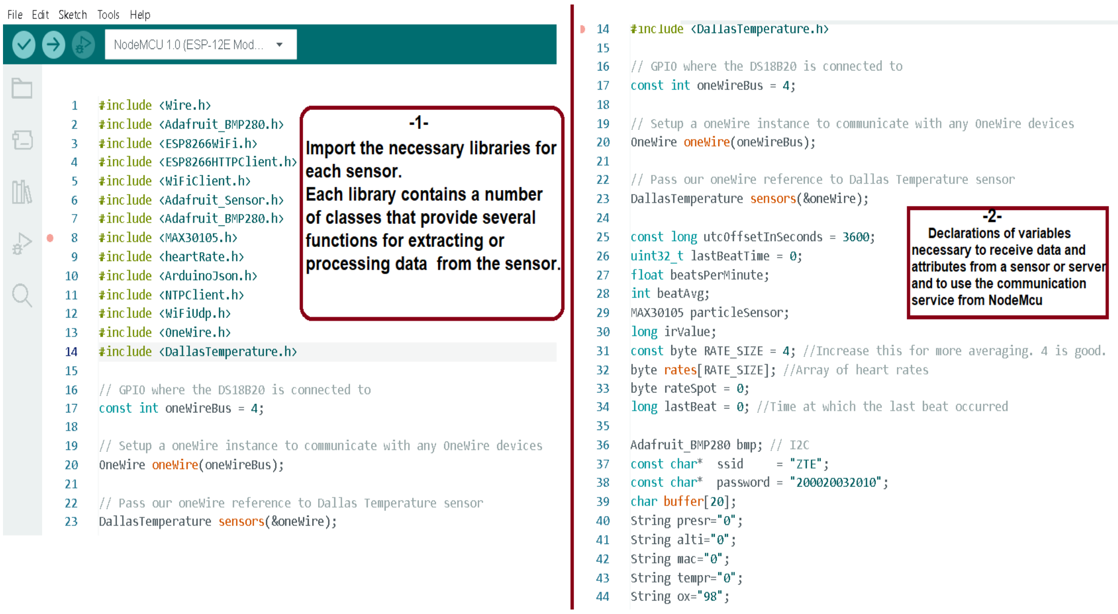


FIGURE 4.5: Connecting to microcontroller

FIGURE 4.6: Connect sensors (send receive to server)

FIGURE 4.7: Parts of the code on the side of the smart bracelet

After confirming and experimenting with the various elements with each other, we went to the process of designing a three-dimensional prototype of the body that contains all these elements, taking into account the patient's comfort and the conditions that facilitate the work of the sensors using the SolidWorks program, and the result is represented in the documents below.

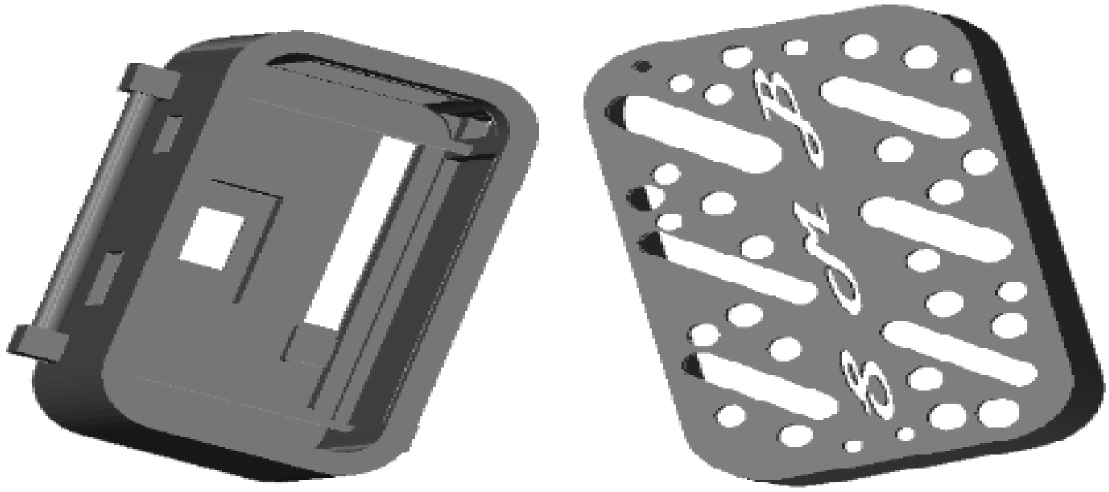


FIGURE 4.8: 3D Box Design in Simulation (Solidworks)

Finally, after confirming the dimensions of all objects and their compatibility with the 3D design, we converted it into a format compatible with 3D printing, and these are some pictures that show that.

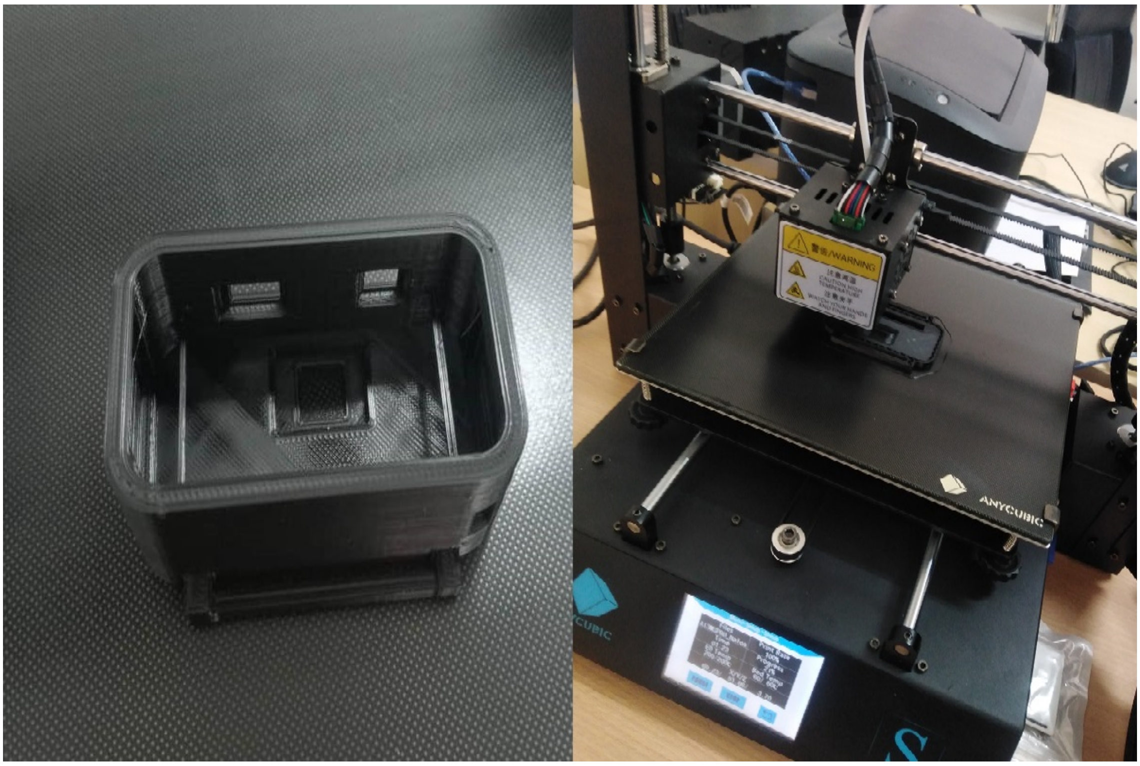


FIGURE 4.9: Print the box using a 3D printer

Here are pictures of the bracelet completed and put together

4.4 Mobile Application Interfaces

In this part, we look at the patient monitoring application for the smartphone, where we used the ANDROID Studio environment in the development, where we find: First, the login interface, as each member of the medical staff has his own username and password that enables him to log in and use the application. Picture 1 of figure 1 explains this: Secondly, we find the main interface that displays information about the patient who wears the bracelet, which is specified in the list of bracelets, picture 2 of figure 1. We also find a button for opening the map interface, which enables us to know the current location of the patient with his personal and medical information, as illustrated in Picture 3 of figure 1. In addition to another button that opens an interface for the artificial intelligence service, which is illustrated in Picture 4 of figure 1

We also have services that take place in the background, where all the values of the vital indicators are checked periodically, if they are outside the normal range for a healthy person, they are alerted (sound and writing) of their presence and attached to the current location and the type of abnormal indicator. Photo 1 Document 2

There is another service for alerts represented in SOS call by the patient to the medical staff shown in Picture 2 Document 2

4.5 Desktop Application Interfaces

In this part, we have a computer application that provides additional functions that are not available in the smartphone application.

First, we have an entry interface through which interfaces are opened for lists according to the hierarchy of jobs and pre-defined by the manager.

FIGURE 4.10: Login(Desktop Application)

Director: He has comprehensive access powers, among which we mention the modification of doctors, main specialists, and assistants, access to all their tasks.

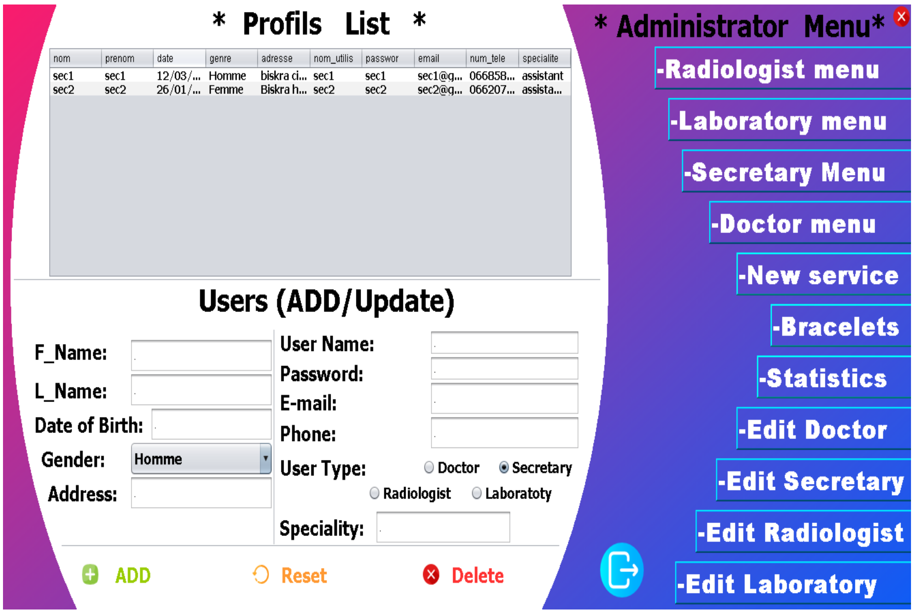


FIGURE 4.11: Administrator menu Interface

Doctors: has access to specific tasks shown in the following image, including the creation of medical prescriptions, sick leave, and most importantly, the monitoring part and the prediction part.

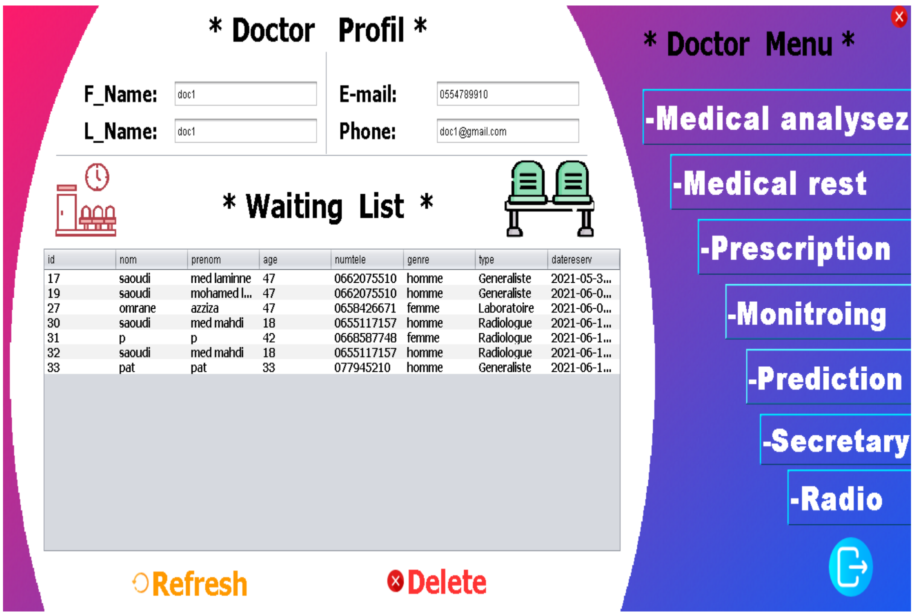


FIGURE 4.12: Doctor menu Interface(Desktop Application)

Where we find the monitoring part is explained in the following document and how to use it was mentioned in the serial diagram in the part.

