Department of Computer, Control and Management Engineering

Control Engineering

Satellite for smart cities with the application of IoT based smart healthcare

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Contents

I. Abstract

Internet of Things and cloud computing brought new technologies all over the world and as a result the concept of “smart city” has introduced and grown rapidly in recent years. The traditional urban system has a very inefficient mode of operation due to the reason that there is no effective interconnection between the information of the systems. The concept of the Internet of Things (IoT) integrated with embedded system and new technologies in the healthcare sector has opened a new field of research. The idea of smart healthcare has increasingly gained traction as information technology advances. Smart healthcare employs a new generation of information technology, such as the internet of things, big data, cloud computing, and artificial intelligence, to completely reinvent the conventional medical system, making it more efficient and personalized. With the aim of incorporating the idea of smart healthcare, we list the main technologies that help smart healthcare and discuss the current state of smart healthcare in many key fields in including smart hospital and smart medicine. The ultimate aim of smart hospitals is to provide the best possible patient treatment by using advanced ICT. All relevant information is available when needed; access to internal and external expertise is available when needed; and reliable and successful surgical/diagnosis procedures are available to help achieve this aim with a low error rate and at a reasonable cost. Moreover, The natural decrease in physical condition of old peoples and simultaneously the increase of different diseases, force them to take medicine on time to improve their health conditions which leads us to the concept of smart medicine. In order to solve this series of such problems in this article all these concepts will be discussed.

II. Introduction

1. Satellite for smart cities

By 2050 more than half of the worlds’ population will be living in urban areas. This increase in the rate of urbanization leads into challenges like urban mobilization, climate adaptation, energy and sustainability. By rapid urban transition demands for efficient energy systems, smart infrastructure and sustainable resources there is a need to replace the current operating model of cities with more reliable and smarter one. An IoT-based city that using sensors, actuators and other Communication technologies by transmitting data across different devices is known as smart city. The aim of a smart city is to link all layers of the city, as well as its inhabitants. The IoT is a network of many physical connected devices, like vehicles or home appliances, that enable these ‘things’ to connect and exchange data thus transforming the traditional urban life elements to next generation intelligent systems hence enabling smart cities. The aim of building a smart city is connected to the application of the Internet. Internet is one of the different technologies that are widely used to the construction of smart cities include: big data, cloud computing and Internet of Things technologies and the main role of the Internet of Things technology in the construction of smart cities is to receive large data from different sources. The combination of these data can be named as big data. Cloud computing refers to the distribution of computing resources over the internet, such as servers, storage, databases, networking, applications, analytics, and intelligence, in order to allow faster and more cost-effective innovation. Cloud computing is responsible for the big data information through the distributed computing resources in the cloud. At the construction of smart cities, is equivalent to collecting, analyzing and storing the data related to IT [1]. An illustration of IoT based smart city is shown in Figure 1 and Sectors and services for IoT are listed in Table 1[2].

Figure 1-An illustration of IoT based smart city [3]

Table 1-Examples of sectors and services in IoT

Service sector	Application group	Location	Devices
Buildings	Commercial, institutional, industrial	Office, school, hospital, airport, stadium	Lighting, fire & safety tools
Energy	Generation, distribution, demand	Solar power plant, wind power plant (inshore or offshore), power grid, pipelines	Turbines, windmills, batteries, UPS, power meters
Healthcare	Public care, home care	Hospitals, home	Electro-medical equipments
Industrial	Process control, process automation	Extractive site, manufacturing plant	Pumps, valves, motors, packaging
Transportation	Terrestrial, aeronautical, maritime	Ground, air, sea, road, railroad	Cars, ships, airplanes, traffic lights, toll booth
Retail	Stores, specialty, hospitality	Cinema, theatre, fuel station, supermarket, shopping center, hotel, restaurant	Vending machines, tags, POS terminals, cash registers
Public and Safety security	Emergency services, law enforcement, monitoring	Country level, city level, environment, battlefield	Jeep, car, ambulance, environment sensor
ICT and networks	Public, enterprise, e-commerce	Data center, service providers, telecomm. networks, office	Servers, routers, PC, tablets, phones

In several application scenarios, sensors and actuators are deployed in remote areas that are not served by terrestrial access networks; as a result, the use of satellite communication systems for the Internet of Remote Things becomes essential (IoRT). Interoperability between sensors/actuators and satellites is one of the most important enabling factors in satellite communications for IoRT. The satellite collects data measurements from sensor nodes and sends them to a ground station for data management, as shown in Fig 2. Furthermore, ground stations send control data to the satellite, which is then sent to the actuator nodes. Direct and indirect access are the two types of interoperability between satellites and sensors/actuators. Indirect access mode allows each sensor and actuator in a wireless sensor and actuator network (WSAN) to communicate with the satellite directly, whereas direct access mode allows each sensor and actuator to communicate with the satellite through a sink node [2] .

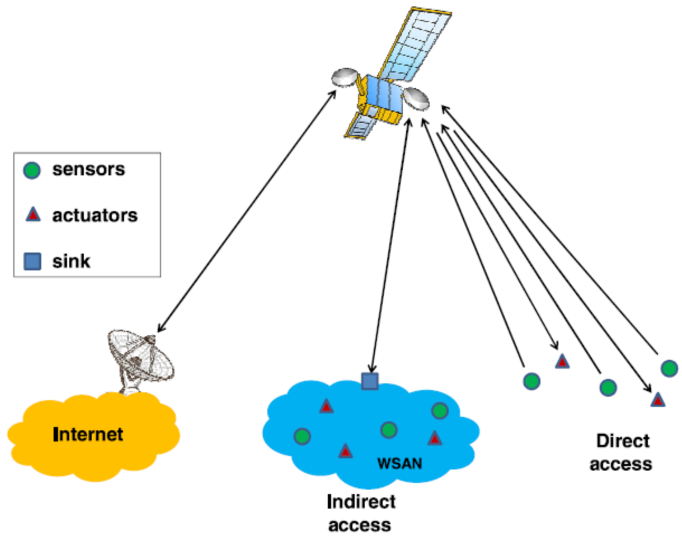


Figure 2-Example of a satellite system communicating with sensors and actuators.

To ensure coverage in satellite-based Internet of Things, a combination of satellite direct reception and terrestrial 5G infrastructure is required, especially in smart cities where buildings can cause high power losses. With improved bandwidth and higher consumer data speeds than today's capabilities, 5G networks are supposed to offer access to everyone, anywhere, at any time. This would be especially useful in establishing the Internet of Things (IoT), which aims to collect and transmit data for various purposes and scenarios. Furthermore, smart cities would place a high demand on broadcasting infrastructures with high-speed Internet access and secure emergency communication networks. The use of a range of communication systems, including non-terrestrial channels, would support both of these facilities. As a result, researchers and the 5G industry are working hard to establish new standards for interworking between various access technologies, with a particular emphasis on the convergence of different terrestrial and satellite networks, with the aim of maximizing synergies. Satellites are also seen as a better choice for some machine-to-machine communications, information dissemination, broadcast, and some delay-tolerant services. Furthermore, since the introduction of the first High-Throughput Satellites, the cost of satellite bandwidth has decreased significantly. Smart Cities are attempting to cope with the rise of urbanization by seeking creative and long-term solutions to problems such as climate change. Satellites are now an integral part of the city-building process, as they have proved to be cost-effective for governments. The review of the ongoing 5G specification indicates two key alternatives for the satellite radio access network (RAN) in the potential 5G architecture (Figure 3), according to the European Commission's Horizon 2020 5G Public Private Partnership Phase 2 project "SaT5G" (Satellite and Terrestrial Network for 5G):

- Remote access: Via a satellite connection, satellite-capable UE (User Equipment) has direct access to the 5G network.
- Indirect access: UE connects to a RAN via a satellite connection that is linked to the 5G core [4].

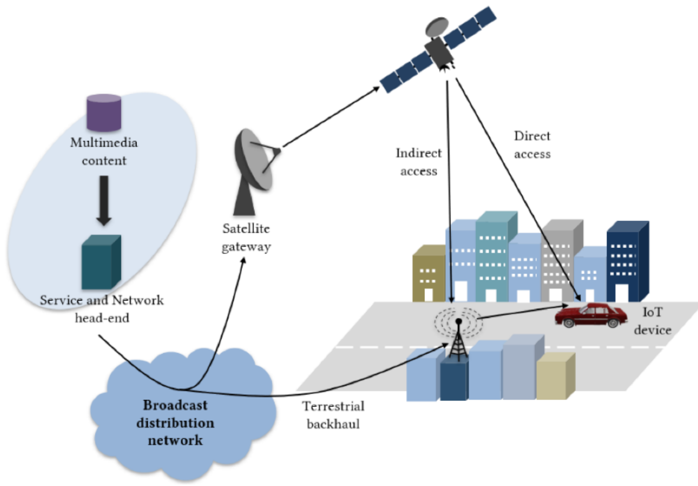


Figure 3-Example of integrated terrestrial-satellite network architecture

3G (3rd generation), LTE (Long-term evolution), Wi-Fi (Wireless fidelity), WiMAX (worldwide interoperability for microwave access), ZigBee, CATV (cable television), and satellite networking are examples of existing communication networks used in Smart City infrastructure (see Figure 4). The main goal is to integrate all kinds of things (sensors and IoTs) that can help make citizens' lives easier and safer. For example, GPS devices use satellite networks, smart phones use wireless services such as GSM/3G/4G, and PCs and other navigation devices use the internet to collect raw data [5].

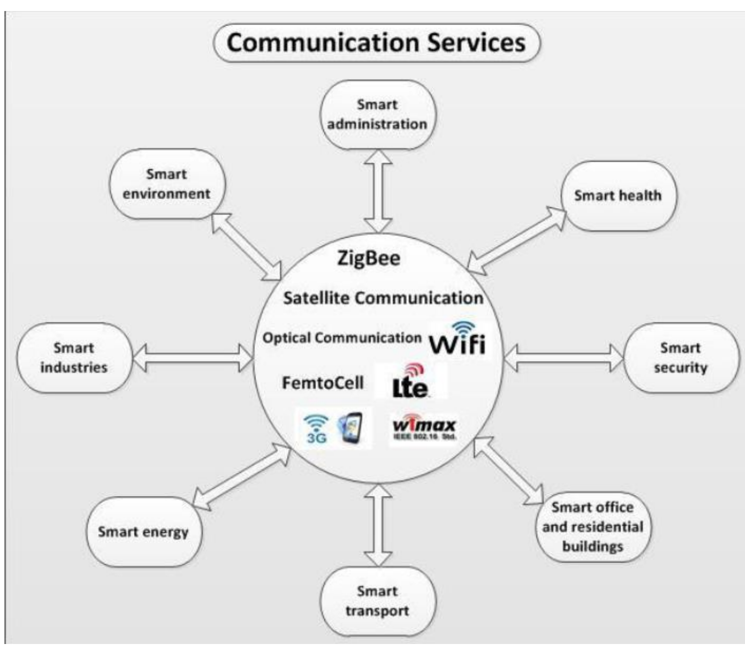


Figure 4-Communication Services

IoT based smart city applications can be categorized based on the different criteria such as type of network, scalability, coverage, flexibility and end-user involvements. These applications can be grouped into enterprises, personal and home, utilities and mobile. As an example, personal and home applications include e-healthcare services which help a doctor to monitor patients remotely or more widely smart hospital, a highly immersive world filled with high-end, ubiquitous gadgets. Utilities applications include smart grid, smart metering/monitoring, and video-based surveillance. Similarly, mobile applications include intelligent transportation system (ITS), traffic management and congestion control and in this field Satellites, as part of space technology, play a critical role in the development of smart cities, especially when it comes to autonomous vehicles, which would aid the population's secure and efficient mobility. Autonomous cars will receive updated information through monitoring and address assignment, avoiding traffic and accidents. IoT-based smart city includes billions of devices in the network. If the concept of smart city has the ability to provide connectivity to every available IoT device with sensing capabilities which produce significant information can be successful. In smart cities, the IoT devices can utilize any available communication networks such as public Wi-Fi, Bluetooth, cellular networks and satellites to communicate with the cloud-based application center [3]. This upcoming technology can also enhance the existing Electric Vehicles (EVs) charging paradigm. Indeed, in recent years, they are emerging as a favorable strategy to meet the increasing environmental concerns and energy insufficiency, and this trend is expected to grow in the near future. Moreover, the automotive industry is also motivated to adopt cleaner and more sustainable technologies by the governmental regulations and international agreements. As largely recognized, massive Electric Vehicles (EVs) charging represents a concern for the operation of electricity distribution grids, but also an opportunity, due to the possibility of exploiting the flexibility offered by the vehicles during charging. By utilizing the advantages of the Internet of Things (IoT) technology, is possible to provide a better EV charging system, in order to climb over the inadequate charging stations (CS) which block the widespread of EVs and a real-time monitoring of the EV stations, managed within one platform. So, connectivity between the charging stations (CS) is mandatory. Furthermore the end users assume an important role: they can easily use the CS based on their requirements[6].