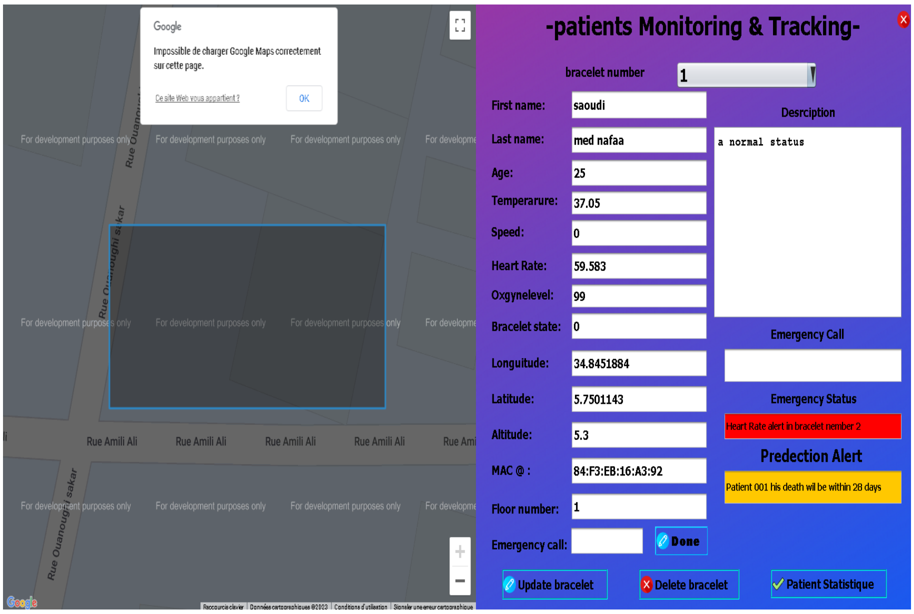


FIGURE 4.13: Monitoring Interface (Desktop Application)

And the prediction part works in two automatic ways depending on the momentary information captured, and another works by entering information available from outside the system. This is shown in the following picture.

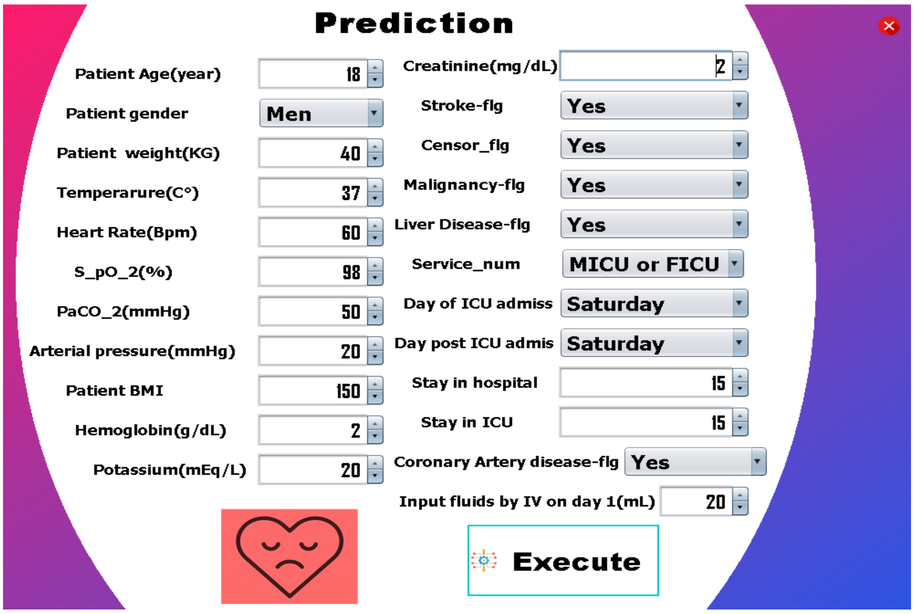


FIGURE 4.14: Prediction Interface (Desktop Application)

Health assistant: They are the element responsible for entering patients' information, assigning bracelets, and modifying the patients' information attached to them. As explained in the following document:

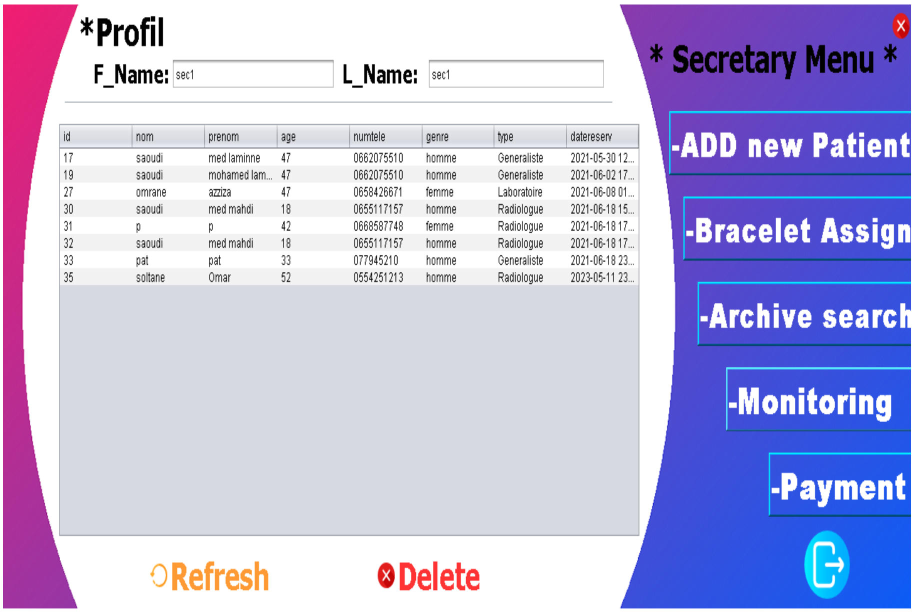


FIGURE 4.15: Secretary Menu interface (Desktop Application)

4.6 Machine Learning Classifier for Death Prediction

In this part, we explain the results of what was discussed and explained in Chapter 3, where we find in:

4.6.1 Data preprocessing

Missing data

The two images in the figure below show the results of using the Drop method in class 0 as the dominant class and we have over-availability, and the KNN algorithm to replacing for the missing values in class 1.

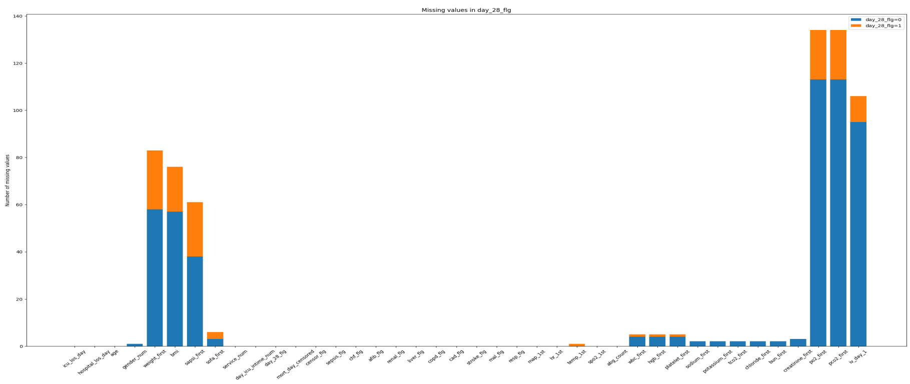


FIGURE 4.16: Chart showing missing data

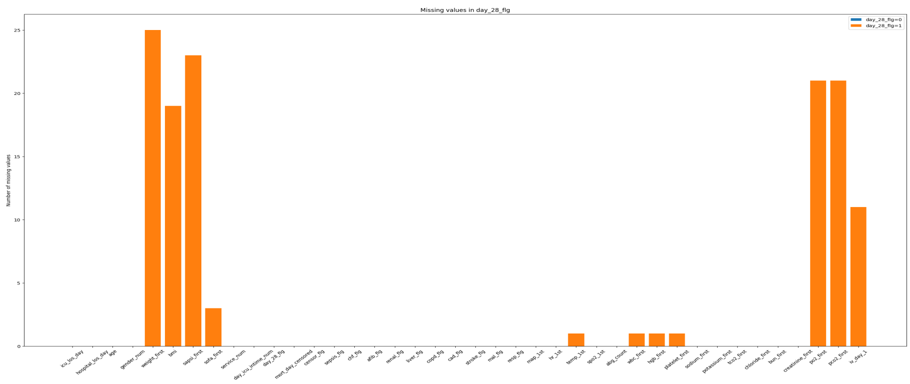


FIGURE 4.17: The Drop method in class 0

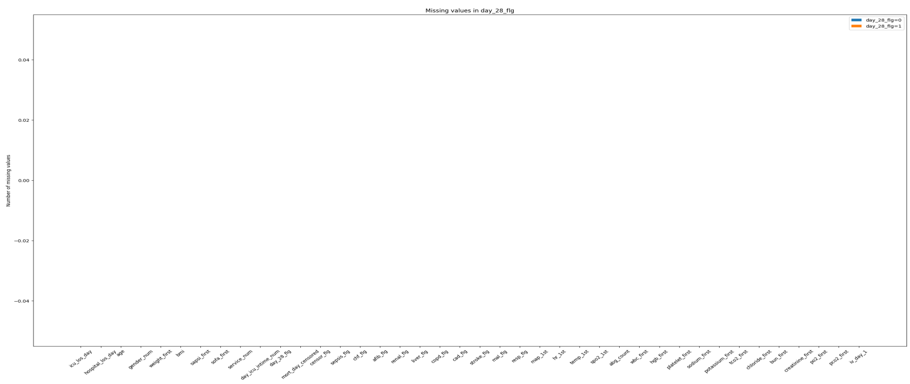


FIGURE 4.18: The KNN algorithm for the missing values in class 1

Scaling data

The figure below show the results of using the MaxMinScaler methods in Field between 0 and 1 after eliminate the features that contain categorical and binary data.

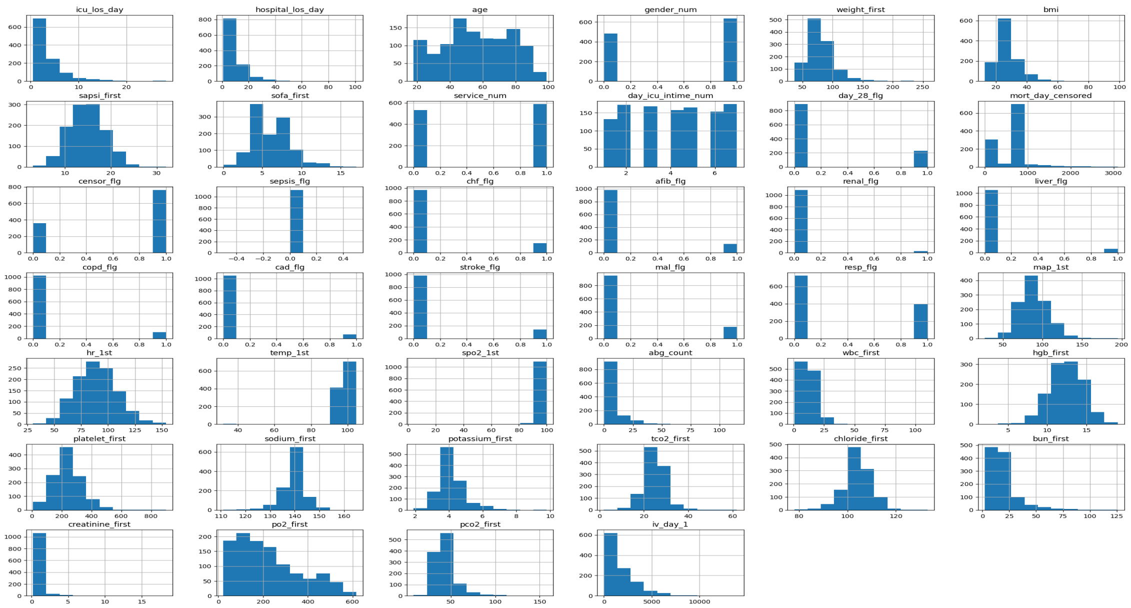


FIGURE 4.19: A chart showing the distribution of data values

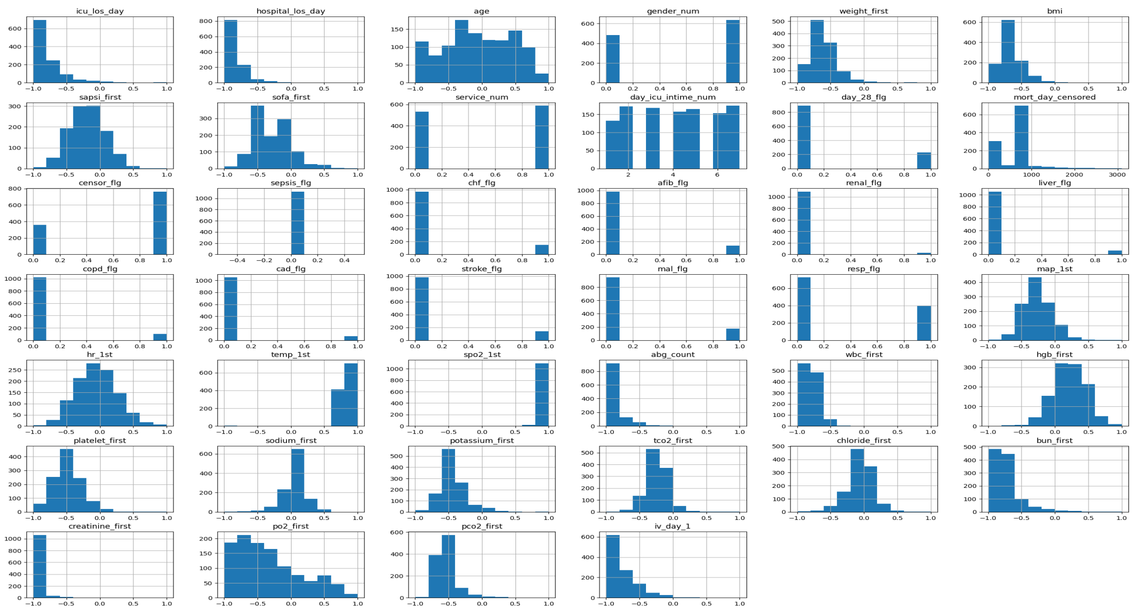


FIGURE 4.20: Chart showing the distribution of data values after using the Scaling technique

FIGURE 4.21: The distribution of data values

4.6.2 Feature selection

The figure below shows the results of using the a genetic algorithm and the random forest algorithm, and the results were as follows: Out of 39 elements from the basic database, 23 of them were nominated as basic elements and have a relationship with each other and with the result to be expected, as we used: The algorithm uses the DEAP library, which is a framework for evolutionary algorithms in Python.

The code defines three functions: 'getFitness', 'geneticAlgorithm', and 'bestIndividual'.

The 'getFitness' function takes an individual, a set of features, and a target variable, and returns a fitness score based on the accuracy of a random forest classifier. The fitness score is calculated using cross-validation. The function first checks if the individual contains any zeros, indicating that a feature should be excluded. It then selects the subset of features that are not excluded and converts them into a one-hot encoded format. It then applies a random forest classifier to this subset of features and calculates the accuracy using cross-validation.

The 'geneticAlgorithm' function takes a dataset, a population size, and a number of generations, and uses a genetic algorithm to select the best features. The function first defines the fitness function as 'getFitness' and creates a DEAP toolbox. It then initializes the population and creates the statistics and hall of fame objects. Finally, it calls the 'eaSimple' function from the DEAP library to run the genetic algorithm.

The 'bestIndividual' function takes the hall of fame and returns the individual with the highest fitness score.

The main function reads the data from an Excel file, applies the genetic algorithm to select the best features, and fits a random forest classifier to the selected features. The accuracy of the classifier is then calculated using cross-validation. The code prints the accuracy of the classifier with all features and the accuracy of the classifier with the selected features.

Random forest is used because it is a popular classification algorithm that is known for its high accuracy and robustness to overfitting. It is an ensemble method that creates multiple decision trees and combines their predictions to make the final classification. Random forest can handle a large number of features, making it a suitable algorithm for feature selection problems [139].

In this code, the goal is to perform feature selection by selecting a subset of features that can provide the highest classification accuracy. The fitness function evaluates each individual feature subset by training a random forest classifier and using cross-validation to estimate the accuracy. The genetic algorithm is used to evolve a population of individuals (feature subsets) over multiple generations to find the best feature subset that maximizes the accuracy of the random forest classifier.

4.6.3 Imbalanced Data

In this part, since the dataset is not linearly separable (see Figure **??**) and to avoid generating new fake data using a technique of data augmentation and balancing such as SMOTE (Synthetic Minority Over-sampling Technique) and ADASYN (Adaptive Synthetic Sampling), we prefer to applying some modification on ML models parameters to acheive best result with this dataset.

4.6.4 Model Validation

Since the chosen dataset is small, we need to validate the applied ML models on this data using K-fold cross-validation method, which represent the performance of the system on the 80% of the data instead of just 20% of the training set. K-fold cross-validation method provides robust estimate model's performance compared to a single imbalanced train-test split dataset. Moreover, K-fold cross-validation helps to reduce the impact of the dataset's random variations on the performance evaluation. Also, it provides a better understanding of how the model generalizes to unseen data.

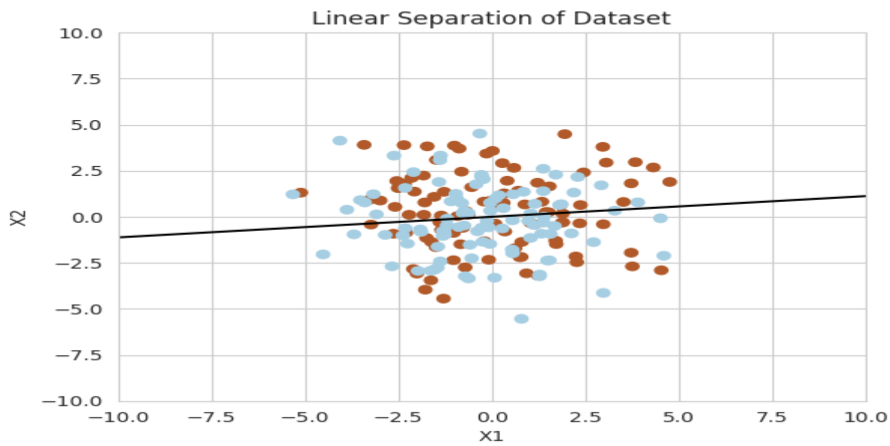


FIGURE 4.22: Linearly Separable Data Visualisation

4.6.5 Evaluating Model

The figure below shows the implementation of using several different classification models, their training and the results obtained.

Initial State

This part shows the initial result of the chosen evaluating metrics of models as shown in Figure 4.23. We notice that all models that we have tried their accuracy around 80%. While Naive Bayes algorithm provides the lowest accuracy 58%. Though, XGBoost provides the best results in the measured metrics such as Accuracy with 86%, F1-score 86%, Recall 84%, Precision 86% (see table 4.24).

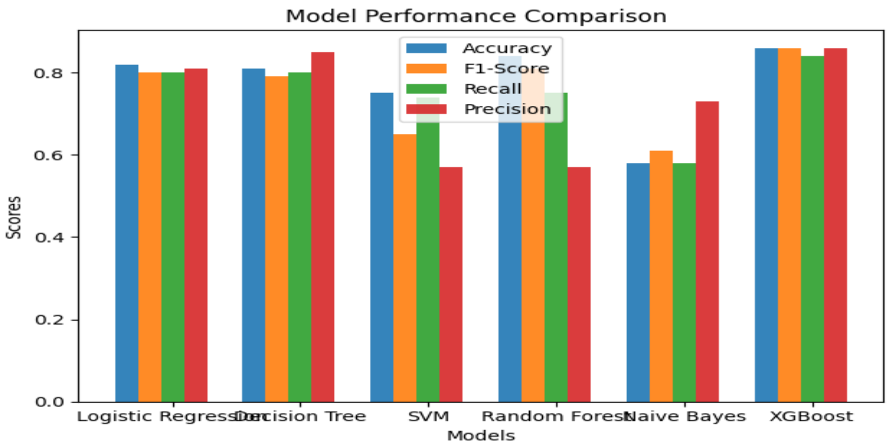


FIGURE 4.23: Model Performance Comparison Chart

Basics	Accuracy	F1-Score	Recall	Precision
Logistic Regression	0.82	0.80	0.80	0.81
Decision Tree	0.81	0.79	0.80	0.85
SVM	0.75	0.65	0.74	0.57
Random Forest	0.84	0.81	0.75	0.57
Naive Bayes	0.58	0.61	0.58	0.73
XGBoost	0.86	0.86	0.84	0.86

FIGURE 4.24: Model Performance Comparison Table

Final State

This part shows the final result of the chosen evaluating metrics of models in the validation step using K-Fold Cross-Validation (see Figure 4.25). We notice that after applying Genetic Algorithm for feature selection and some modification on ML Models (4.25), we found that all models preform more better with Accuracy, F1-score, Recall, and Precision all around 90%. Furthermore, Random Forest performs very well in this model within this Dataset compared to others with 99.91% as Accuracy, followed by XGBoost which provides the second highest Accuracy 99.83%. However, since this bracelet is oriented to medical field where we are more interested to precision, we select XGBoost which is the top 1 in this model within this Dataset with 99.97% as Precision (see 4.26 and 4.27).

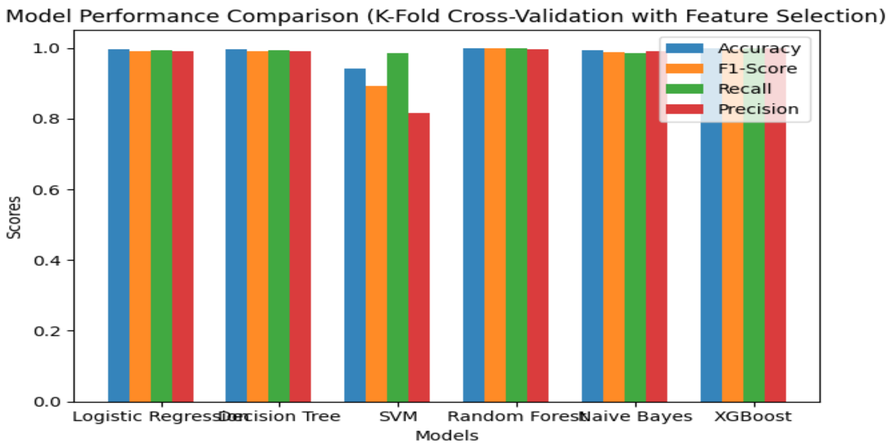


FIGURE 4.25: Model Performance Comparison Chart

K-Fold Cross-Validation with features selection	Accuracy	F1-Score	Recall	Precision
Logistic Regression	0.9957	0.9911	0.9929	0.9896
Decision Tree	0.9950	0.9900	0.9933	0.9917
SVM	0.9413	0.8913	0.9859	0.8146
Random Forest	0.9991	0.9982	0.9999	0.9965
Naive Bayes	0.9940	0.9875	0.9858	0.9894
XGBoost	**0.9983**	**0.9963**	**0.9981**	**0.9997**

FIGURE 4.26: Model Performance Comparison in Validation Step Table

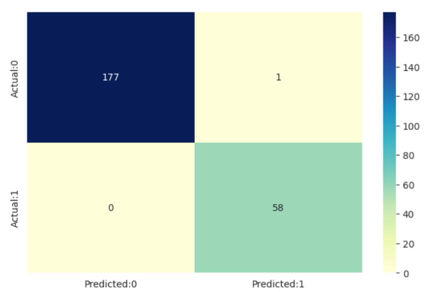
```
Mean Training Accuracy 99.94680851063829
Mean Training Precision 0.9955752254897
Mean Training Recall 0.9977777777777778
Mean Training F1 Score 0.998885793871866
/////////////////////////////////////////////
Mean Validation Accuracy 99.83893617021276
Mean Validation Precision 0.9963521739130434
Mean Validation Recall 0.9981522426944103
Mean Validation F1 Score 0.9978021978021978
```

FIGURE 4.27: XGBoost Performance

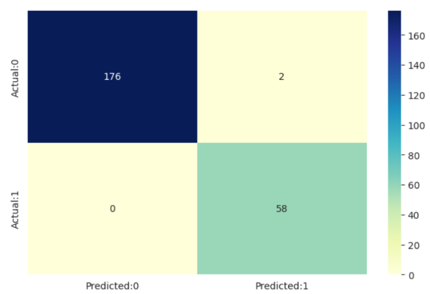
In addition, in the test step, the XGBoost model outperformed all other models and achieved the highest scores across all metrics. It has the best Accuracy, Precision, Recall, and F1 score, which indicates that it classified all instances correctly. The Random Forest and Decision Tree models also performed well but had slightly lower scores compared to the XGBoost model. The Logistic Regression, and Support Vector Machine and Naive Bayes models achieved lower scores, indicating that they might have struggled more with accurate classification (see figure 4.28).