III. Applications of satellite for smart city in the field of smart healthcare

1.1. Smart healthcare and smart hospital

Connected medical devices are changing how the healthcare industry operates, both within hospitals and amongst various stakeholders. When connected to clinical information systems, connected medical devices will improve patient safety and performance. When this is applied to the whole healthcare ecosystem, it is referred to as a "Smart Hospital." However, the increased flow of information within and between hospitals introduces threats that hospital C-level executives (CIOs, CISOs, and others) must address. The risks include potential damage to patient safety or the loss of personal health information, and they may be caused by human errors, device or third-party failures, or natural phenomena, among other things. With the advent of connected devices, the attack surface expands exponentially, increasing the attack potential [7].

1.1.1. Smart Hospitals (enisa project)

A. The smart hospital environment

To strengthen current patient care procedures and implement new capabilities, a smart hospital relies on optimized and automated processes built on an ICT environment of interconnected assets, especially based on Internet of things (IoT). The objectives of a smart hospital is depicted in Figure 5.

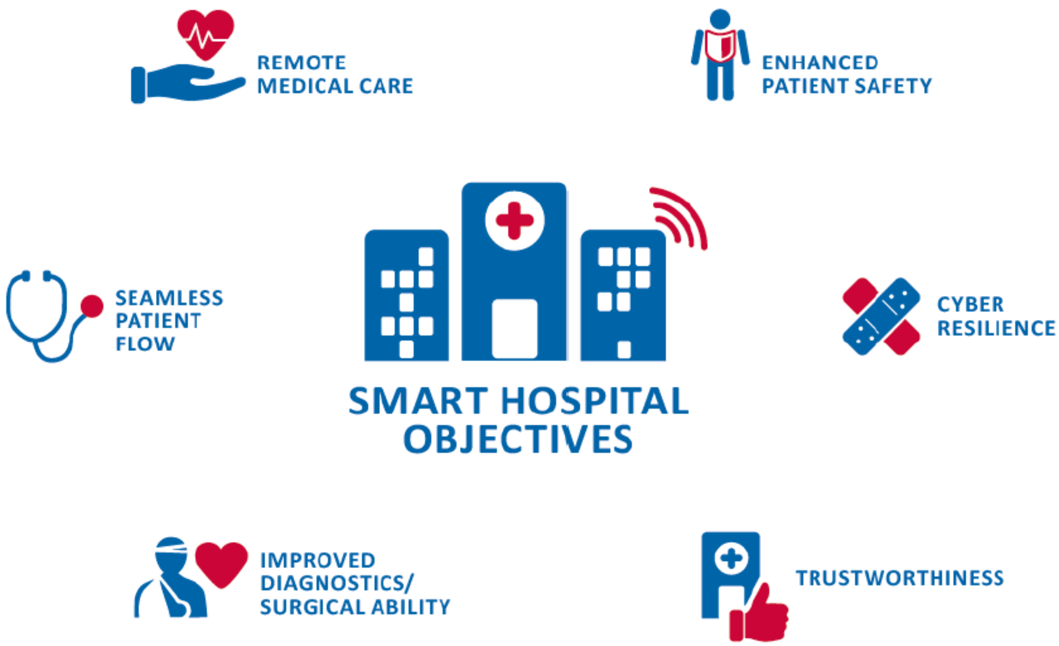


Figure 5- Smart hospital objectives

- **Improved diagnostics or surgical capability:** Information and communication technology (ICT) can not only allow new treatment methods (e.g., surgical robots can conduct micro-surgery that clinicians cannot), but it can also enhance existing ones. Hospitals are increasingly able to mine patient data to aid in diagnosis and care planning, and advanced technological tools are enabling them to fine-tune their administrative processes.
- **Seamless patient flow:** Effective healthcare, as well as patient flow that is seamless, can minimize waiting times and length of hospital stays, as well as reduce complications, increase profits, and improve patient (and employee) satisfaction. ICT can be used to locate, analyze, and eliminate bottlenecks, resulting in more reliable healthcare and patient flow. Automatic updates of medical information through networked devices and information systems can, for example, support efficient healthcare and patient flow in smart hospitals.
- **Remote medical care:** Extending the hospital's boundaries and providing remote medical care is one of the main goals of bringing IoT devices into the healthcare context. Various medical devices, such as implantable devices, wearable devices, and other mobile devices, allow real-time patient monitoring by measuring key vital signs and making these

measurements accessible to hospital staff and systems through network connections. Several medical devices that provide the ability to function (e.g., administer a medical dose) on the patient based on status or through remote controls complement these remote patient care capabilities. As a result, hospital admissions can be limited to certain conditions that are considered appropriate, resulting in lower health care expenses and a better patient experience because the patient can now receive treatment from the comfort of his or her own home.

- **Enhanced patient safety:** Patient and clinical safety are also improved by improving healthcare quality and patient flow. However, it is important that healthcare quality and patient flow do not deteriorate at the cost of patient safety. Without a question, properly connected devices that collect data on patient vital signs and medication consumption, as well as tracking life support machines, will contribute to improved patient safety.
- **Cyber Resilience:** The capacity of a hospital to ensure the availability and continuity of its services that depend on ICT assets is referred to as cyber resilience. Increased ICT adoption eventually leads to increased ICT reliance, which raises the importance of information security in smart hospitals.
- **Trustworthiness:** In areas where choosing between different providers is a choice, being viewed as trustworthy and having a good reputation is a competitive problem. Adherence to prescriptions and quality of treatment are often affected by trustworthiness, which has consequences for the results a hospital can achieve. Being at the forefront of ICT adoption has undeniable reputational benefits. Around the same time, in order to prevent a bad name, patient protection and privacy must not be jeopardized.

B. Smart hospital assets

Hospitals have a diverse collection of properties that are critical to their operations and must be safeguarded. Although some smart hospital assets are useful in conventional hospitals as well, others are unique to smart hospitals because they are intelligently linked and capable of making decisions on their own.

1. **Remote care system assets:** The ICT ecosystem that enables the smart hospital to expand its boundaries and offer healthcare services to patients in remote locations (such as at home) is made up of the following remote care system assets:
    - Medical equipment for tele-monitoring and tele-diagnosis (e.g., blood pressure, pulse rate, glucose measurements, ECG and other remote physiological measurements, threshold-triggered warning generators, etc.)
    - health devices for medication delivery (automated dosing equipment) or treatment administration.
    - telehealth computer system for patients to record their physiological measurements themselves (including patient-side application/software if applicable); telehealth devices, such as cameras, sensors, and telephone/internet connections.
2. **Networked medical devices:** Smart hospitals are characterized by their widespread use of these technologies, which also allow remote patient monitoring, which is a key service that smart hospitals can offer to national healthcare management as compared to conventional hospitals. Furthermore, new implantable devices like pacemakers can be upgraded, which reduces the amount of reasons for replacement. Modern hospitals have made extensive use of both stationary and mobile devices. They are, however, intelligently linked with recognition

components and clinical information systems in the smart hospital sense, increasing the degree of automation and decision-making capacity. Here are some examples:

- mobile devices (e.g. glucose measuring devices);
- wearable external devices (e.g. portable insulin pumps, wireless temperature counters);
- implantable devices (e.g. cardiac pacemakers);
- stationary devices (e.g. computer tomography (CT) scanners, life support machines, chemotherapy dispensing stations);
- supportive devices (e.g. assistive robots).

3. **Identification systems:** Patients, nurses, and medical equipment such as beds are both tracked and authenticated using identification systems. Biometric scanners in smart hospitals don't just read identification systems; they're also intelligently networked with sensors and information systems. Furthermore, in smart hospitals, closed-circuit security systems play a critical role in authentication and, as a result, authorization (e.g., enabling access to specific areas). Here are some examples:
    - Tags, bracelets, stickers, and smart badges (e.g., ultrasound-enabled identification systems).
    - Scanners for biometric data.
    - RFID systems with location services (software components) for assessing and monitoring relative asset/patient/staff movement.
    - CCTV (closed-circuit television) with identification and authentication capabilities
4. **Networking equipment:** The communications backbone for smart hospitals is provided by networking equipment. The needed equipment is similar to that used in a typical hospital, but it has additional features (e.g. routing protocols, bandwidth). Among the many examples:
    - Transmission media;
    - Network interface cards;
    - Backbone network equipment (hubs, switches, routers, and so on);
    - IoT Gateways, which process data collected by devices and send it to a data center or the cloud for further analysis.
5. **Mobile client devices:** In smart hospitals, mobile client devices are intelligently integrated to make the right information accessible at the right time in the right place and to enable staff and patients to move about more freely. Here are some examples:
    - Mobile clients (e.g. desktop computers, tablets, laptops, pagers);
    - Smartphone and tablet applications;
    - Mobile alarm and emergency communication applications
6. **Interconnected clinical information systems:** To allow smart end-to-end patient care processes, are deployed in smart hospitals alongside medical devices and identification components. Furthermore, clinical networked information systems in smart hospitals are becoming increasingly capable of making autonomous decisions. Here are some examples:
    - Hospital information systems (HIS);
    - Laboratory information systems (LIS);
    - Radiology information systems (RIS);
    - Pharmacy information system (PIS);
    - Pathology information system;
    - Blood bank system;
    - Picture archiving and communication systems (PACS);
    - Research information system.

7. **Data:** In terms of information protection, data is often regarded as a valuable asset. The majority of the decisions made by a smart device are focused on data analysis. Here are some examples:
    - Clinical and administrative patient data (e.g., medical history, test results, and contact information);
    - financial, organizational, and other hospital data;
    - research data (e.g., clinical trial reports) and data intended for secondary use;
    - staff data;
    - tracking logs;
8. **Buildings and services:** which involve end-to-end smart processes that handle various functions, are essential for smart hospital operations. Intelligent facility management systems are used to perform a variety of critical functions related to patient safety. Here are some examples:
    - Power and climate control systems, including intelligent ventilation;
    - Sensors that measure temperature;
    - Smart patient room operation and management systems, including smart boards, patient screens, medical staff screens, and so on;
    - Smart locks (e.g., interconnected locks, wireless locks, etc.) and lock control applications/tokens are part of an automated door lock system.

Figure 6 is a diagram that depicts a high-level overview of the main properties.

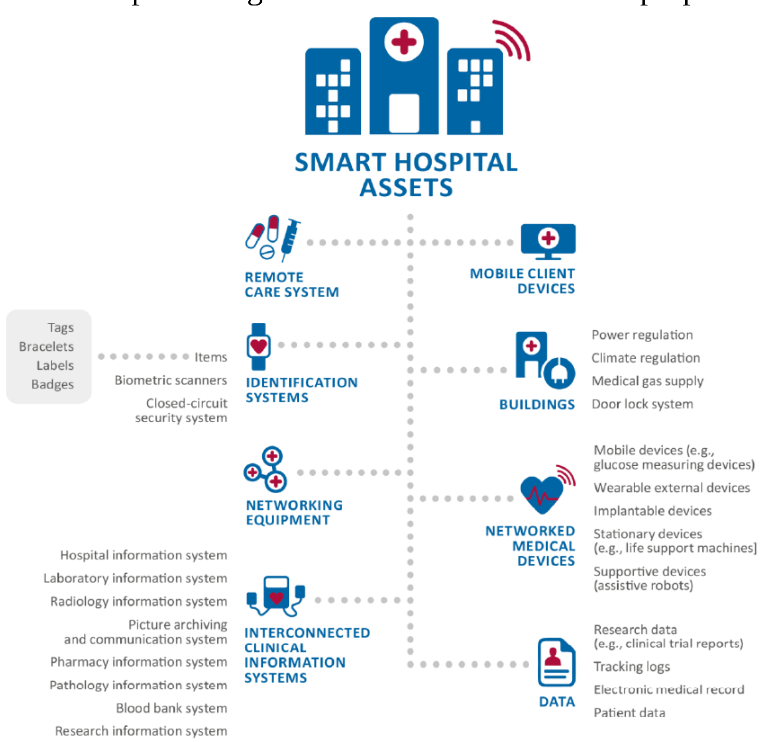


Figure 6-Smart hospital assets

1.1.2. Smart Hospital based on Internet of Things

In this paper, a smart hospital architecture and scheme based on the Internet of Things (IOT) to address the shortcomings of the current hospital information system, such as fixed information points and inflexible networking modes is suggested. Experiment shows that deploying a smart hospital can effectively address the most pressing issues in hospital diagnosis and care, as well as have a significant and profound impact on the current diagnosis and treatment mode. The popularity and partial use of HIS (patient information system) has helped the hospital achieve a certain level of informatization in the advancing phase of hospital informatization. However, it has some flaws, such as manual medical data entry, a fixed information point, a fixed networking mode, a single feature, and relative independence between departments, all of which severely limit the construction of hospital informatization. The rapid growth of the internet of things has created a new concept for solving the problems described above [8].

i. Key technologies of IoT

- **Internet Technology:** Since IOT, or the next-generation internet, is basically a network, the internet is a necessary precondition for IOT to interact with any person or entity at any time and in any place.
- **RFID Technology:** RFID is a form of non-contact automatic identification technology that uses non-contact reading and writing devices to identify objects or articles.
- **Sensor Network Technology:** Sensor networks are at the heart of the Internet of Things, and they can work together with RFID systems to help monitor the status of objects, such as their position, temperature, and movements. Sensor networks are made up of a large number (often hundreds) of sensing nodes that communicate in a wireless multihop fashion.
- **Wireless Communication Technology:** Wireless communication technology is a key technology in IOT because it automatically transmits the information stored in RFID tags to the central information system. Some popular wireless communication technologies include Bluetooth, WIFI (wireless Fidelity), UWB (ultrawideband), Zigbee, IrDA (Infrared Data Association), and so on.
- **Embedded Technology:** In essence, IOT is an internet-connected embedded framework. Since more and more intelligent terminal devices need networking, the production of IOT concept has accelerated , so IOT is an unavoidable result of embedded technology growth, and it cannot be widely used without embedded technology help.

ii. Smart hospital

Smart hospital, built with the vector of various application service systems and based on IOT technology, is a concentrated representation of IOT implemented in a special place of hospital, and it is a new type of hospital that integrates the functions of diagnosis, care, management, and decision-making.

iii. Architecture of smart hospital

Figure 7 shows the smart hospital architecture, which is made up of three layers: perception, network, and application.

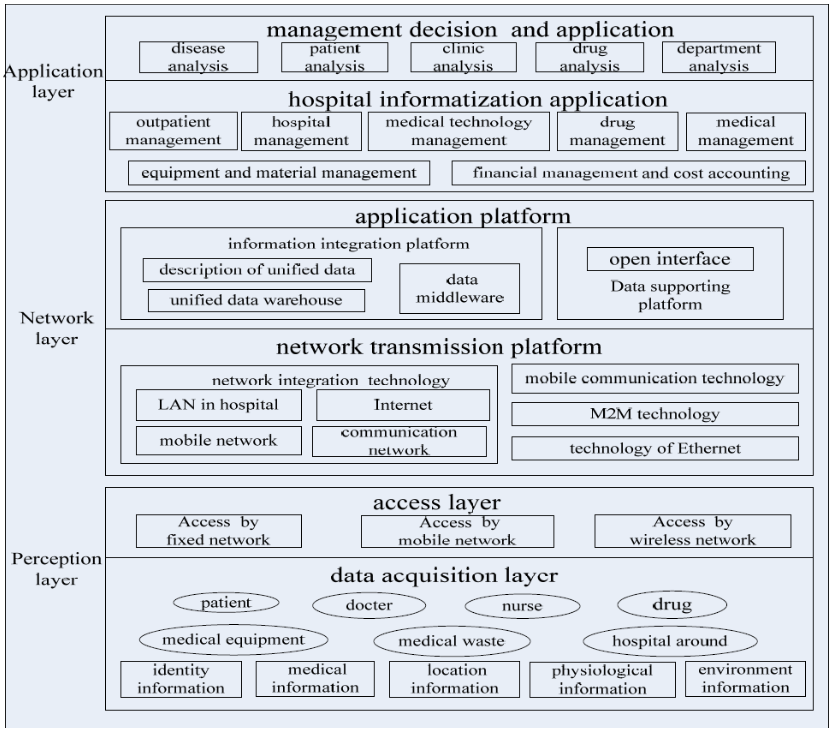


Figure 7-Architecture of smart hospital

- **Perception Layer:** The perception layer is divided into two sublayers: data collection layer and access layer, respectively. The aim of the data acquisition layer is to identify hospital networking nodes, as well as to perceive and acquire relevant data, such as doctor and nurse identity information, patient identity and medical information, basic information and location information about pharmaceuticals, and medical equipment. The data acquired from the sublayer is transmitted to the backbone network, namely the global object-conjunction network, through the access layer.
- **Network Layer:** The network layer is divided into two sub layers: network transmission platform and application platform, respectively. The backbone of every network is its transmission platform. Real-time, barrier-free, and highly secure hospital network knowledge transmission as perceived by mobile awareness layer uses Ethernet technology M2M, connectivity, and so forth. The aim of the application platform is to incorporate the integration of various data, such as unified data descriptions, unified data warehouses, and data middleware technology, and to create a service platform to provide an open interface for the various services of the application layer, so that third parties can build various applications for medical staff and patients on this platform.
- **Application Layer:** The application layer is divided into two sections, one for hospital informatization and the other for management decision and application.

iv. Network Supporting Environment

As it can be seen from Figure 8, this hospital's network system uses a wired and wireless hybrid structure, deploying the wireless network to achieve wireless coverage of the outpatient building, surgical ward building, medical ward building, medical technology building, pharmacy (drug storehouse), administration building, and outdoor public areas, based on its original wired network design.

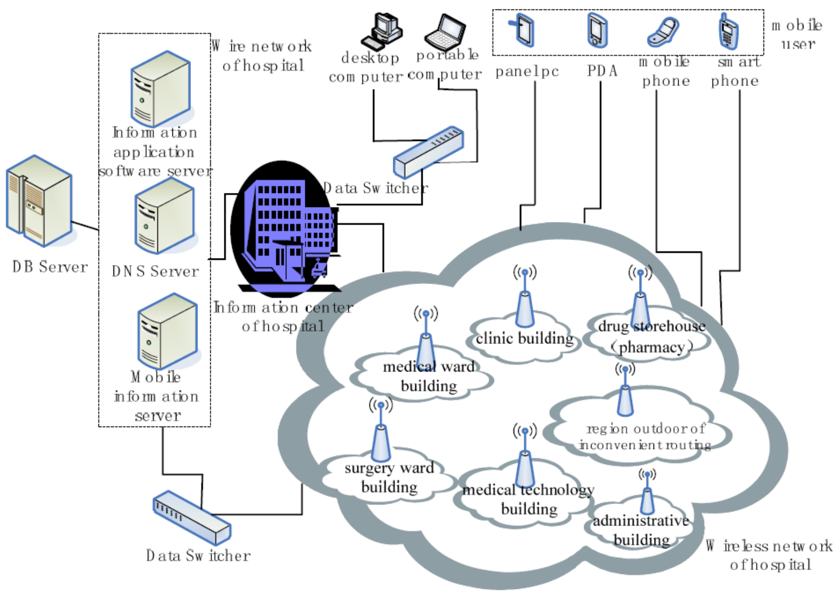


Figure 8-Network structure of smart hospital

1.1.3. Building a Smart Hospital using RFID technologies

Radio frequency identification (RFID) technologies are rapidly evolving, and healthcare is expected to be one of the fastest-growing sectors. This paper explains how this new technology can be used to create a smart hospital after briefly introducing the RFID field's common terminology and current standards. RFID can help optimize business processes in healthcare and increase patient safety when used in conjunction with mobile devices in eHealth applications [9].

a. **Terminology of RFID:** RFID (Radio Frequency Identification) is a technique for remotely storing and retrieving data via RFID tags or transponders. An RFID tag is a small object that can be applied to or inserted into a product, such as an adhesive sticker. An antenna is attached to an electronic chip in RFID tags. These chips convert the energy of radio-frequency queries from an RFID reader or transceiver into information and transmit it back to the reader or transceiver. Finally, the reader is piloted and the data it sends is processed by a device running a particular RFID program or middleware.
b. **Towards smart hospital:** Many of the facilities' properties and performers must be "tagged":
   - RFID tags must be embedded in medical equipment.
   - Physicians, nurses, caregivers, and other employees wear a "smart badge" with their employee ID number stored on it.
   - Each patient is given a wristband with an embedded RFID tag that contains a unique identifier as well as some personal information.

- Self-adhesive RFID labels with a specific number are attached to all of the patients' medical records and other relevant documents.
- RFID stickers can be seen on blister packs and other drug packets.
- A self-adhesive RFID label with a unique identifier, the hospital tracking code, and some relevant details about the contained type of blood is attached to the blood bags.
- RFID readers are also strategically located in the hospital.

c. Use Cases in a Smart Hospital: This segment focuses on how RFID (and related standards) will aid in the development of the hospital of the future. It provides the most up-to-date information on RFID technologies used in healthcare applications.

- **Patient Identification:** Any patient admitted to the hospital receives an RFID-based wristband that looks like a watch and contains a passive RFID chip3. In order to speed care, this chip stores a specific patient ID number as well as some important medical details such as the patient's blood type. To read the data encoded on the patients' ID bracelets, the caregiver uses a handheld device with an RFID interrogator (an RFID-enabled PDA). The hospital staff can access the patient's encrypted confidential medical history as well as care record through a wireless LAN link, as well as details on which medications and dosages the patients would need.
- **Blood Tracking:** Each bag of blood arriving at the hospital receives a self-adhesive RFID label in a smart hospital. This chip contains memory for storing a unique identification number as well as information about the blood type found within it. These numbers are often saved in a protected database that contains information about the blood's sources, intended use, and recipient until dispensed. When a nurse has to plan a blood transfusion, she uses a PDA with a reader to read the data encoded on the RFID chip in the blood bag as well as the patient ID bracelet. Before the blood can be used, the data from the patient and the bag must match. The overall method of handling blood bags is made easier and faster with this approach. Furthermore, the probability of patients having the incorrect blood type is reduced.

1.1.4. Smart hospital emergency system

A new framework called Smart Hospital Emergency System is suggested in this paper (SHES). SHES' key goal is to save lives by enhancing contact between patients and emergency responders. SHES aims to improve emergency communication throughput while reducing emergency call system problems and making the emergency response process more effective by using the latest technology and algorithms. SHES aims to process health data stored on a personal smartphone, as well as internal monitored data (GPU, Accelerometer, Gyroscope, and so on), effectively and safely, via automated communications with emergency services, reducing communication bottlenecks. SHES is also focusing on live video-streaming through real-time video communication protocols to enhance initial interactions between emergency responders and patients [10].