K-Fold Cross-Validation Test	Accuracy	F1-Score	Recall	Precision
Logistic Regression	0.8983	0.8963	0.8981	0.8997
Decision Tree	0.9616	0.9600	0.9633	0.9617
SVM	0.8413	0.7913	0.8859	0.8146
Random Forest	0.8991	0.8982	0.8999	0.8965
Naive Bayes	0.8940	0.8875	0.8858	0.8894
Naive Bayes	0.9623	0.9600	0.9629	0.9596

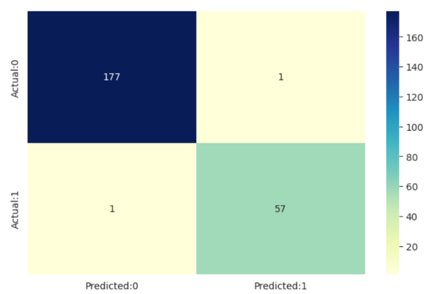
FIGURE 4.28: Model Performance Comparison in Testing Step Table



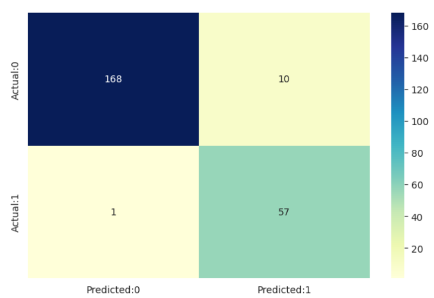
(a) Random Forest



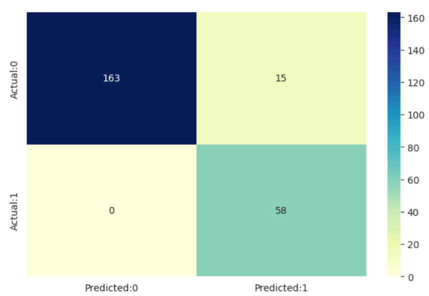
(b) Logistic Regression



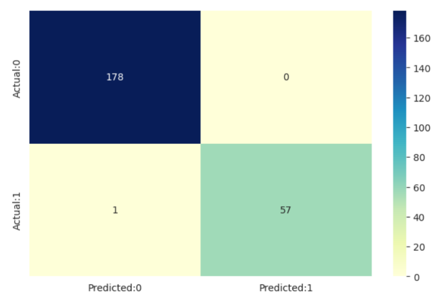
(c) Naive Bayes



(d) Decision Tree



(e) Support Vector Machine



(f) XG-Boost

FIGURE 4.29: Confusion matrix visualization for different models

Based on the provided evaluation metrics and the confusion matrix (Figure 4.29), the models that performed the best training on this dataset are XG-Boost ,Random Forest, and Decision Trees . These models achieved perfect accuracy, F1 score, and precision, indicating exceptional performance on the given dataset. The choice among these models may depend on other factors such as computational efficiency, interpretability, or specific requirements of the problem at hand.

4.7 Comparison with Related Work Results

Performance measures were calculated using cross-validated area under the receiver operating characteristic curve (AUROC). We notice that our model reaches the highest AUC with 99.4% compared to the recent related work

[140] and [141], we have chosen these work since they have used the same dataset and target variable.

Work	AUC
Our work XGBoost model	0.994
Work [140] ADABoost model	0.801
Work [141] Random Forest model	0.901

Comparing these results, we can see that the XGBoost model from our work achieved the highest AUC score of 0.994, indicating excellent performance in distinguishing between positive and negative classes. The Random Forest model from Work [140] achieved the second-highest AUC score of 0.901, while the ADABoost model from Work [139] had the lowest AUC score of 0.801.

Based on these results, the XGBoost model from our work can be considered as the best performing model in terms of AUC. It demonstrates superior discriminatory power and is more effective in data classification compared to the other two models, and this is due to the set of steps that were studied, and several methods were tried in each step before its final application, and this is what distinguishes our work, which was built on good and tight planning.

4.8 Conclusion

In conclusion, the implementation of a comprehensive system consisting of a smart bracelet, mobile application, desktop application, and machine learning model for death prediction in hospital patients has shown significant potential in revolutionizing patient monitoring and improving outcomes. The system enables continuous monitoring of vital signs and patient data, while the mobile and desktop applications provide healthcare professionals with user-friendly interfaces for data analysis and intervention. The machine learning model accurately predicts mortality risks by analyzing historical patient data. Challenges include data accuracy, model validation, and privacy concerns. Overall, this integrated system enhances patient care, interventions, and resource allocation, leading to improved outcomes and potentially saving lives.

Chapter 5

Conclusions

The healthcare industry has seen significant developments in recent years, particularly in the area of patient monitoring. Smart wearable devices, such as wristbands, have emerged as a promising solution for continuous monitoring and tracking of hospital patients. These devices collect a wealth of data that can be used to improve patient care and outcomes. This text explores the use of smart wristbands to monitor and track hospital patients and predict the probability of death within 28 days using machine learning models.

In traditional hospital settings, patient monitoring is primarily done through periodic manual evaluations, which can lead to delayed intervention and insufficient real-time monitoring. This approach may result in missed critical events and suboptimal patient care. Therefore, a more proactive and continuous monitoring solution is needed to identify patients at high risk of adverse outcomes, such as mortality.

The proposed solution includes the deployment of smart wristbands equipped with various sensors to continuously monitor vital signs, movement patterns, sleep quality, and other relevant patient data. These wristbands securely transmit the collected data to a central system where advanced machine learning models are used to analyze and interpret the information.

By using machine learning algorithms, the system can learn about patterns and correlations within the data to identify early warning signs associated with worsening health conditions. This allows healthcare providers to immediately intervene and implement personalized treatment plans for patients at high risk of dying within the next 28 days. In addition, the system can generate automated alerts for healthcare professionals, ensuring timely and targeted interventions.

While the concept of using smart wristbands to monitor a patient and predict death holds huge potential, there are some limitations that need to be considered. First, the accuracy and reliability of machine learning models depend greatly on the quality and completeness of the data collected. Ensuring smooth data collection and addressing potential data biases will be critical to improving the predictive capabilities of the system.

Furthermore, the deployment and integration of such a system within a hospital environment requires careful consideration of privacy and security concerns. Strict protocols and safeguards must be put in place to protect patient data and ensure compliance with privacy regulations.

In addition to the in-depth study and careful work in the field of energy consumption, extending the life of the battery, and ensuring its operation for the largest possible period.

In terms of future work, continued research and development efforts should focus on improving machine learning models to enhance their predictive accuracy. In addition, expanding the range of monitored parameters and incorporating additional sources of data, such as electronic health records, can provide a more comprehensive patient profile for improved prediction and personalized care.

Appendix A

Smart Bracelet to Monitor and Track hospital patient

الجمهورية الجزائرية الديمقراطية الشعبية
وزارة التعليم العالي و البحث العلمي
جامعة محمد خيضر بسكرة
القرار اطار في ناشئة مؤسسة شهادة لنيل مشروع
1275 الوزاري

Smart Bracelet to Monitor and Track hospital patient

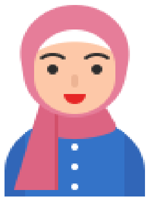
سوار ذكي لمراقبة وتتبع مرضى المستشفى

JUNE 22

COMPANY NAME: SMB- Enterprise
Authored by: Saoudi Med NAFAE

SMB (Smart Medical Bracelet)

1- فريق الاشراف:



التخصص:	الاستاذة المشرفة:
اعلام الي	بن عيسى يسرى

2- فريق العمل:

التخصص:	الطالب :
اعلام الي شبكات و انطمة معلومات	سعودي محمد نافع


فهرس المحتويات
تقديم المشروع
الجوانب الابتكارية
التحليل الاستراتيجي للسوق
خطة الإنتاج والتنظيم
الخطة المالية
النموذج الاولي التجريبي

سوار ذكي لمراقبة وتتبع مرضى المستشفى

المحور الأول: تقديم المشروع

1. فكرة المشروع (الحل المقترح)

نبتكر منتجا الكترونيا بسيط و سهل الاستخدام و عصري يعوض الفرد المرافق و ينقذ ارواح اقاربنا و افراد عائلاتنا و يجمع اكبر قدر من المعلومات الحيوية للمريض لحظيا و كذلك موقعه الحالي بدقة عالية و يوفر برمجيات متابعة و عرض دعم مزايا اضافية و الاهم بتكلفة منخفضة تتماشى مع متطلبات السوق و متوسط الدخل الفردي البسيط الذي يعاني في صمت من الغلاء و هذا الحل يتمثل في سوار ذكي.

2. القيم المقترحة

- الابتكار و الدعم التقني و السرعة.
- الدقة و الوضوح.
- الامان و الخصوصية و الراحة.
- سهولة الاستخدام و التوافق.
- التكلفة الفعالة.
- الشراكة و التعاون و التثقيف

3. فريق العمل

-الطالب سعودي محمد نافع , تخصص اعلام الي شبكات و انظمة المعلوماتية

-الاستاذة بن عيسى يسرى.

4. أهداف المشروع

- تطوير سوار ذكي مبتكر: الهدف الرئيسي للمشروع هو صناعة وتطوير سوار ذكي يجمع المؤشرات الحيوية للمرضى بدقة ويحدد موقعهم بدقة عالية. يتم استخدام تقنيات حساسة ومتطورة لقياس مؤشرات حيوية مثل ضغط الدم ومعدل ضربات القلب ومستوى الأكسجين في الدم وحرارة الجسم و كذا توقع مدى استجابة المريض للعلاج بالاظافة الى التنبؤ بالموت المفاجئ للمرضى .

- توفير رعاية صحية مستمرة: يهدف المشروع إلى توفير رعاية صحية مستمرة للأفراد المصابين بالأمراض المزمنة. من خلال جمع ومراقبة المؤشرات الحيوية وتحديد الموقع بشكل مستمر، يمكن للمرضى الاستفادة من رعاية صحية شخصية ومراقبة دائمة لحالتهم الصحية.

- تعزيز التواصل بين المريض ومقدمي الرعاية الصحية: يوفر التطبيق المرتبط بالسوار الذكي وسيلة للتواصل بين المريض ومقدمي الرعاية الصحية. يتم نقل البيانات المتولدة و المتحسسة من السوار إلى

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التطبيق، مما يتيح للمرضى ومقدمي الرعاية الصحية متابعة الحالة الصحية بدقة وتبادل المعلومات واتخاذ القرارات الصحية السليمة.

- تحسين جودة الرعاية الصحية: من خلال توفير رصد مستمر للحالة الصحية، يمكن للمشروع أن يساهم في تحسين جودة الرعاية الصحية عمومًا. يتيح السوار الذكي المستخدمين تحليل بياناتهم الصحية بشكل مباشر، مما يساعدهم على اتخاذ إجراءات وتعديلات لتحسين صحتهم الشخصية والوقاية من المشكلات الصحية.

- توسيع نطاق الرعاية الصحية الفردية: من خلال توفير سوار ذكي سهل الاستخدام وعصري، نسعى لتمكين الأفراد من مراقبة صحتهم الشخصية بطريقة سهلة وفعالة. يمكن للمستخدمين أن يكونوا شركاء في رعايتهم الصحية واتخاذ قرارات مستنيرة بناءً على المعلومات المتاحة من السوار الذكي.

- تشجيع التدخل المبكر: بفضل الرصد المستمر والدقيق للمؤشرات الحيوية و كذا مكان المريض ، يمكن اكتشاف التغييرات المبكرة في حالة الصحة واتخاذ إجراءات فورية. يساهم السوار الذكي في تحقيق التدخل المبكر في حالات الأمراض المزمنة ويساعد في تجنب تفاقم المشكلات الصحية.

- توفير معلومات دقيقة للمقدمين الصحيين: يمكن للسوار الذكي أن يسهم في تحسين التواصل وتبادل المعلومات بين المريض ومقدمي الرعاية الصحية. يمكن للمقدمين الحصول على بيانات مؤشرات الصحة بشكل دقيق وفوري، مما يسهل تشخيص ألي او يدوي للمشكلات ووضع خطط علاجية فعالة.

- الاستفادة من نمو سوق الأجهزة الطبية الذكية: يستهدف المشروع الاستفادة من النمو المتزايد لصناعة الأجهزة الطبية الذكية. من خلال تطوير سوار ذكي متقدم وتسويقه بشكل فعال، نتطلع إلى توسيع حصة السوق وتحقيق نجاح تجاري قوي.

5. جدول زمني لتحقيق المشروع :

	الاسبوع	1	2	3	4	5
1	الدراسات الاولية(اختيار مقر الوحدة الانتاجية و تجهيز الوثائق المطلوبة)	(√)	(√)			
2	طلب التجهيزات من الخارج		(√)	(√)		
3	بناء مقر للانتاج (المصنع)		(√)	(√)	(√)	
4	تركيب المعدات			(√)	(√)	(√)
5	اقتناء المواد الاولية					(√)
6	بداية انتاج اول منتج					(√)

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المحور الثاني: الجوانب الابتكارية

❖ طبيعة الابتكارات:

في هذا المشروع، يمكن وصف الابتكارات المعتمدة على النحو التالي:

- ابتكارات تكنولوجية: يتم استخدام التكنولوجيا المتقدمة في مجال الاستشعار وتحليل البيانات والاتصالات اللاسلكية لتطوير السوار الذكي. هذه الابتكارات تعزز دقة وكفاءة جمع المعلومات الصحية وتحسين قدرة المستخدمين على مراقبة صحتهم.

- ابتكارات السوق: يتم تصميم السوار الذكي ليلبي احتياجات ومتطلبات السوق والمستخدمين المحتملين. يركز التصميم على الراحة والملاءمة والأداء العالي لتلبية توقعات المستهلكين وتحقيق النجاح التجاري.

- ابتكارات متزايدة: يتم توفير إمكانية التحسينات والتعديلات المستمرة على السوار الذكي بناءً على ملاحظات المستخدمين وتطور التكنولوجيا. يتم العمل على تحديثات برامج التشغيل وإضافة ميزات جديدة لتحسين أداء السوار وتجربة المستخدم.

بشكل عام، يمكن القول إن المشروع يستند إلى ابتكارات تكنولوجية متطورة ويهدف إلى تلبية احتياجات السوق وتحسين تجربة المستخدم. كما أنه يستمر في التحسين والتطوير المستمر للتكنولوجيا والتصميم لتحقيق النجاح والتفوق في مجال رعاية الصحة الذكية.

❖ مجالات الابتكارات:

مجالات الابتكار يمكن أن تنطبق بشكل عام في:

- تطوير تقنيات جديدة: يمكن أن تتضمن الابتكارات في هذا المجال تطوير تقنيات جديدة لقياس المؤشرات الحيوية بدقة أعلى وكفاءة أكبر و طذا معلافة موقع و مكتن المرض بدقة و تفصيل سواء داخل البنايات او خارجها. قد تكون هناك حاجة لاستخدام أجهزة استشعار متطورة أو تقنيات تحليل بيانات جديدة.
- تصميم منتج مبتكر: يمكن أن تشمل الابتكارات في هذا المجال تصميم سوار ذكي فريد من نوعه يتميز بالراحة والأناقة وسهولة الاستخدام. قد تكون هناك حاجة لتصميم مواد جديدة وتقنيات تصنيع مبتكرة.

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- توسيع نطاق الاستخدامات: قد تحتاج إلى استكشاف وتطوير استخدامات جديدة للسوار الذكي في مجال رعاية الصحة. يمكن أن تشمل ذلك توسيع التطبيقات المتاحة وتطوير وظائف إضافية تلبي احتياجات متنوعة للمرضى ومقدمي الرعاية الصحية.
- تقديم خدمات متكاملة: قد تحتاج إلى الابتكار في تقديم خدمات متكاملة ترتبط بالسوار الذكي، مثل منصة تتبع الصحة عبر الإنترنت أو تطبيق محمول يوفر تحليلات مفصلة ونصائح صحية مخصصة.
- شراكات استراتيجية: قد تحتاج إلى استكشاف شراكات استراتيجية مع مقدمي الرعاية الصحية أو شركات التكنولوجيا الأخرى لتعزيز قدراتك وتوسيع نطاق توزيع المنتج والوصول إلى العملاء بشكل أفضل.
- تحليل البيانات والذكاء الاصطناعي: استخدم التحليلات المتقدمة وتقنيات الذكاء الاصطناعي لفهم المعلومات المستخرجة من البيانات التي يجمعها السوار الذكي. يمكنك استخدام هذه البيانات لاكتشاف أنماط واتجاهات جديدة وتحسين الرصد والتشخيص الصحي.
- الاتصالات والتواصل: استكشف كيفية تحسين التواصل والتفاعل بين المرضى ومقدمي الرعاية الصحية باستخدام التقنيات الحديثة. يمكنك تطوير نظام للتواصل عبر التطبيقات المحمولة أو الرسائل القصيرة أو الإشعارات لتوفير المعلومات الصحية والتوجيهات بشكل سلس وفعال.
- توفير الأمان والخصوصية: قم بتطوير إجراءات وتقنيات لضمان أمان وخصوصية البيانات الحساسة المتعلقة بالمرضى. يجب أن يشعر المرضى بالثقة في استخدام السوار الذكي ومشاركة بياناتهم الشخصية مع المقدمين الصحيين.
- الاستدامة والبيئة: اهتم بتصميم سوار ذكي يكون مستدامًا وصديقًا للبيئة، باستخدام مواد قابلة لإعادة التدوير وتقنيات تصنيع مستدامة. قد يكون هناك أيضًا فرصة لتشجيع المرضى على الممارسات الصحية المستدامة.

هذه المجالات تعكس أفكارًا عامة للاستفادة من الابتكار في مشروعنا، ومن الممكن أن تكون هناك مجالات أخرى تتناسب ايضا بشكل خاص...

المحور الثالث: التحليل الاستراتيجي للسوق

القطاع السوقي في حالتنا هذه هو قطاع الرعاية الصحية والصحة الشخصية. يمكن أن يشمل هذا القطاع مجموعة متنوعة من الجمهور المحتمل والمستهدف الذين يهتمون بالرعاية الصحية وتحسين صحتهم الشخصية. قد يكون القطاع السوقي لمشروعنا يشمل:

- المرضى المزمنين: يشتري هذا الجمهور منتجنا لأنه يعاني من أمراض مزمنة تتطلب رعاية صحية مستمرة. قد يكونون بحاجة إلى رصد دوري للمؤشرات الحيوية وتقديم تحليلات مفصلة لحالتهم الصحية.
- الأشخاص الراغبين في تحسين صحتهم: يمكن أن يشتري هذا الجمهور منتجك لأنه يرغب في رصد ومراقبة حالته الصحية بشكل مستمر والعمل على تحسينها. قد يكونون يسعون للحفاظ على لياقتهم البدنية أو إدارة ضغط الدم أو التحكم في وزنهم.

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- مقدمو الرعاية الصحية: يمكن أن يكون لدينا جمهورًا من مقدمي الرعاية الصحية الذين يهتمون بمراقبة حالة مرضاهم بشكل مستمر وتقديم الرعاية الشخصية. يمكن أن يكون لمنتجنا قيمة كبيرة في تزويدهم بالمعلومات والبيانات الدقيقة عن المرضى.
- الأشخاص الراغبين في تحسين صحتهم: يمكن أن يشتري هذا الجمهور منتجنا لأنه يرغب في رصد ومراقبة حالته الصحية بشكل مستمر والعمل على تحسينها. قد يكونون يسعون للحفاظ على لياقتهم البدنية أو إدارة ضغط الدم أو التحكم في وزنهم.
- الاباء و الاولياء: لمراقبة صحة ابنائهم و كدا تتبع حراكاتهم و سلوكاتهم.

مبررات اختيار السوق المستهدف:

- ❖ توجد زيادة في انتشار الأمراض المزمنة والحاجة إلى رعاية صحية مستمرة، مما يفتح فرصًا لمنتجنا الذي يساعد في مراقبة وتحسين حالة المرضى.
- ❖ هناك طلب متزايد على التكنولوجيا في قطاع الرعاية الصحية. الناس يبحثون عن حلول تكنولوجية مبتكرة تسهم في تحسين رعايتهم الصحية وتوفير الراحة والراحة. تقدم التكنولوجيا الحديثة فرصًا لتطوير منتجات وخدمات تلبي احتياجات المرضى وتعزز نوعية حياتهم.
- ❖ باستخدام التكنولوجيا المتقدمة مثل الأجهزة القابلة للارتداء وتطبيقات الهاتف المحمول والتحليلات الضخمة للبيانات، يمكنني تقديم منتج فريد ومبتكر يلبي احتياجات العملاء في مجال الرعاية الصحية. من خلال توفير معلومات دقيقة ومفيدة وتحليلات شاملة، يمكن للمرضى ومقدمي الرعاية الصحية استخدام منتجنا لتحقيق تحسينات ملموسة في الرعاية الصحية والصحة الشخصية.

باختصار، السوق المستهدف يشهد طلبًا متزايدًا على التكنولوجيا المبتكرة في مجال الرعاية الصحية، واعتمادا على دراستنا للسوق نأمن بأن منتجنا سيستجيب لهذا الطلب وسيوفر حلاً شاملاً و متكاملا وفعالًا للعملاء.

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أولا- تحليل المتغيرات الكلية (PESTEL)

نموذج تحليل بيستلPESTEL

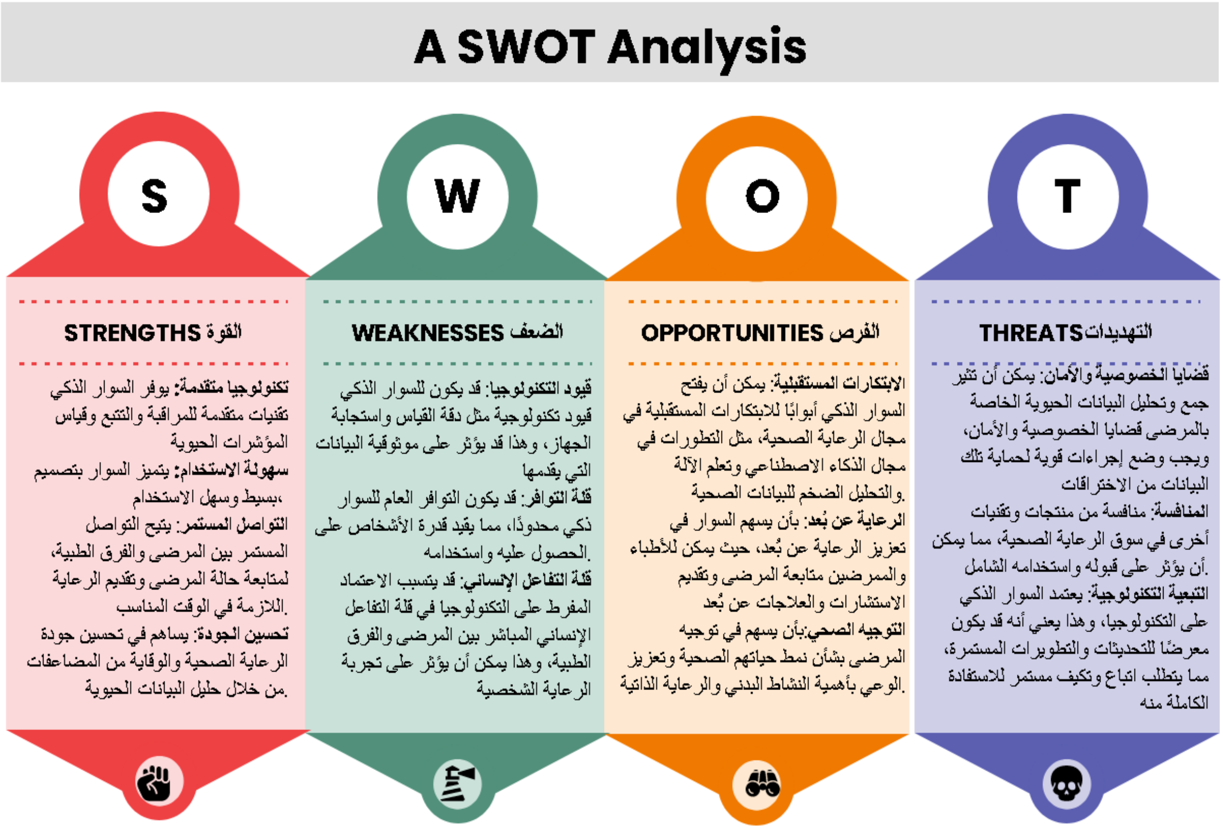
	العوامل	شرح العوامل	مثال
P	العوامل السياسية Political Factors	- السياسات والتشريعات الحكومية. - درجة الاستقرار السياسي في الأسواق الخارجية. - سياسة التجارة الخارجية، والقيود التجارية. - السياسات الضريبية، والتسهيلات الممنوحة. - قانون العمل والعمّال.	[أثرت السياسات الحكومية الجزائرية على حركة التجارة والاستيراد والتصدير بين الدول المتقدمة. جرّاء ذلك تمكنت الشركات المحلية و المؤسسات الناشئة من الحصول على دعم من السياسات الحكومية في البلاد وساعدها ذلك على الازدهار والتقدم غير المسبوق داخل الجزائر.]
E	العوامل الاقتصادية Economic Factors	- معدلات النمو الاقتصادي. - التضخم وارتفاع الأسعار. - معدلات البطالة. - أسعار الصرف وأسعار الفائدة. - الدخل المتاح للأفراد والشركات	[تسببت التسهيلات البنكية وارتفاع الدخل المتاح و انخفاض تكلفة الادوات التكنولوجية و تنوعها إلى زيادة معدلات إنفاق الأفراد على احتياجاتهم.]
S	العوامل الاجتماعية Social Factors	- التعداد والنمو السُكاني وديموغرافية السُكان. - الصحة السُكانية ومستويات التعليم. - المعتقدات والقيم الأخلاقية.	[نظرًا لارتفاع مستويات التعليم في الدول النامية فقد زادت رغبتهم في استخدام الهواتف الذكية و الادوات التكنولوجية وذلك لأنها تُسهل عليهم حياتهم وأدائهم لأعمالهم.]
T	العوامل التكنولوجية Technological Factors	- البُنية التحتية. - مستويات الإبداع والابتكار. - الوعي التكنولوجي.	[بسبب زيادة اهتمام الناس بالرياضة فقد لجأت العديد من شركات التكنولوجيا إلى تصميم ساعات ذكية يمكنها أن تحسب للشخص عدد الخطوات التي يسيرها ومعدل حرقه للسعرات الحرارية وما شابه ذلك.]
E	العوامل البيئية Environmental Factors	- المُناخ والتلوث. - القوانين والسياسات البيئية. - إعادة التدوير والحد من التلوث. - مصادر الطاقة المتجددة.	[زيادة الوعي البيئي لدى الأشخاص، أدى لظهور ادوات تكنولوجية صديقة البيئة.]
L	العوامل القانونية Legal Factors	- قوانين التوظيف. - حقوق المٌلكية. - قوانين التجارة الدولية. - قوانين الصحة والسلامة. - سلامة المنتجات ووضع العلامات.	[عدم وجود قوانين مٌطبقة فعليًا لحماية حقوق الكُتّاب وصانعي المحتوى، تؤثر على رغبة المستهلك بشراء الكتب الإلكترونية.]