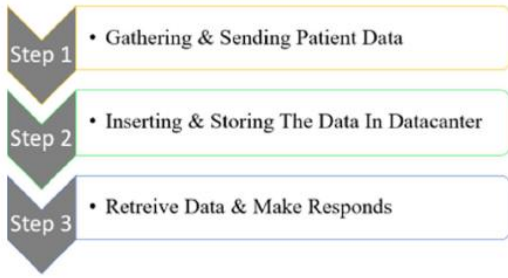
a. Emergency call system issues

- **Caller location:** The caller's location is one of the most important pieces of information requested during an emergency because it helps the dispatcher to know where to send assistance. The answer would be quicker if this information is retrieved quickly. Callers can find it difficult to offer their position verbally in some cases. In this situation, operators may need to use alternative methods to track down a caller's address. Since phone numbers are registered to a particular address, calls made from a landline are the easiest to track; however, cell phones, which account for 60% of all emergency calls, are more difficult to locate. The current location of a cell phone can be determined in three ways. There are the following:

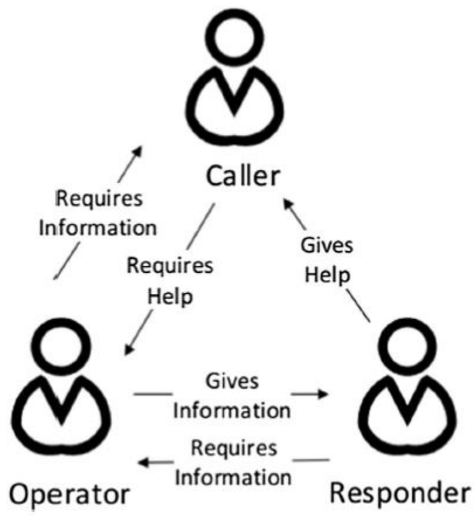
1- **Cell Towers:** Since mobile phones send and receive calls using nearby cell towers, their location can be narrowed down to the area covered by that tower's signal, which is usually 1-2 miles. By triangulating a phone's signal from several cell towers, more precise readings can be obtained.
2- **Global Positioning System (GPS):** Since more smart phones today have a built-in GPS transmitter than ever before, this feature can be used to collect the caller's location and send it to the emergency operator. With up to 15 meters of error, having a caller's GPS position, which is also made to their latitude and longitude, will be the most accurate. The inability to use GPS due to frequency blackouts is a problem. Since GPS signals move at a frequency that makes it difficult for them to pass through solid objects like rooftops and walls, there is no guarantee that they will function within buildings.
3- **Wi-Fi**: The Wi-Fi Positioning System (WPS) uses Wi-Fi access points to calculate the strength of a mobile Wi-Fi signal. This system is useful in large urban areas where Wi-Fi signals are plentiful, but it is less so in rural areas where Wi-Fi dead zones are widespread. Wi-Fi, on the other hand, can be used to transfer data for devices over the internet when it is available.

b. Proposed SHES system

The proposed Smart Hospital Emergency System (SHES) aims to improve emergency service productivity by offering quicker response time by using technologies embedded within smart phones (e.g., sensors and location services). The main goal of SHES is to automate the transmission of patient information rather than relying on callers to transmit their information verbally over the phone. The overarching goal of SHES would be to reduce the time it takes to respond to emergency calls by streamlining the number of tasks involved in the current phase. The methodology we use to create the SHES is focused on researching call system problems as well as features that can be improved to change the standard approach to calling for help in an emergency. As a result, we look at the systems in place for patient and operator communications, as well as the systems used by both parties to collect data to benefit both parties, which includes the caller's mobile apps (i.e. patients) as well as the operator's web-platforms (i.e. doctors and paramedic). The key steps taken by the device when collecting and processing information from callers are depicted in Figure 9a. Three participants is defined who play a role within the system when looking at who will use it (Figure 9b). Each of these user groups expects something different from the framework. Data is collected in two ways by the system. The device collects patient data via the mobile application in the first case, and operator data via the operator web-platform in the second case. After the data is processed, it is sent to a data center for processing before being made available to the operator at any time and from anywhere.



(a) System work-flow



(b) Outline of system users

Figure 9- SHES Workflow & Users

The flowchart in Figure 10 depicts the method of requesting an ambulance, in which the rationale of starting the SHES application first determines whether the patient is a first-time user or not. If this is a first-time user, registration is required so that the system can recognize the user's unique identifier (e.g. NHS Number) and use it during the emergency request process. Additionally, since users' mobile locations can be traced, this may aid in the prevention of malicious requests. Users will be able to automatically synchronize information such as their name, age, status, and current GPS coordinates inside the SHES mobile app. As a result, all of this information is sent over the internet (via Wi-Fi, 3G, 4G, or other means) to data centers, where it is processed and made available for use/access by approved healthcare providers. Finally, to view patient requests, a web-platform (also known as an operator platform) is linked to the data center. Different types of information/data are required to be displayed in the operator platform, but primarily the user's identity (i.e., NHS Number), GPS data, and other relevant data to patient status.

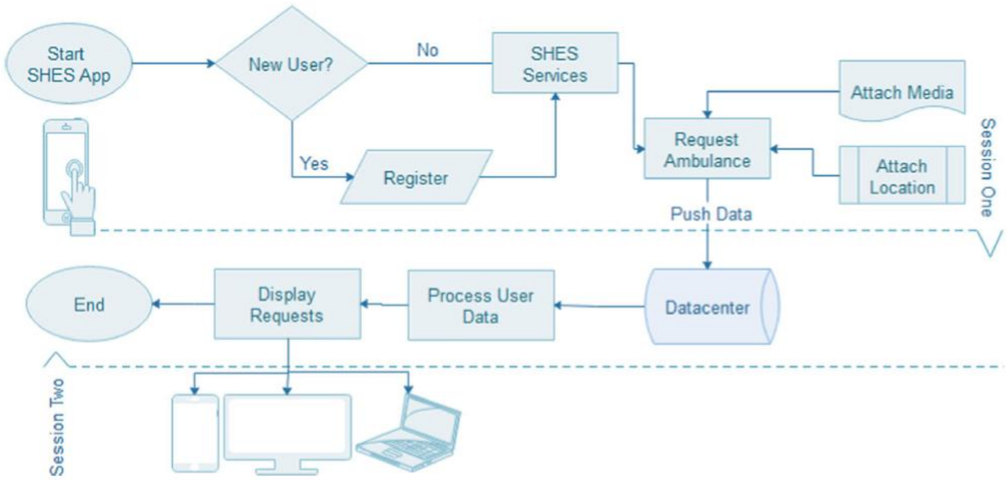


Figure 10-Flowchart to demonstrate the ambulance requesting service

c. SHES architecture

SHES is a mobile-based program that connects to the hospital network (i.e., the emergency and injury unit) and responds to patient inquiries as well as requests for ambulance services. The app can mostly be used for one of two purposes: either to order an ambulance in an emergency or to keep track of a patient's symptoms on a daily basis (such as blood pressure, heart-rate and etc.). The SHES architecture is depicted in Figure 11 and consists of three layers: patient side, data center, and doctor platform.

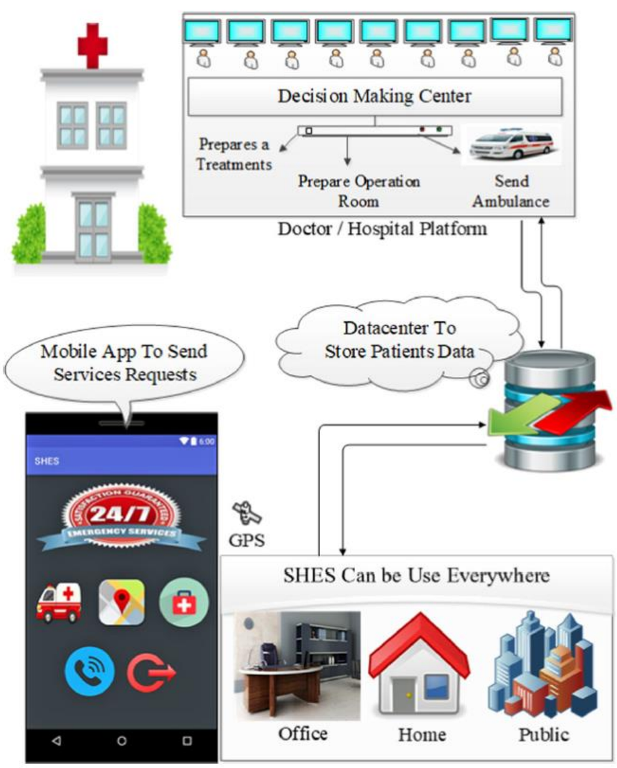


Figure 11-SHES System Architecture, from patient's app to doctors platform

1.2. Smart healthcare and smart medicine

The idea of smart healthcare is becoming more relevant as information technology advances. Smart healthcare employs a new generation of information technology such as the Internet of Things (IoT), big data, cloud computing, and artificial intelligence to turn the conventional medical system into one that is more reliable and intelligent. The main technologies that help smart healthcare are implemented, and the current status of smart healthcare in many important fields are considered in this research with the aim of introducing the idea of smart healthcare [11]. IBM proposed the idea of "Smart Planet" in 2009, which inspired the concept of smart healthcare. Smart Planet is an intelligent infrastructure that detects information with sensors, transmits it through IoT, and processes it with supercomputers and cloud computing. Smart healthcare is a health-care delivery system that makes use of technology such as wearable devices, the internet of things, and mobile internet to access information, link individuals, materials, and organizations, and then intelligently manage them. Smart healthcare will ensure that participants receive the services they need, as well as assisting parties in making informed decisions and facilitating resource allocation. In the health-care sector, Big Data Analytics is commonly used. Data mining and information discovery are two analytic methodologies that can be used to capture, analyze, and manipulate user, patient, clinical, and other forms of data using a variety of sensors. The sensors' main purpose is to reliably replicate the various methods used by physicians to perform a physical and medical examination of their patients. The method of performing a physical and medical examination on a patient can be divided into four sections. Each of these four components can be described by a different form of sensor that collects data remotely so that physicians can make diagnoses or simply check on the patient's status. 1) Examination, 2) Palpation, 3) Percussion, and 4) Auscultation are the four pieces. The physician essentially tests the patient's condition with his eyes during the assessment to see if there are any clear signs of injuries or infection. In the case of a big data analytics-based framework capable of performing comprehensive visual checks on patients, the cameras would act as the physicians' eyes, doing most of the data mining procedures remotely. Another form of test that can be mimicked by a sensor that can record and deliver auditory data from the patient to the receiver is percussion. For the vast majority of applications, a sensor with a high-definition microphone will suffice. The data collected by the sensors will have to be sent to a central database located near a hospital or other designated medical facility, or it could be sent over the cloud for free. Smart health can be classified as a subset of e-health and s-health in terms of ICT infrastructure based on this definition. There is a distinction to be made between s-health and m-health. In s-health, for example, it's possible that the established fundamental contact is mobile or not. The relation between these two concepts is evident in Figure 12.

1) Case 1: Classical health which means being visited by a doctor using traditional tools.
2) Case 2: E-Health which use databases and electronic health records (EHR) for saving patients' medical information.
3) Case 3:M-Health. The ability of patient to check their prescriptions from their personal mobile devices which is considered as a subset of e-health.
4) Case 4:S-Health. The patient is given details to verify the amount of dust, pollen, and pollution to which they are allergic.
5) Case 5:M-Health amplified with s- Health. This can be shown by a cyclist wearing an accelerometer-equipped band or bracelet. In the event of an accident, the body sensor network will assist in detecting the individual's fall and will notify the city infrastructure. When the system

receives a warning, the traffic situation is assessed, and an ambulance is dispatched via the best route available. Furthermore, city traffic lights can be adjusted to reduce the time it takes for an ambulance to arrive at the scene [12].

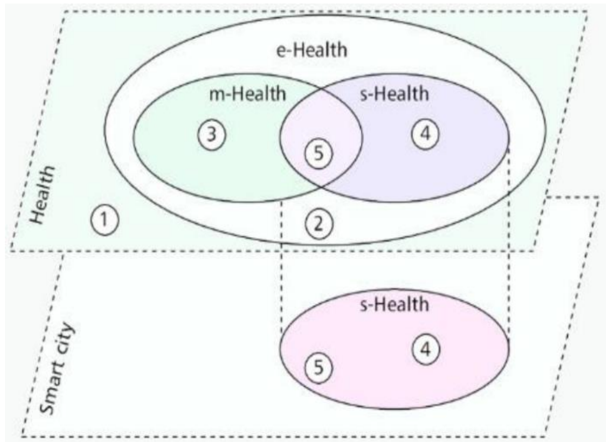


Figure 12-Smart City and Smart Health

Elderly people have had a drug intake problem for a long time because they either do not pay attention to or fail to take their medications on time. Furthermore, there have been instances where patients have made prescription errors, such as taking the incorrect medication. As a result, the idea of proposing a smart medical or smart medicine has emerged. The principle of smart medicine has been used in a variety of applications, and most of the most recent applications have been covered and explained in depth in this study.

1.2.1. Smart healthcare monitoring, diagnosis, and medication through IoT

It is important to reliably predict heart disease in order to treat cardiac patients efficiently before they have a heart attack, which can be done with the help of an optimal machine learning model and reliable healthcare data on heart diseases. Various machine learning-based systems for predicting and diagnosing heart disease have recently been developed, but these systems are unable to manage large datasets due to the lack of a smart architecture that can use multiple sources of data for heart disease prediction. Furthermore, existing programs that use traditional methods for selecting features from a dataset and calculating a general weight for them based on their importance failed to improve the accuracy of heart disease diagnosis.

In the paper of Farman Ali et al [13] a smart healthcare system for heart disease prediction using ensemble deep learning and feature fusion approaches is proposed.

In another research done by Ghazanfar Latif et al [14] , With an IoT prototype of a Wireless Sensor Network and a Cloud-based framework, a novel approach is developed. Continuous health surveillance, scheduled prompt treatment, emergency medication, life-saving emergency reporting, and early stage diagnosis were all achieved by this method.

In this part these two researches in the field of healthcare monitoring, diagnosis is discussed.

1.2.1.1. A smart healthcare monitoring system for heart disease prediction based on ensemble deep learning and feature fusion

In this research a method for feature fusion combines the extracted features from both sensor data and electronic medical records for generating valuable healthcare data. Then an elimination of irrelevant and redundant features applied and the important ones which improve the system performance is selected. Additionally, for each class the conditional probability approach computes a specific feature weight which further improves system performance. In the final step, the ensemble deep learning model is trained for prediction of heart disease.

I. Wearable sensor–based heart disease diagnostic systems

Wearable sensors and EMRs are two important factors in a healthcare monitoring system for heart disease patients. However, there is a challenge in feature extraction from sensor data and EMRs, and then feature fusing in order to transform them into structured data. Moreover, assigning valuable weights to selected features is another challenge for machine learning (ML)-based systems. In recent years, many systems which used wearable sensors to improve the process of heart disease prediction is proposed but most of them failed in efficient feature extraction and feature weighting approach. HealthFog system was presented to automatically treat heart patients using Internet of Things (IoT) devices and a deep learning model. The main aim of it is to control the heart patient data coming from the IoT devices. In addition, a new framework for a decision support system was presented for detecting disease in patients which combines collected medical data and data from wearable medical devices.

II. Information extraction and fusion

The information extraction from medical records and the fusing of sensor data play an important role in the diagnosis of heart diseases. Data fusion is the method of combining data from various sources to produce more reliable and relevant information. Various models for extracting functionality from healthcare textual data and fusing sensor data with other data have recently been proposed. To predict heart disease, a real-time framework based on machine learning classifiers was presented. This framework extracts features from a healthcare dataset using two separate approaches. Furthermore, the findings of echocardiography were used in another method to estimate the mortality rate of cardiac patients in the hospital. Text mining techniques are used to extract features, and then a deep learning algorithm is used to predict mortality rates. Another approach involves extracting heart-critical variables from unstructured EMRs and measuring a heart attack risk score in diabetic patients using text mining techniques. Using fuzzy logic and genetic algorithms, these methods pick important features that help the heart disease prediction system improve accuracy. Another approach for predicting heart diseases in patients is a decision support system based on a fuzzy analytic hierarchy process (AHP) and an artificial neural network (ANN). The fuzzy AHP technique is used to assign weights to the features, which are then used to train the ANN for heart disease prediction.

III. Smart healthcare monitoring system (SHMS) for heart disease prediction

Figure 13 depicts the SHMS's overall structure. In the SHMS, there are two key data points. One is the wireless body sensor network (WBSN), and the other is electronic medical records (EMRs). WBSN uses medical sensors to gather physiological data such as an electrocardiogram (ECG), an electroencephalogram (EEG), an electromyogram (EMG), the heart rate, blood pressure (BP), position, and movements, respiration rate, and the patient's blood sugar, oxygen saturation, and cholesterol levels for regular health monitoring (Task 1). Patient observation reports, medical records, smoking history, diabetes history, and comprehensive clinical evaluations are all provided by EMRs (Task 2). The proposed system transfers data from a heart patient to the related gateway devices after sensing the data. The physiological data is transmitted through Bluetooth and Wi-Fi devices in this system (Task 3). Both the sensed data and the EMRs are processed in a healthcare big data database (Task 4). The SHMS's aim is to use the data obtained to predict disease risk in patients. As a result, based on the collected data, which can be both structured and unstructured, a health condition prediction and disease detection engine is used to predict heart disease (Task 5). This engine consists of four main steps: 1) data fusion, 2) preprocessing, 3) ensemble deep learning–based heart disease prediction, and 4) ontology-based recommendations. The extracted features from both structured and unstructured data are fused using the proposed fusion method in the data fusion process. The data is preprocessed using data mining techniques in the preprocessing phase. The preprocessed data is then sent to a deep learning classifier trained on a heart disease dataset for accurate prediction of heart diseases in the third stage. An ontology is used in the final step to prescribe a food plan or activities based on the patient's health condition (Task 6).

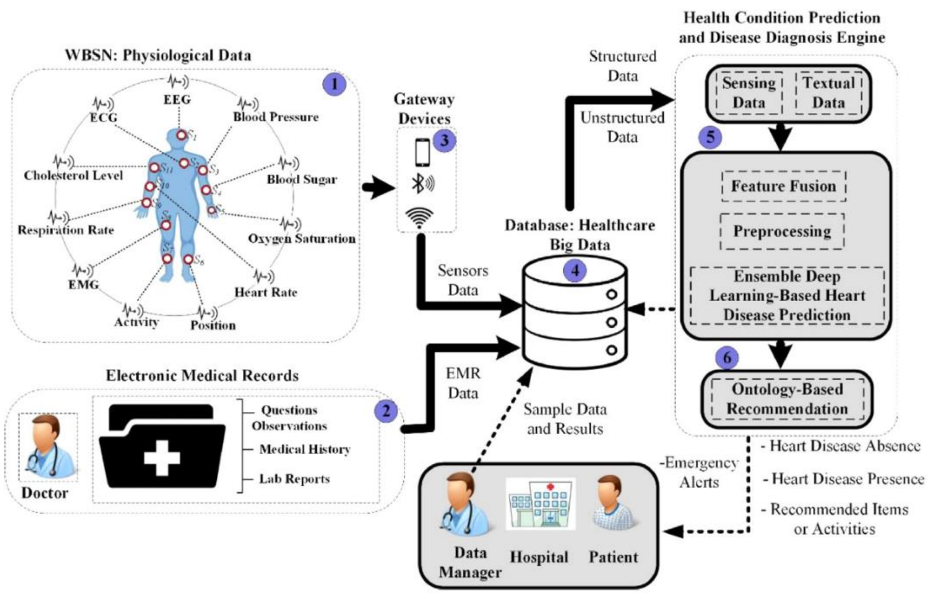


Figure 13-The structure of the smart healthcare monitoring system for heart disease prediction

1.2.1.2. I-CARES: advancing health diagnosis and medication through IoT

In this paper, an IoT prototype of a Wireless Sensor Network and Cloud-based system is developed with the goal of providing continuous monitoring of a patient's health status, ensuring timely scheduled and unscheduled medicinal dosage based on real-time patient vitals measurement, and predicting and communicating life-saving emergencies. A wearable health tracking system, Smart Medicine Dispensing System, Cloud-based Big Data analytical diagnostic, and Artificial Intelligence (AI) based reporting platform make up the planned integrated prototype.

A. Cloud computing and big data analysis

Many researchers study cloud-based solutions for electronic health record (EHR) systems with the aim of developing a cloud-based solution that enables institutional healthcare systems to communicate with one another. These algorithms may be a step forward in medicine, allowing for more personalized treatment and lower healthcare costs. Preventive medicine and lifesaving action may be supported by big data mining and analytics on the cloud.

B. Health data compliances

The idea of information protection becomes critical when providing electronic data of patient health records. Patients have the right to keep their health records private under privacy laws and regulations, and they must agree to their information being shared with others. This is why in the health sector, safe communication and secure storage of electronic health records are critical.

C. IoT-based cloud-application Rx expert system (I-CARES)

CARES is the first device to use both wireless and wired sensors, and it is the first to be expandable, allowing the patient to add additional sensors to the system. I-CARES also has a subset of features that includes the following functions:

a. I-CARES senses an emergency situation and notifies caregivers and emergency personnel via contact networks, as well as sending the precise location of patients via GPS.
b. I-CARES serves as a reminder to patients about their prescription regimens.
c. I-CARES utilizes QR barcode for medication identification.
d. I-CARES sends all readings to a Health Medical Information System located in the cloud (HMIS).
e. I-CARES Processes Big Data and provides reports for medical doctors with suggested decisions.

I-CARES use two methods for contacting emergency personal which are integrate one with Internet communication and other through text when internet is not available. The I-CARES architecture is shown in Figure 14 which consists of a health monitoring system with sensors that can measure vital signs including but not limited to Electrocardiography (ECG), pulse rate, blood pressure, body temperature, stress level, sweating, and peripheral capillary oxygen saturation (SpO2) but this system is expandable and a setup program after login enables patients to add new sensors and Configure sensor settings such as sensor type, reading frequency and threshold levels. The monitoring system sends the information to the Smart Medicine dispenser, which in turn sends the information to the cloud. This system can also communicate with monitoring system to send alarms to the patient to remind him/her of the scheduled and out of schedule medicine dosages. Figure 15 shows the Internal components used for I-CARES monitoring system. The monitoring device is Wi-Fi enabled so that the readings can be sent to the medication dispenser, which then sends them to the cloud for emergency case reporting.