ثانيا - تحليل القوى التنافسية (PORTER)

العنصر	التفاصيل
المنتج (Product):	-سوار ذكي قابل للارتداء ومريح. -قدرات قياس وتسجيل دقيقة للمؤشرات الحيوية. -تقنيات متقدمة لتحليل وتفسير البيانات الحيوية. -واجهة سهلة الاستخدام وتطبيق محمول لعرض البيانات و التوصيات الشخصية.
السعر (Price)	-تحديد سعر مناسب يناسب قيمة المنتج و التنافسية في السوق.
المكان (Place)	-إنشاء قنوات توزيع فعالة وشراكات استراتيجية مع مقدمي الرعاية الصحية. -توفير السوار الذكي في الصيدليات و المستشفيات و المتاجر عبر الإنترنت.
التسويق (Promotion)	-استخدام استراتيجيات التسويق الرقمي و الترويج عبر وسائل الاعلام الاجتماعية. -الترويج للمميزات التنافسية للمنتج وتسليط الضوء على قدرات القياس الدقيقة.
الشخص (People)	-فريق متخصص في البحث و التطوير وتصنيع الأجهزة الطبية الذكية. -دعم فني وخدمة عملاء متميزة للمرضى ومقدمي الرعاية الصحية. -توفير التدريب و التوعية للمستخدمين بشأن استخدام السوار الذكي وفهم البيانات المسجلة.

سوار ذكي لمراقبة وتتبع مرضى المستشفى

ثالثا - تحليل (SWOT)



رابعا : المزيج التسويقي

- المنتج:(Product)

يتعلق بتصميم وتطوير السوار الذكي وميزاته. يجب أن يكون المنتج مبتكرًا وعالي الجودة، ويتوافق مع احتياجات وتوقعات العملاء المستهدفين. يمكنك تحسين المنتج من خلال توفير ميزات واضافية و فريدة، مثل الدقة في قياس المؤشرات الحيوية والتتبع الدقيق للموقع، بالإضافة إلى تصميم جذاب ومريح.

- السعر (Price)

يجب تحديد سعر مناسب للسوار الذكي بناءً على تكلفة الإنتاج والمصنعية وقيمته المتوقعة في السوق. يجب أن يكون السعر تنافسيًا مقارنة بالمنتجات المشابهة الموجودة في السوق، وفي نفس الوقت يمكن أن تحقق من خلاله الربحية المستهدفة. يمكنك أيضًا اعتماد استراتيجيات التسعير المختلفة مثل السعر المتميز أو السعر التنافسي.

- التوزيع(Place)

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يتعلق بكيفية توزيع المنتج ووصوله إلى العملاء المستهدفين. يمكنك تشكيل قنوات توزيع فعالة مثل التوزيع عبر الإنترنت، والتعاون مع الشركات المتخصصة في بيع المنتجات الصحية، وإنشاء شبكة منافذ بيع في المراكز الطبية والصيدليات. يجب أن تضمن تواجد المنتج في الأماكن المناسبة وفي الوقت المناسب لتلبية احتياجات العملاء.

- الترويج(Promotion)

تتعلق بكيفية تسويق المنتج وإشعار الجمهور المستهدف بوجوده وفوائده. يمكنك استخدام مجموعة متنوعة من وسائل الترويج لجذب انتباه العملاء وتعزيز مشروعنا. يمكنك استخدام العديد من الأدوات الترويجية مثل التسويق الرقمي والإعلانات عبر الإنترنت، ووسائل التواصل الاجتماعي، والتسويق عبر البريد الإلكتروني، والعروض الترويجية والخصومات الخاصة. يمكنك أيضًا التعاون مع مدونين ومؤثرين في مجال الصحة والتكنولوجيا للترويج لمنتجك. هدفك هو إيصال رسالتك التسويقية وزيادة الوعي بالسوار الذكي وفوائده.

باستخدام المزيج التسويقي بشكل فعال، يمكنني تعزيز مشروعنا وجذب العملاء المستهدفين. يرجى ملاحظة أنه يجب أن تتناسب استراتيجيات المزيج التسويقي مع خصائص السوق المستهدفة واحتياجات العملاء، ويمكن أن نستمر في تحسينها وتعديلها بناءً على التغيرات في السوق ومتطلبات العملاء.

خامسا: الاستراتيجيات التسويقية.

- استراتيجية القيادة بالتكلفة:

هي استراتيجية أعتمدها في مشروعنا لتحقيق تفوق تنافسي من خلال تقديم المنتجات أو الخدمات بأقل تكلفة ممكنة. نحن نركز على تحسين الكفاءة في الإنتاج وتحسين العمليات الداخلية لتقليل التكاليف وتحقيق أفضل قيمة للعملاء.

لتحقيق هذه الاستراتيجية، نعمل على تحليل وتحسين عمليات المشروع بحيث تكون أكثر كفاءة وتوفيرًا للتكاليف. نقوم بتقديم التدريب والتعليم المستمر لفريق العمل لزيادة مهاراتهم وتحسين أدائهم في سبيل تقليل التكاليف العملية وزيادة الإنتاجية.

أيضًا، نسعى لإقامة شراكات مع موردين يقدمون المواد الخام بأسعار تنافسية وجودة عالية. بالتعاون معهم، نحاول تحقيق اقتصاديات الحجم والتوفير في تكاليف المشتريات للحصول على أفضل عروض وشروط.

نستثمر أيضًا في تكنولوجيا الإنتاج المتقدمة والمبتكرة لتحسين عمليات الإنتاج وتقليل التكاليف. يمكن أن تشمل هذه التكنولوجيا استخدام الآلات والمعدات المتطورة وتنفيذ أتمتة العمليات التي تزيد من كفاءة الإنتاج وتقلل من الخطأ البشري.

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بشكل عام، نسعى جاهدين لتقديم المنتجات بجودة عالية وبأسعار تنافسية في السوق. نعتمد على تحليل البيانات واستخلاص الأرقام لتحديد تكاليف الإنتاج وضبطها بشكل مناسب، وذلك لتحقيق ربحية مستدامة وتلبية احتياجات العملاء بأفضل قيمة من خلال تحليل البيانات المالية والاقتصادية وفهم احتياجات السوق، نحن نعمل على تحديد سعر منتجاتنا بدقة لضمان تحقيق توازن بين القيمة المقدمة والتكلفة. كما نسعى لتحقيق ميزة تكلفة على المنافسين من خلال التحكم في التكاليف وتقليل المصاريف غير الضرورية.

بالنسبة للتمويل، نقوم بإعداد خطة مالية متكاملة تشمل تقديرات التكاليف المتوقعة للإنتاج والتسويق والتوزيع. بالإضافة إلى ذلك، نعد جدولًا لحسابات الناتج المتوقع والعائدات المتوقعة لتحديد الربحية والتوقعات المالية للمشروع.

أيضًا،نقوم بإدارة التدفقات النقدية بعناية لضمان توفر السيولة الكافية لتلبية الاحتياجات اليومية للمشروع. نعمل على تحديد وتقدير المصادر والاستخدامات المالية وإعداد خطة خزينة قوية تعكس استدامة المشروع وتقليل المخاطر المالية.

- استراتيجية التميز

بالنسبة لاستراتيجية التميز، نعتمد على تقديم منتجات وخدمات فريدة ومتميزة عن المنافسين في السوق. و نسعى لإنشاء علامة تجارية قوية تتميز بالجودة والابتكار والتصميم المتفرد.

أولاً وقبل كل شيء، نحرص على تحليل وفهم احتياجات ورغبات العملاء بدقة. بناءً على هذا التحليل، و نقوم بتطوير منتجات وخدمات فريدة تلبي تلك الاحتياجات بطرق مبتكرة ومتفوقة.

ثانياً، نقوم بالاهتمام بجودة المنتجات والخدمات التي نقدمها. نعمل على تحسين العمليات والمعايير الداخلية لضمان جودة عالية والتزام بأعلى المعايير في كل مرحلة من مراحل الإنتاج والتسويق.

ثالثاً، نعمل على تطوير عوامل التمييز التي تميز منتجاتنا عن المنافسين. قد يكون ذلك عبر توفير مزايا فنية أو تقنية متقدمة، أو تصميم فريد وجذاب، أو تجربة عملاء متميزة، أو خدمة ما بعد البيع المميزة.

أيضاً، أولوية التواصل الفعال مع العملاء وبناء علاقات قوية معهم. نحن نسعى لفهم احتياجاتهم المستمرة وتوقعاتهم، ونعمل على تلبية تلك الاحتياجات وتجاوز توقعاتهم.

باستخدام استراتيجية التميز، نهدف إلى جذب فئة مستهدفة من العملاء الذين يقدرون القيمة المضافة والاختلاف في المنتجات والخدمات. و نعمل على بناء سمعة قوية في السوق كمزود موثوق ومتميز، وذلك من خلال الترويج والتسويق وإقامة شراكات استراتيجية مع أطراف أخرى في السوق.

لاستراتيجية التميز، يجب أن نكون مستعدين للاستثمار في البحث والتطوير للابتكار وتحسين المنتجات والخدمات بشكل مستمر. يتطلب ذلك التواجد في طليعة التكنولوجيا والتصميم والاتجاهات الصناعية.

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من الناحية التسويقية، يتعين علينا أن نبرز مزايا منتجاتنا المميزة وأن أوضح القيمة التي ستحصل عليها العملاء من اختيار منتجاتنا على منافسينا. يجب أن نعمل على تسليط الضوء على العناصر الفريدة والمميزة في استراتيجيتينا، سواء من خلال التسويق الرقمي، أو الدعاية والإعلان، أو العروض الترويجية المستهدفة.

مع استراتيجية التمييز، نتطلع للحفاظ على تميزنا وميزتينا التنافسية على المدى الطويل. لذلك، يجب أن نكون حريصًا على مراقبة السوق والتغيرات في احتياجات وتفضيلات العملاء، ونعمل على تطوير وتحسين منتجاتنا بشكل مستمر للبقاء في صدارة السوق.

باستراتيجية التميز، نحن نستهدف عملاء ذوي قدرة شرائية عالية و متوسطة والذين يبحثون عن منتجات وخدمات فريدة ومتميزة. قد يكون هذا النهج مثاليًا في الأسواق التي يوجد بها منافسة شرسة ويسعى المستهلكون إلى التمييز والتفرد.

- استراتيجية التركيز

استراتيجية التركيز تركز على استهداف فئة محددة من العملاء أو سوق محدودة بدلاً من محاولة استهداف الجميع. تهدف هذه الاستراتيجية إلى تلبية احتياجات ورغبات شريحة محددة من العملاء بشكل مميز وفعال.

عند تبني استراتيجية التركيز، نقوم بتحديد الشريحة المستهدفة بدقة وفهم احتياجاتها ومتطلباتها الخاصة. كما نعمل على تصميم منتجات وخدمات تلبي تلك الاحتياجات بشكل مميز وفريد.