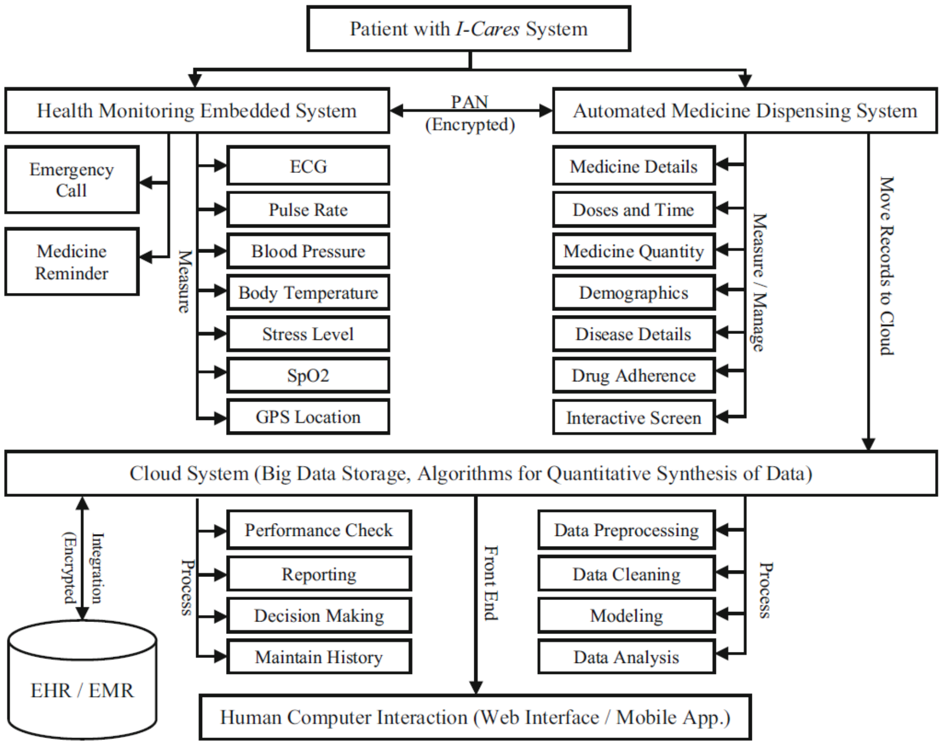
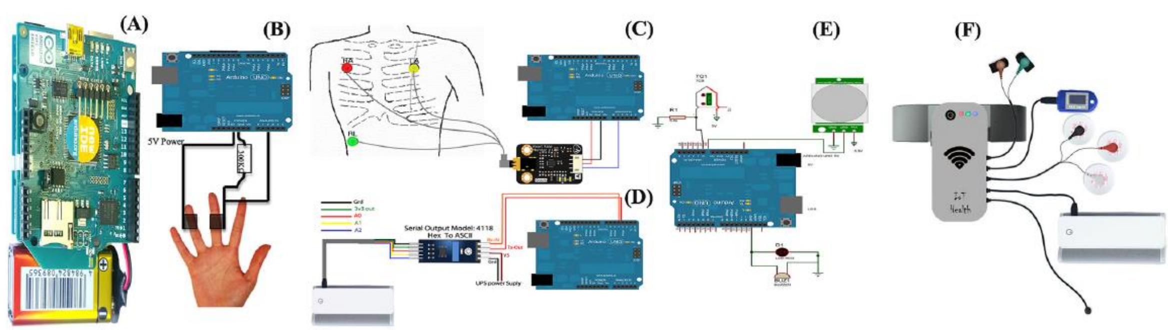


Figure 14-Proposed architecture of the I-CARES system



Internal components used for I-CARES monitoring system Prototype (on left). **a** Arduino UNO, Wi-Fi shield and power battery, **b** GSR sensor connectivity with UNO, **c** ECG sensor connectivity, **d** blood pressure sensor connectivity, **f** temperature and SpO_2 sensor connectivity, **e** final prototype of I-CARES wearable monitoring system

Figure 15-Internal components used for I-CARES monitoring system

The I-CARES system also includes a smart Medication Dispensing Device that recognizes medicines using QR barcodes. To manage low-priority emergency cases, the medication dispensing system makes smart decisions within medically permissible limits and allows out-of-schedule doses based on medical readings. A personal area network connects the health monitoring and smart medication dispensing systems. Users can provide reliable feedback on negative drug side effects, configure monitoring device sensors (such as frequency of readings and other attributes), set medication doses, and communicate with the doctor using the Smart Medical Dispenser's interactive LCD screen. The Interactive control device on this LCD screen, on the other hand, receives the doctor's prescription and shows the dosage type and frequency. It can also use Wi-Fi to link to the health monitor and cloud server. The automatic drug dispenser is smart in the sense that it can interact with both the patient and the doctor. The healthcare provider can communicate with the dispenser remotely to prescribe medication and speed, and the patient can interact with the device physically to ensure that he or she receives the required reminders and dosage. For applications with a large number of users spread over many locations, cloud storage is the best option. We used Amazon Web Services GovCloud as part of the initial prototype. Data is sent to the cloud by both the I-CARES monitoring device and the smart Medicine dispensing system. A function of the new system allows for long-term medical assessment. It can be scheduled regularly, monthly, quarterly, or annually, depending on the patient's needs, to predict the probability of an illness occurring in the future. The long-term analysis algorithm is designed to predict possible future diseases based on the measured attributes using the ICARES monitoring system.

1.2.2. IoT based smart medicine kit

The rapid advancement of technology and lifestyle helps the health sector in modernizing the planet. Just half of people in the current decade are aware of their drug schedule in order to get the most out of their prescriptions. The remainder of the population is preoccupied with their hectic schedules, resulting in erratic medication intake. Patients with progressive memory loss, such as the elderly, fail to take their medications on time. When a patient fails to obey the clinician's prescribed drug schedule, the procedure becomes unsuccessful. Many attempts have been made in recent days to design a "Medicine Box" that would assist people with prescription reminders, storing their medicine uptake information, and providing appropriate temperature conditions for storage. Some of the suggested methods are discussed in this section.

According to current technologies, K. Bhavya et al [15] proposed this work, which also includes some features to the medicine box, such as health tracking, emergency alerts via SMS sent to their predefined guardian, and automatic opening and closing of the cover. Vital parameters are registered, uploaded to the cloud, and checked by clinicians using an IoT device. This aids the clinician in learning more about the patient's deteriorating health. It eliminates the hassle of patients keeping their prescription information and medical history, allowing them to live independently.

Furthermore, Al-Mahmud et al [16], proposed a smart IoT-based healthcare system that includes an information medicine box linked to sensors and a server for routine health monitoring. This smart medicine box with wireless internet access allows patients to receive routine health care and facilitate contact between the doctor and the patient without having to meet in person. The proposed medicine box assists the patient in taking the appropriate medicine at the appropriate time, as well as an email that will assist the patient in taking the medication. A laptop serves as a server, storing specific information about the doctor and the patient, as well as the prescription and appointment date. For accessing the server, both the doctor and the patient have IDs and passwords. Additionally, for the convenience of the doctor, prescription and patient temperature data are stored on the server. If required, the Doctor will change the patient's prescription, and the patient will be informed by email. Furthermore, in the event of an emergency, the doctor should take urgent action.

A Medication Management System (MMS) is developed by JIE LI et al. [17]to control medication mismanagement and automate prescription restocking processes using drones. The researchers suggested a medicine case design driven by the Internet of Things (IoT) in this case, which aids multi-user medication at the institutional level. The drone is used in a pinpoint distribution method to reload medication until it runs out of use from elderly residents for medicine restocking. As a result, MMS improves drug control and automates prescription distribution in elderly care facilities. As a result, the proposed scheme aids in the adoption of cutting-edge IoT technology by the elderly.

Danyllo V. da Silva et al research [18] proposes a low-cost IoT device prototype to assist users during medicine manipulation. The proposal uses the idea of edge computing to introduce an intermediate layer that improves connectivity between devices and services.

1.2.2.1. A Smart Medicine Box for Medication Management using IoT

This project aids in the tracking of a patient's vital parameters in order to minimize the number of times a patient sees a clinician. The critical parameters are stored in a cloud server designed specifically for clinician analysis, along with the Host Management System (HMS). As a result, this project of an adequate temperature storage box for medicine enables elderly patients to live independently by providing a reminder alarm and automated wireless health switch. As shown in Figure 16, this architecture consists of both hardware and software modules.

The required hardware modules are housed in a compartmented medicine cabinet. The box is divided into sections based on storage temperature and medical requirements. The box is divided into two categories based on storage temperature: room temperature and cold temperature. The Peltier module is designed to produce a lower temperature that is suitable for drug storage. Peltier is installed in one of the cold storage compartments, while other compartments are left without Peltier for room temperature storage. The box is divided to store medications that must be taken three times a day, according to medical guidelines (i.e. morning, afternoon, night). It is further divided into two sections for each time of day to store medications to be taken before and after meals. Switches are given for each of the main compartments, which are designed to store medicines to be taken three times a day. Stepper motor-controlled switches open and close these compartments in response to an electrical signal from the Arduino microcontroller. The power supply includes a buck converter for distributing power to the device's other modules. The Arduino-Mega is used to program the unit, which is connected to an alarm and an LED display. The sensor probe detects and transmits the patient's vital signs, such as body temperature and heart rate. When it is activated by strangers or guardians in an emergency situation, an additional switch is installed to warn the preset guardian via GSM module. It's attached to the back of the medicine cabinet. The wireless Wi-Fi module is used to upload patient vital sign data to a cloud server, where it is saved for further review by clinicians. In addition to drug dispensing, software assisted the upload of patient data to a webpage for clinician examination and analysis of the patient's health status.

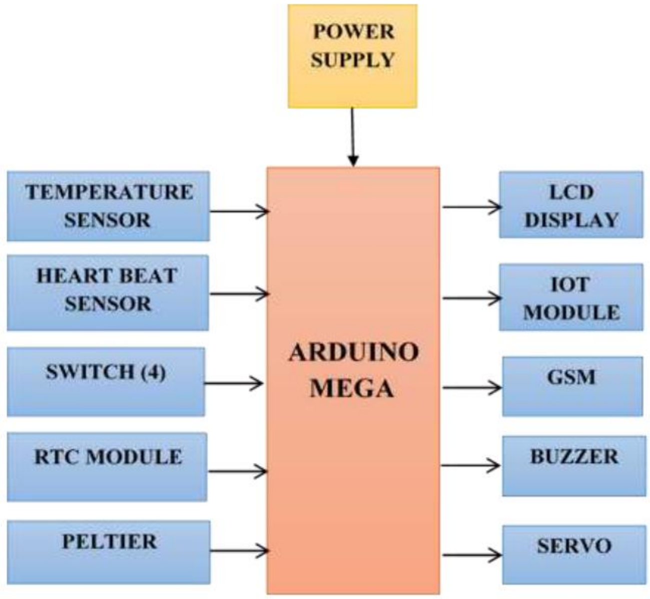


Figure 16-Block Diagram of SMB

- **RTC module:** The Real Time Clock module is a battery-powered clock that draws only a small amount of power from the power supply.
- **WiFi module:** When a wireless link is established, the system becomes more comfortable. The Node MCU is used here, which is based on the ESP 8266 WIFI SOC. This microchip is based on the integrated board's ESP-12 module. GPIO, PWM, I2C, and ADC are all built into the board. The Node MCU is recommended because of its small size, low cost, and sufficient number of serial communication pins.
- **Arduino-Mega:** The Arduino Mega 2560 is a microcontroller board that connects the device's software and hardware modules.
- **GSM module:** The GSM or GPRS module is used to send SMS to their families, guardians, and physicians, who are provided with a SIM card. It comes with a 12v battery charger. The knowledge about the tablet taken status of a day is output as “TABLET TAKEN,” “TABLET NOT TAKEN” by combining the inputs of logic gates of switches from three compartments. When the alarm switch is triggered in an emergency, it sends an SMS to the guardian or doctor with the message "PATIENT NEEDS HELP IMMEDIATE ATTENTION."
- **Temperature sensor:** One of the patient's health sign calibration modules is the LM35 sensor. It is operated by a low-power deriving module that runs on +5v.
- **Peltier module:** In a medicine cabinet, the Peltier module can be used as a thermoelectric generator.
- **Heart rate sensor:** When the finger is positioned in the heart beat sensor, it produces a digital output of the heart beat. For each heartbeat, a bright light blinked from an LED while I was working. At each pulse, it operates on the principle of light modulation through blood flow through the finger.

1.2.2.2. Internet of Things (IoT) Based Smart Health Care Medical Box for Elderly People

The intelligent medicine box in this project will assist a patient by reminding him or her when it is time to take his or her medication. If a patient has to take medication at 6 a.m., for example. The box would alert him in the morning by making a sound and sending an alarm. If he forgets when to take medication and goes to take it at any moment, the medicine box will not open because it is locked by a servo motor. When it's time to take the medication, the package will make a noise and send a warning before the user takes the medicine or opens the drawer. In addition, if the user is away from home, the medicine box can use the Wi-Fi module to send an email notification to the user's specified email address. The device also includes a temperature sensor to control the user's temperature, as temperature is an important factor to consider when monitoring a patient's health. The temperature and medication data will be stored on a server that both the patient and the doctor can access, so that when it is time, the doctor can check the medicine and make any necessary changes. It would also be beneficial for doctors to stay informed about the patient's physical health. Doctors can quickly see if their patients are correctly taking their medications. The doctor will take the required measures for his patient after observing the dosage period.