يمكن أن تكون استراتيجية التركيز متجهة نحو الأسواق الجغرافية مثل استهداف سوق محلي معين أو سوق إقليمي، أو يمكن أن تكون متجهة نحو الفئات الديموغرافية مثل استهداف فئة عمرية معينة أو فئة دخل محددة. يمكن أيضًا توجيه استراتيجية التركيز نحو احتياجات ومتطلبات خاصة مثل الفئات العمرية الصغيرة أو العملاء ذوي الاحتياجات الخاصة.

استراتيجية التركيز تمنحنا القدرة على تخصيص الموارد والجهود بشكل فعال نحو الشريحة المستهدفة، مما يساعدنا على تحقيق تفوق تنافسي في هذا القطاع المحدد. كما أنها تمكننا من تقديم منتجات وخدمات تفوق توقعات العملاء في هذه الشريحة المستهدفة.

من الجوانب الإيجابية لاستراتيجية التركيز أنها تسمح لنا ببناء علاقات قوية مع العملاء المستهدفين وتحقيق رضاهم وولاءهم. كما أنها تمكننا من تفادي المنافسة المباشرة مع اللاعبين الكبار في السوق.

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المحور الرابع :خطة الإنتاج والتنظيم

خطة الإنتاج والتنظيم هي جزء حيوي من مشروعنا، حيث تهدف إلى ضمان تنفيذ عملية الإنتاج بطريقة فعالة ومنظمة...

- **اقتناء المواد الأولية**: سيتعين علينا تحديد واقتناء المواد الأولية اللازمة لتصنيع سوارنا الذكي. سنحتاج إلى مواد عالية الجودة ومتوافقة مع مواصفات المنتج. سيتطلب ذلك تحديد الموردين الموثوق بهم والمتخصصين في توفير هذه المواد.
- **التصنيع**: سيتم تنفيذ عملية التصنيع لصنع الأجزاء المختلفة للسوار الذكي وتجميعها. يتضمن ذلك استخدام تقنيات التصنيع المتقدمة والمعدات المناسبة لضمان جودة المنتج النهائي.
- **تكييف المنتج**: بعد التصنيع، سيتعين علينا تكييف المنتج لضمان أدائه الأمثل ووظائفه الفعالة. قد يتطلب ذلك ضبط إعدادات البرمجيات أو تنفيذ تعديلات تقنية لتلبية احتياجات العملاء والمستخدمين.
- التعبئة والتغليف: بعد تجهيز السوار الذكي، سيتعين علينا تغليفه بشكل مناسب وتوفير عبوات آمنة وجذابة. سيتم تصميم العبوة بعناية لحماية المنتج وتوفير سهولة في التخزين والشحن وعرض المنتج للعملاء.

عملية الإنتاج ستتطلب التنسيق والتنظيم الجيد لضمان أن تتم جميع المراحل بشكل فعال وفي الوقت المحدد. سيتم تعيين فريق متخصص لإدارة ومراقبة عملية الإنتاج، بما في ذلك تخطيط الموارد وتنظيم سير العمل. سيتم تحديد المهام وتوزيعها على الفرق المعنية بكل مرحلة من مراحل الإنتاج، وسيتم وضع جدول زمني محدد لكل مرحلة وتعيين مسؤوليات محددة لضمان التنفيذ السلس والمنظم.

بالإضافة إلى ذلك، سيتم النظر في جوانب الجودة وضمانها طوال عملية الإنتاج. سيتم وضع إجراءات مراقبة الجودة واختبار المنتجات للتحقق من أنها تفي بالمعايير المطلوبة قبل التوزيع والتسويق.

سيتم أيضًا النظر في تنظيم سلسلة التوريد لضمان توافر المواد الأولية في الوقت المناسب وبكميات كافية للإنتاج. سيتم تعيين الموردين الموثوق بهم وتنسيق عملية الشراء والتوريد بشكل فعال.

باختصار، ستتم مراعاة جميع جوانب الإنتاج والتنظيم لضمان تنفيذها بنجاح.

تموين المشروع:

سيتطلب مشروعنا تموينًا فعالًا لضمان توافر الموارد والمواد اللازمة لعملية الإنتاج. سيتم تحديد الموارد المطلوبة مثل المواد الأولية والمكونات والمعدات والأدوات والتكنولوجيا المطلوبة. سنعمل على تطوير علاقات قوية مع الموردين والشركات المصنعة لضمان توفر هذه الموارد بجودة عالية وبأسعار مناسبة. سنقوم بمراجعة وتقييم الموردين بانتظام لضمان استمرارية التموين وتحقيق أفضل قيمة للمشروع.

اليد العاملة:

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ستكون اليد العاملة جزءًا أساسيًا في عملية الإنتاج. سنحتاج إلى فريق مؤهل ومدرب يتمتع بالخبرة المناسبة في مجالات مثل التصميم والهندسة والتصنيع ومراقبة الجودة. سنضمن توفر العمالة الماهرة والملتزمة بمعايير الجودة والكفاءة. سنحرص على توفير بيئة عمل مناسبة وتطوير فرق عمل متعاونة ومحفزة لتحقيق أهداف المشروع بنجاح.

الشراكات الرئيسية:

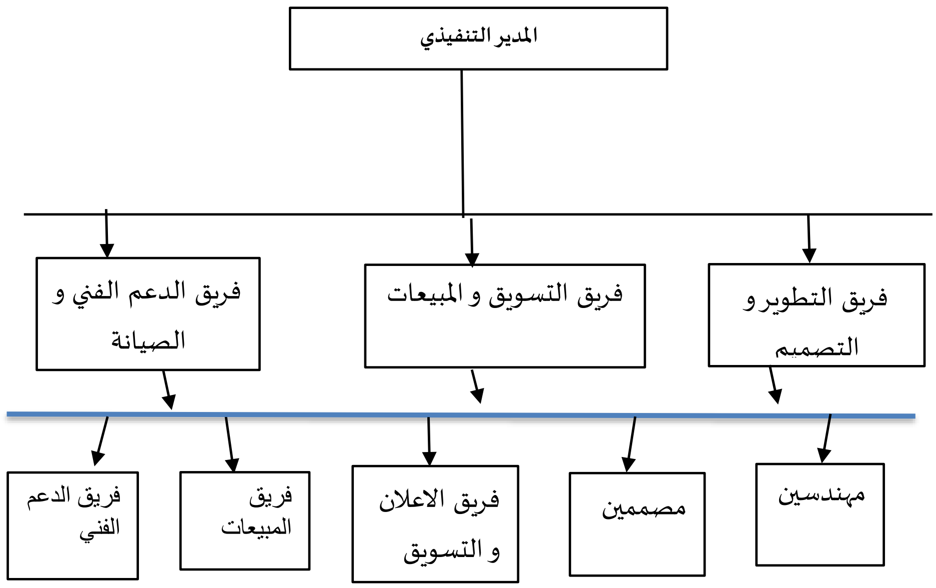
سنسعى لتطوير شراكات استراتيجية رئيسية تدعم نجاح المشروع. قد تشمل هذه الشراكات الشركات المصنعة للمواد الأولية والمكونات، والشركات التقنية للتكنولوجيا المستخدمة في السوار الذكي، والشركات المتخصصة في التعبئة والتغليف، وشركات النقل والتوزيع. سنعمل على تطوير علاقات مستدامة ومبنية على الثقة والتعاون مع هذه الشركات لضمان توافر الموارد والتكنولوجيا وتحقيق أفضل تجربة للعملاء.

الاستراتيجية التي ستدعمنا في مختلف جوانب العمل، ومن بينها:

1. **شركات المبيعات والتسويق**: سنعمل على تشكيل شراكات مع شركات التسويق والمبيعات لتعزيز وتسويق منتجنا في السوق المستهدف. ستقوم هذه الشركات بتسويق وبيع المنتجات وتوسيع قاعدة العملاء وزيادة الوعي بالعلامة التجارية لدينا.
2. **مقدمي خدمات التكنولوجيا**: ستكون لدينا شراكات مع شركات التكنولوجيا لدعمنا في تطوير وتحسين تكنولوجيا السوار الذكي. ستعمل هذه الشركات على تقديم الخبرة والمعرفة التقنية والتحديثات اللازمة لتحسين أداء المنتج وتلبية احتياجات العملاء.
3. **الموردين ومصنعي المكونات**: سيتطلب مشروعنا التعاون مع موردين ومصنعي المكونات الأساسية للسوار الذكي. سنبني شراكات معهم لضمان توفر المكونات عالية الجودة والمتوافقة مع مواصفاتنا وفقًا للجدول الزمني المحدد لعملية الإنتاج.
4.
5. **الشركات المتخصصة في التعبئة والتغليف**: سنعمل مع شركات التعبئة والتغليف المحترفة لتطوير تصاميم جذابة وعملية لعبوات منتجاتنا. ستقوم هذه الشركات بتوفير حلول تعبئة وتغليف فعالة تضمن سلامة المنتج وتقديم تجربة مميزة للعملاء.

سوار ذكي لمراقبة وتتبع مرضى المستشفى

المخطط التنظيمي:



المحور الخامس: الخطة المالية PLAN FINANCIER

تعتبر عنصرًا هامًا في إدارة المشروع، وتشمل التكاليف والإيرادات وجدول حسابات الناتج المتوقع وخطة الخزينة.

أولا- تكاليف المشروع واهتلاك الاستثمار.

:تكاليف المشروع: تتمثل التكاليف الاجمالية للمشروع في التكاليف الاستثمارية والتكاليف التشغيلية

التكاليف الاستثمارية:

الأصول	التكلفة
المباني	15000
الآلات والمعدات	25000
الأثاث	10000
رأس المال العامل	10000
المجموع	60000

التكاليف التشغيلية:

الأصول	التكلفة
مواد أولية	**5000 DZ**
أجور	**0**
الهاتف والانترنت	**650 DZ**
الكهرباء والماء	**1000 DZ**
المجموع	**6600 DZ**

سوار ذكي لمراقبة وتتبع مرضى المستشفى

1- **الهيكل التمويلي:** يتم تمويل مشروعنا بالاعتماد الكلي على الأموال الخاصة لصاحب المشروع وهذا ما يسمى بالتمويل الذاتي كما هو موضح في الجدول التالي:

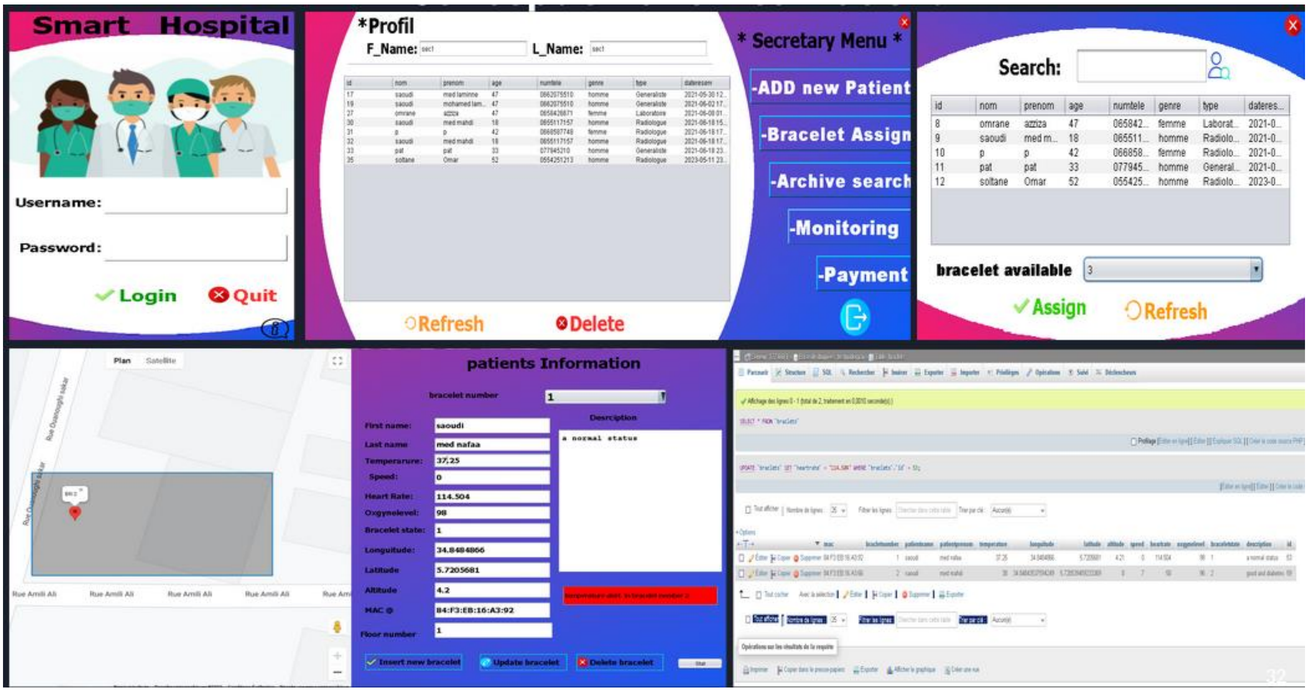
البيان	النسبة	القيمة
أموال خاصة	100 %	**100000 DZ**
القروض	0%	0 DZ
المجموع		**100000**