- **System configuration:** The main two components of this project are the Arduino UNO and the Node MCU Wi-Fi module, which are linked through serial communication. The Arduino is primarily in charge of the medicine box's three compartments, while the Node MCU is in charge of the temperature monitor, sending emails to patients' cell phones, and storing drug time and temperature data on the server. The Wi-Fi module will use a mail transmitting protocol developed using IFTTT to send email to the patient's phone in order to remind him or her to take medication. IFTTT (If This Then That) is a free web-based service that allows users to build “Applets,” which are chains of simple conditional statements. IFTTT allows users to perform unique acts on applications such as Gmail, Facebook, and Telegram. In Figure 17 block diagram of the smart medicine box is shown.

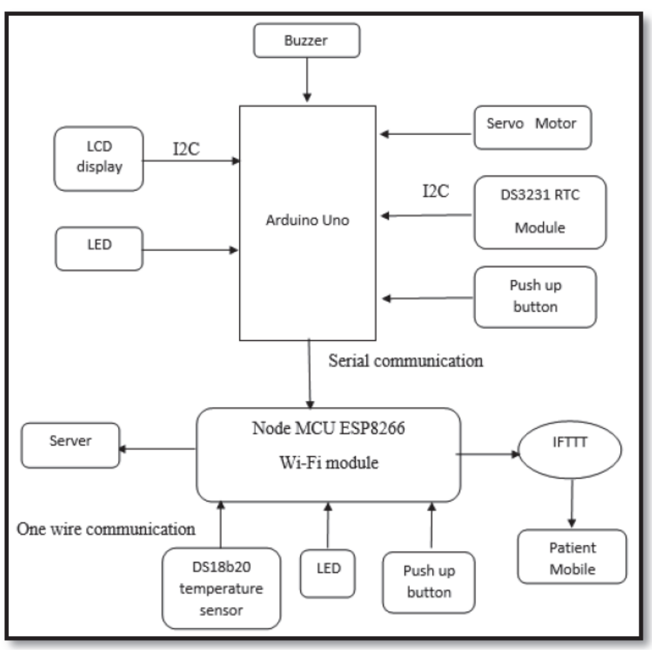


Figure 17-Block Diagram of the smart medicine box.

- **Control Algorithm:** To use the smart medicine box, a user must first enter their medical information and when they should be taken. Since there are three compartments, the patient may hold three different types of medication under the supervision of a doctor. The RTC module is used to build a real-time clock. In the code compiled for this project, the medication time or alarm tone is set. If the produced real-time clock matches the medication time, an alarm will be set off, the Buzzer will sound, an email will be sent to the patient's mobile device as a reminder, the LED light in that compartment will glow, and the medicine name will be shown on the screen. The light in the compartment will shine and the patient's name will be written on the screen if the patient does not take medication or ignores any notifications. The LED will turn off after you remove the medication from the compartment. Another aspect of this project is the measurement of the patient's body temperature and the storage of the calculated temperature data for the doctor's review. This project includes a temperature sensor for monitoring the patient's body temperature. The calculated information is saved on the server. The calculated data will be stored on the server and used by the doctor for observation. The temperature of a patient's body will provide details to the doctor. The patient will insert the sensor into his body like a thermometer, click a button, and an LED lamp will light up, indicating that the sensor will read data for 60 seconds. The maximum value from the reading is extracted by the Wi-Fi module and displayed on the LCD monitor. The collected maximum data will be sent to the server after 60 seconds to assist the doctor in remotely monitoring the patient.
- **Server and Homepage of the Website:** A server has been set up to store information about the doctor and the patient, as well as prescription time and body temperature data. By installing the XAMPP program on a PC, it can be used as a server. For Windows, OS, and Linux platforms, XAMPP is one of the most common PHP development environments. A website with doctor and patient login options has been developed. On the website, you can see all sorts of accurate details about the doctor and the patient, as well as drug time data and temperature data. The hospital administrator is in charge of the computer.

1.2.2.3. A design of IoT-based medicine case for the multi-user medication management using drone in elderly centre

Routine medication is an important part of many elderly people's activities of daily living (ADLs) due to a variety of problems in geriatric treatment. Medicine mismanagement becomes a fatal factor for the elderly in care facilities in this situation. Many centers, however, do have manually operated medication closets, which hide the hazards of medicine retardation, mismatch, or overdosage, which may occur accidentally or by sloppy caregivers. Nonetheless, when medication runs out of stock, it is delivered by caregivers or family members, but any act of forgetting or delaying medicine delivery is regarded as unpleasant, bordering on neglect in center medicine management. As a result, the aim of this study is to address the aforementioned issues and enhance the efficiency of medicine management, which is critical for pharmacy and medication administration at the care center level. The aim of this study is to design and build a Medication Management System (MMS) that will control medication management and automate medicine delivery using an unmanned aerial vehicle (UAV) for system automation and self-sufficiency in an elderly center.

A. Review of literature

○ Smart medicine box

Many studies stressed the importance of a medication alert or box for a single consumer at home or at work. In most cases, the data from the medicine box must be organized and translated into smartphones for visual display and data manipulation convenience. The pillbox, buzzer alarm, LED/LCD module, real-time clock, input and output modules, and SD card shield are all included in most smart medicine products. This way, the device will track and warn users if a case of "missed medicine" occurs, which is particularly common among children and elderly patients.

○ Unmanned aerial vehicle (UAV)

The pilotless aerial craft operated by remote control technology is referred to as a UAV. Drone delivery is a preferred method, especially for “last-mile” tasks since it uses less energy than conventional logistic approaches. After all, as compared to traditional approaches, the use of drone technology promotes green and renewable energy initiatives. The IoT-Collaborative drone will play a critical role in a city's smartness as well as residents' quality of life. The drone's ability to perform first-aid missions and carry blood samples has been demonstrated. The Internet of Drones, first and foremost, portrays the fundamentals of layered architecture control for UAVs to operate in both outdoor and indoor contact environments. UAVs have been commonly used in healthcare for emergency treatment, laboratory research, organ delivery, and disease/injury monitoring . Furthermore, several research studies show that the UAV solution for addressing emergencies excels in real-time tracking and transportation of drug supplies.

○ GPS/INS navigation

UAV navigation based on GPS/INS is a well-established technology that has been adopted to automate drone flight. The user's location information can be collected by the Global Positioning System (GPS) module, which is embedded with a microcontroller. In terms of autonomous flight, a UAV's flight mode can be switched in various degrees of autonomy either by a human operator or by the drone's on-board CPU. However, the Inertial Navigation System (INS) Autopilot software with the proportional integral derivative algorithm will be used with GPS information to identify the mission of the UAV by labeling the waypoint in the near and open routine of the flying path under multiple modes of rotation and expansion. Wearable devices can send physiological information and GPS coordinates through the GSM network to communicate with the drone in this case, thanks to the GPS and GSM module. As a result, the UAV will navigate to the specified destination using the GPS coordinates obtained. Fakhrulddin et al. [19] created a GPS/GSM module-based first-aid kit delivery system (Figure 18) to deal with emergency situations such as falls and heart attacks.

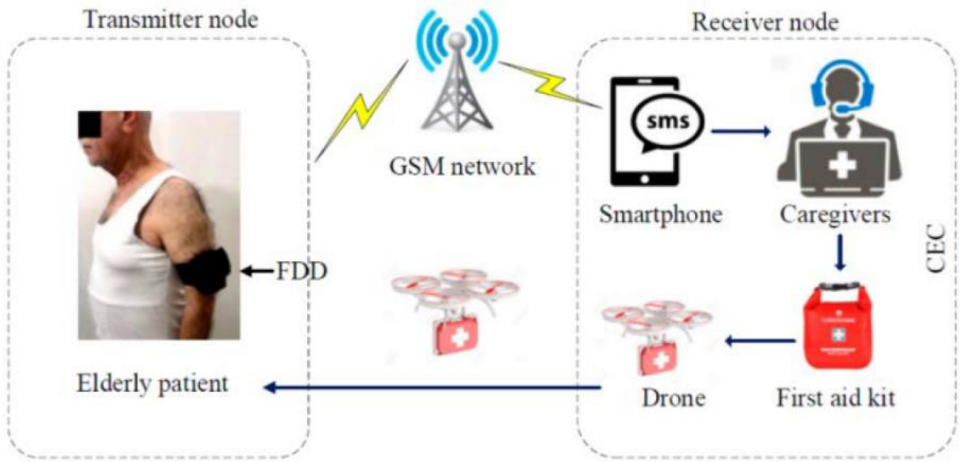


Figure 18-First-Aid kit delivery using UAV

The drone will adjust its navigation based on an embedded algorithm using the Inertial Navigation System (INS). In 2019, a new UAV-based environment monitoring model revealed blueprints for using wireless sensors in conjunction with a drone. To transmit the GPS information needed, the GPS/GSM module can be used with wireless devices connected to network infrastructure such as WSNs in both indoor and outdoor environments.

There are some other ways of navigation in which the drone delivery system makes use of space assets (SEDDCR Project):

- **Satellite Communication (SatCom):** the drones fly autonomously on pre-programmed flights, but they are monitored by a qualified drone pilot. The drones communicate with the pilot through a communications connection that includes both LTE (mobile phone networks) and SatCom (satellite communications). Although the intensity of the LTE signal varies depending on the drone's position and altitude, SatCom is still present, allowing drone pilots to track the drone's output and take control if necessary. As a result, the SatCom connection is an important safety redundancy component of the overall drone delivery system.
- **Satellite navigation:** Drones use satellite navigation to fly pre-programmed routes that pass through waypoints identified by GNSS co-ordinates and altitude levels. The drones are equipped with a Global Navigation Satellite System (GNSS) receiver that uses GNSS constellations to determine their location.
- **Satellite-enabled Mission Planning:** Mission preparation is a crucial activity that entails researching the geography and terrain of the region to be overflied in order to ensure that the operation is carried out safely and in accordance with UK aviation regulations. Understanding elevation ranges, possible obstructions, and the ground risk profile is significantly enhanced by having up-to-date and reliable satellite imagery.

○ **Drone routing**

For distribution and monitoring services, UAVs can be beneficial in terms of cost and time savings. A good routing plan backed by a mathematics-based computing algorithm will effectively reinforce the logic and efficiency of applications in drone-based delivery cases. Drone homing is a concept that uses shortcut navigation to return a drone to its original location. The altitude measurement is calculated with the aid of a visual measuring approach that uses an actual camera. In a shortcut route plan, the simultaneous localization and mapping approach (SLAM) will solve the issues of position estimation with the variable's location and a map of the environment.

B. The Proposed Research Framework for Elderly

The majority of smart medicine reminder device designs are geared toward scheduling a single user-based medicine intake arrangement. The proposed scheme, in comparison to other systems, is intended to assist caregivers in managing multi-elderly drug control and reducing the risk of medication-intake incidents. Furthermore, since the drone is part of our system, it is used to retrieve medicines from a hospital or pharmacy using a pre-programmed pinpoint navigation path. The MMS system is depicted in Figure 19. In the institutional sense, a prototype of the medicine case will be created to serve and plan drug treatment for multiple-elderly users. It includes several pillboxes that are allocated to elderly people in care centers in the proposed design. There are several portable compartments for each form of medicine prescribed for a specific individual in each package.