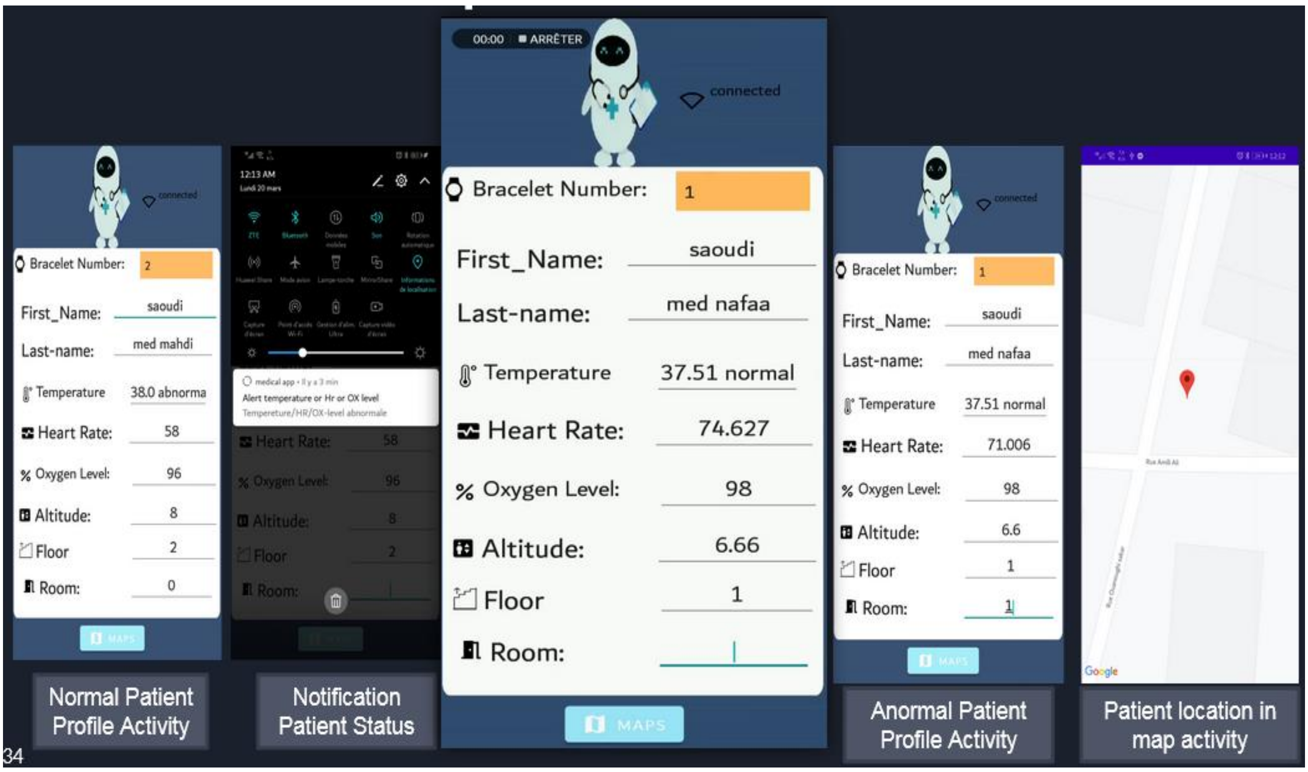
STARTUP : SMB-Entreprise

	PREVISION					
Produit a destiné client	N	N+1	N+2	N+3	N+4	N+5
Quantité produit a	25	50	75	100	150	250
Prix HT produit a	5000					
Vente produit a	8	20	50	80	120	240
Chiffre d'affaire Global (DZ)	40000	100000	250000	400000	600000	1200000
	2554000					

سوار ذكي لمراقبة وتتبع مرضى المستشفى

المحور السادس : النموذج الاولي التجريبي


Smart Hospital
Username:
Password:
Login
Quit
*Profil
F_Name:
L_Name:
Refresh
Delete
* Secretary Menu *
-ADD new Patient
-Bracelet Assign
-Archive search
-Monitoring
-Payment
Search:
bracelet available
Assign
Refresh
patients Information
First name:
Last name
Temperarure:
Speed:
Heart Rate:
Oxygenelevel:
Bracelet state:
Longuitude:
Latitude
Altitude
MAC @
Floor number
Description
a normal status
Insert new bracelet
Update bracelet
Delete bracelet


connected
Bracelet Number:
First_Name:
saoudi
Last-name:
med mahdi
Temperature
38.0 abnorma
Heart Rate:
Oxygen Level:
Altitude:
Floor
Room:
MAPS
Alert temperature or Hr or OX level
Tempereture/HR/OX-level abnormale
00:00
ARRÊTER
med nafaa
37.51 normal
74.627
6.66
71.006
6.6
Normal Patient Profile Activity
Notification Patient Status
Anormal Patient Profile Activity
Patient location in map activity

Comparison with the related devices

Model	Xiaomi Mi Band 6	T800 Ultra	Marcrazy M4 Smart	SMB Prototype(Our Solution)
Price	$39.99	$49.99	$29.99	$26.9
Sensors	HR, SpO2, PPG, Gyroscope	HR, SpO2, PPG, Gyroscope	HR, Pedometer, Gyroscope	HR, SpO2, PPG, Temperature,Barometer
Battery Life	Up to 14 days	Up to 7 days	Up to 10 days	Up to 8 days (Under Optimization
Connectivity	Bluetooth, NFC	Bluetooth	Bluetooth	WIFI, Bluetooth
Waterproof	Yes (5 ATM)	Yes (IP67)	Yes (IP67)	NO
Display	AMOLED touchscreen	OLED touchscreen	Color TFT touchscreen	NO
Sleep Tracking	Yes	Yes	Yes	Under OPTIMISATION
GPS	No	No	No	YES (3D LOCATION)
Companion App	Mi Fit (iOS, Android)	T800 Ultra App (iOS, Android)	Marcrazy App (iOS, Android)	SMB APP(iOS, Android)
Heart Rate	Continuous	Continuous	Continuous	Continuous
SOS Call	No	No	No	YES
ECG Monitoring	No	No	No	NO
Notifications	Call, Message, App Alerts	Call, Message, App Alerts	Call, Message Notifications	Message, App Alerts

Business Model Canvas

الشركاء الأساسيون

قم بسرد شركاءك في العمل التجاري

- فريق التطوير والهندسة لتصميم وتطوير الأساور الذكية والبرمجيات.
- موردي المكونات الإلكترونية والتقنيات المرتبطة.
- موردي البرمجيات والتطبيقات المستخدمة في المراقبة وتحديد المواقع.
- شركاء التوزيع والتسويق.

المهام الأساسية

اشرح ماهي مهام عملك التجاري الأساسية التي ستقوم بها

- بحث وتطوير الأساور الذكية والتقنيات المرتبطة.
- تصنيع وإنتاج الأساور الذكية.
- تطوير وتحديث البرمجيات والتطبيقات المستخدمة في المراقبة وتحديد المواقع.
- التسويق والترويج للأساور الذكية والبرمجيات.
- توفير الدعم الفني والتدريب على استخدام الأساور الذكية والبرمجيات.

المصادر الأساسية

قم بسرد مصادرك الأساسية للقيام بعملك التجاري

- المال لشراء المعدات والمكونات وتطوير البرمجيات.
- الموظفين للتطوير والتصنيع والتسويق.
- شبكة الموردين والشركاء.

القيمة الأساسية

اشرح ماهي القيم الأساسية التي سيقدمها عملك التجاري

- الابتكار: التركيز على تقديم منتجات وخدمات مبتكرة وذات جودة عالية، مع التطور التكنولوجي المستمر والتحسينات المستمرة لتلبية احتياجات العملاء.

الدقة والدقة: التأكد من دقة قياسات ومعلومات الأساور الذكية وبرمجيات المراقبة لضمان تقديم بيانات دقيقة وموثوقة للمرضى والمستشفيات.

- الأمان والخصوصية: التأكد من تطبيق أفضل المعايير والإجراءات لحماية بيانات المرضى وضمان سرية المعلومات الشخصية.

- سهولة الاستخدام والتوافق: توفير واجهة مستخدم سهلة الاستخدام ومفروءة للمستخدمين، مع التوافق مع مختلف الأجهزة والمنصات لضمان قابلية التكامل والتشغيل السلس

التكلفة الفعالة: تقديم منتجات وخدمات ذات قيمة مضافة عالية مقابل تكلفة معقولة ومناسبة للعملاء.

- الدعم الفني والاستجابة السريعة: توفير دعم فني مستمر وفعال للعملاء، بما في ذلك الاستجابة السريعة للاستفسارات والمشاكل التقنية.

- الشراكة والتعاون: بناء شراكات استراتيجية مع الموردين والشركاء لضمان توفير المنتجات والتقنيات الحديثة وتوسيع قاعدة العملاء.

- التوعية والتثقيف: توفير موارد ومعلومات تثقيفية للمرضى والمستشفيات حول فوائد الأساور الذكية وبرمجيات المراقبة عن بُعد والممارسات الصحية.

العلاقة مع العملاء

اشرح كيف ستدير العلاقة بين عملاءك ومنتجاتك التي تقدمها

- الدعم الفني المستمر للعملاء.
- التواصل المنتظم مع المرضى والمستشفيات لمتابعة التحسينات واحتياجات السوق.
- تقديم تحديثات البرمجيات والتطبيقات للعملاء.

القنوات

اشرح كيف تنوي الوصول لعملائك؟ وكيف ستصل منتجاتك لهم؟ وكيف سيتم التواصل معهم؟

- موقع الويب للشركة للترويج والبيع عبر الإنترنت.
- الشركات المصنعة للأجهزة الطبية ومستشفيات ومراكز رعاية الصحة كقنوات توزيع إضافية.
- الشراكات مع شركات التكنولوجيا الأخرى للتسويق والتوزيع.

الشرائح المستهدفة

من هم عملائك؟ وهل ستقوم بتقسيمهم إلى شرائح؟ اذكر شرائح العملاء

المؤسسات الصحية والمستشفيات: تشمل المستشفيات والعيادات ومراكز الرعاية الصحية التي تعتبر مكان عمل المرضى والممرضين والأطباء. يمكن استخدام الأساور الذكية لتتبع المرضى وتحسين عمليات الرعاية الصحية وتوفير السلامة والأمان للمرضى

المرضى وأفراد العائلة: يمكن استخدام الأساور الذكية لمراقبة وتتبع المرضى وتوفير إشعارات وتنبيهات لأفراد العائلة بشأن حالة المريض وموقعه ومعلومات صحية أخرى ذات صلة. قد تكون الأساور مفيدة لمرضى الزهايمر أو الأشخاص ذوي الاحتياجات الخاصة الذين يحتاجون إلى رعاية ومتابعة مستمرة.

- الشركات ومزودي الخدمات الصحية: يمكن أن تكون الأساور الذكية مثيرة للاهتمام للشركات ومزودي الخدمات الصحية الذين يقدمون حلولًا تقنية ومنتجات لقطاع الرعاية الصحية. يمكن أن تساهم الأساور الذكية في تحسين جودة الرعاية وتعزيز كفاءة العمليات وتحقيق التكلفة الفعالة.

- الجمهور العام: قد يكون هناك اهتمام من قبل بعض الأفراد الذين يرغبون في استخدام التكنولوجيا الحديثة لتتبع صحتهم الشخصية ومعرفة المزيد عن حالتهم الصحية ونمط حياتهم. يمكن أن تكون الأساور الذكية خيارًا جذابًا لهؤلاء الأفراد لأغراض التتبع الشخصي واللياقة البدنية.

هيكلة التكاليف

اشرح التكاليف اللازمة لبدء عملك التجاري

- تكاليف البحث والتطوير والتصميم.
- تكاليف التصنيع والإنتاج.
- تكاليف تطوير البرمجيات والتطبيقات.
- تكاليف التسويق والترويج.
- تكاليف توفير الدعم الفني والتدريب.

مصادر الدخل

قم بشرح وسرد مصادر دخل عملك التجاري

- مبيعات الأساور الذكية والتقنيات المرتبطة.
- رسوم تراخيص البرمجيات والتطبيقات.
- خدمات الصيانة والدعم الإضافية.

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