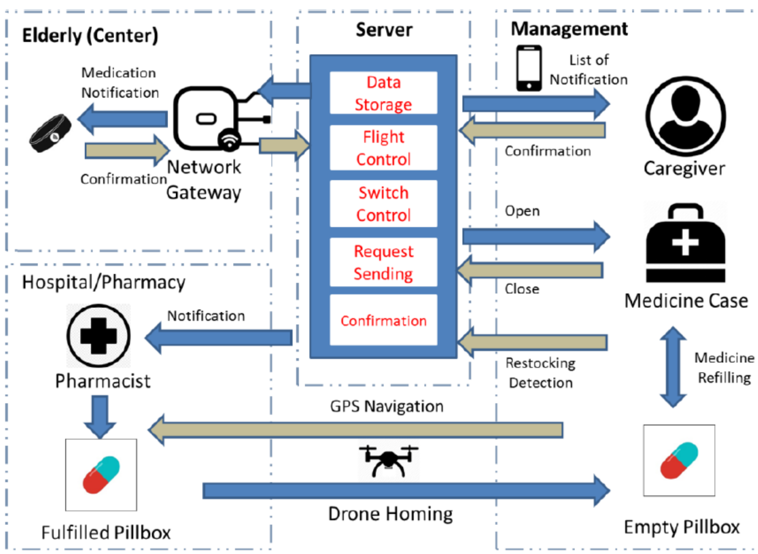


Figure 19-The system framework of the MMS

When it is time to take medication, the medicine case will recognize the medication details (prescription) and respond to the "open" instruction to the appropriate box. Meanwhile, the elderly and caregivers will be notified that the drug practice must be completed. The mobile application will mark down the medicine practice reference in the central server after each practice is finished, while the medicine case will receive the “close” instruction. If a specific drug runs out in the treatment center, the pharmacy will be notified, and the GPS position will be coordinated with the drone operating system so that medicine can be delivered by the drone.

i. The design of medicine case

When it's time to take their medication, elder users and caregivers will be notified via WIFI network on their smart devices with a presentation of medication specifics, including the name of the prescription, time, and resident ID. Meanwhile, the caregivers will receive the "Open" command directly from the server to the device's microcontroller. After the drug intake is done, the caregivers must confirm the operation, and the device marks the process as complete (see Figure 20). For periodic drug practice and distribution issues, our system sends a refill request to caregivers when a compartment's material runs out; and if a form of medicine runs out, caregivers must alert pharmacists according to a person elderly's medical prescriptions so that the medicine delivery module can be initiated. The refilled medicine box would then be collected by the robot. Finally, the caregivers must replace the refilled medications in the prescription package.

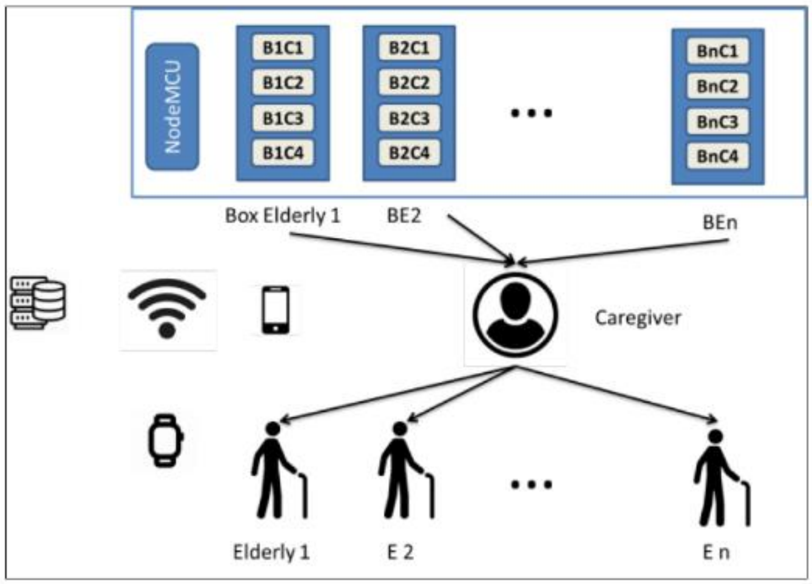


Figure 20-The design of medicine case

ii. **The design of a drone-based medicine delivery**

Medicine distribution in MMS is dependent on the identification of low inventory from the medicine box. In this scenario, once all of the medicines found in the package has been consumed, the central server will be modified to synchronize the GPS of the corresponding pharmacy with the drone operating system, allowing the drone to perform the refilling operation. Each of the compartments in Figure 21 is vulnerable to the central server's restocking warning. Once the caregivers have confirmed the details, the drone transports a specially built container from the center to a nearby pharmacy using a remote flight control system that pre-sets GPS coordinates and altitude for the destination. When the drone arrives at its target, it will automatically land within a 10 meter radius. After that, when the pharmacist refills the drug, it takes off from the place, homing back to the care center. Finally, the caregiver may return the filled container to the medication case in its designated package.

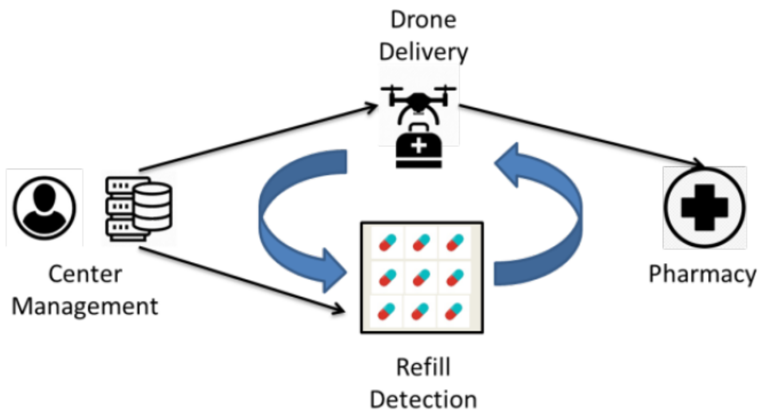


Figure 21-The design of medicine delivery using a drone

1.2.2.4. Using IoT technologies to develop a low-cost smart medicine box

Smartphone alerts, a warning tone, and a visual indication (LEDs) are some of the ways that smart medicine boxes notify users about their medications. Treatment tracking, noncompliance management, health monitoring and diagnostics, regular remote monitoring, online prescription, emergency assistance, and pharmacist notification about medication refill are only a few of the features included in these boxes. Furthermore, healthcare practitioners and pharmacists may observe how patients are being treated and monitor whether the recommended medication is being carried out correctly. Furthermore, certain resources are required for the operation of IoT systems, such as interoperability, scalability, performance, data processing, and security. These solutions are also prohibitively costly, preventing widespread adoption of this technology. As a result, this research proposes the development of a low-cost smart medicine box prototype that will alert users to take their medications on time, according to the schedule previously set on the user interface. The idea of edge computing was used to create a solid architecture that addressed scalability, efficiency, interoperability, and security, among other things. This prototype is a limited-scope initial solution that will be used as a proof of concept.

- **Proposed solution**

The research outlined in this paper proposes a low-cost smart medicine box that will alert users when to take their medications. An ad hoc literature review was conducted to identify the device specifications. The functionalities were then defined and converted to IoT scenarios. Non-functional criteria were also defined in order to meet the characteristics of IoT systems. ScenarIoT is a scenario-based strategy that is used in IoT scenarios. The scenario can be defined as a set of actions or an ordered set of interactions between components. The following are some examples of IoT scenarios:

a. Schedule times to remind the user to take the medicines

Using a web interface, set the times when certain users would take their medications. The smart medicine box will then sound an alarm at the predetermined time.

b. Visualize medicine box state and data

Users can view alarm setup, box state, and slot status through a web interface. This feature allows health practitioners, caregivers, and family members, among others, to monitor and control medication use.

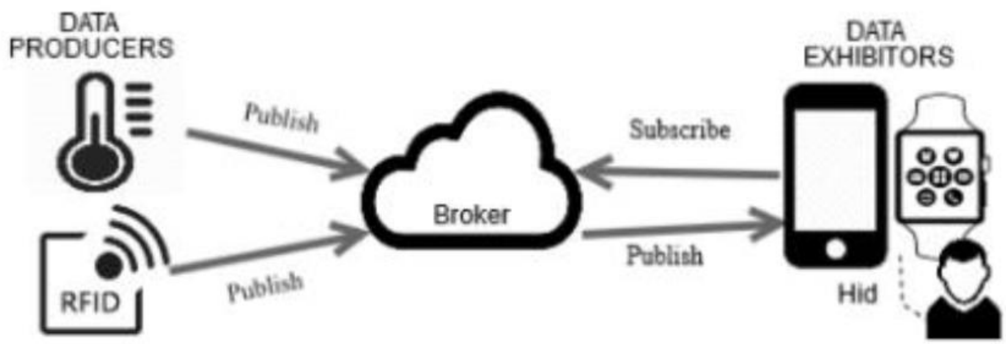


Figure 22-arrangement associated to this scenario

c. Remember users to take their medicines through alarms

To alert users to take their medications, use a visual indicator and a warning sound.

➢ Smart medicine box Architecture

Several issues must be tackled due to the design of IoT systems. A large number of devices necessitates new technical solutions in terms of interoperability, scalability, and latency, among other IoT characteristics. The fog-computing principle can be used to address some of these characteristics. Fog computing, also known as edge computing, is a system architecture based on a hierarchical system architecture that includes a layer between the cloud and end-devices. By incorporating a gateway, the fog layer enhances cloud computing services. Additional services, such as energy efficiency, consistency, reliability, interoperability, mobility, load balancing, efficient scalability, and low-latency response, are provided as a result. The communication between the sensors layer and the cloud layer is also made easier by this layer. As shown in Figure 23, a fog-based IoT architecture is made up of three layers. The smart devices layer is made up of smart devices that have detection, sensing, or actuation capabilities. The edge/fog layer consists of distributed gateways that provide data aggregation, filtering, and dimensionality, among other services. Finally, the cloud layer provides a cloud-computing interface for IoT systems that is highly scalable and reliable. Broadcasting, data warehouse, data analytics, and user interfaces are only a few of the services provided by the cloud layer.

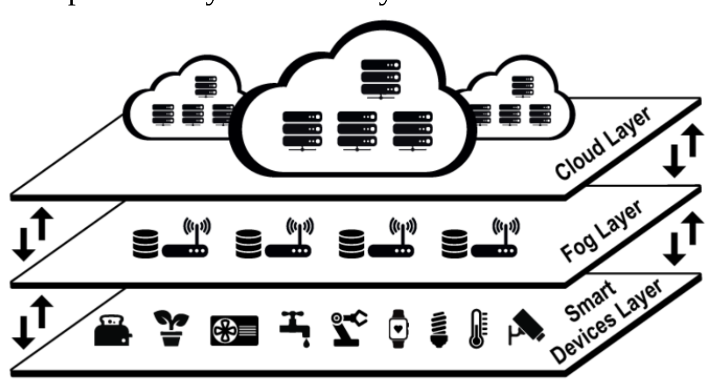


Figure 23-Generic fog-based IoT architecture

- **Smart devices network**

Local networks of devices are formed by smart devices in users' homes or hospitals. These devices have detection, sensing, and communication capabilities, allowing them to provide valuable services to users. The proposed solution consists of only one unit, the smart medicine box, which serves as the system's brain and is in charge of reminding users about their medications. Furthermore, this device performs alarms and visual indications to remind users to take medicines.

- **Distributed gateways**

The link between the smart medicine box and cloud services is managed by this part. Communication management, firewall, access control, lifecycle system management, accessibility, load balancing, scalability, low-latency response, energy efficiency, interoperability, and reliability are just a few of the functions provided by gateways. Gateways can also be used as routers.

- **Cloud server**

Scalability, availability, efficiency, robustness, reliability, protection, ondemand resource use, data storage, data analysis, access management, and device management are just a few of the benefits provided by this component. These services were provided using the following technologies: Google Virtual Machine, Eclipse Kapua IoT cloud platform

- **Web clients**

The user interface for this part displays details about the box state and the four slots. In addition, users can customize the time that their medications are taken.

1.2.3. Development of Smart Interior Environmental Mobile App for Health Monitoring

Migraines are the world's sixth most disabling disease, affecting more than 1 billion people worldwide, and are only one of the illnesses triggered by changes in the home's climate. Migraines caused by environmental causes are often misdiagnosed due to their resemblance to sinus headaches. The aim of developing a smart interior environmental mobile app for health monitoring is to gather environmental data from a user's surroundings, such as temperature, humidity, pressure, and altitude, as well as user data about chronic illnesses caused by environmental changes. These two datasets are then combined to determine a user's typical climate and chronic disease attacks. After the data is gathered, an iOS app analyzes the illness in terms of environmental changes, searching for similarities, common trigger points, and areas of concern in the user's home environment, such as temperature, humidity, and so on. This system is designed for people who have migraine attacks and suspect that their migraines are caused by an environmental factor. This paper explores a proposal for an Internet of Things (IoT) health monitoring analyzer that can help migraine sufferers identify trigger areas in their environment and live a healthier lifestyle[20].

i. Environmental data collection and sensor selection

The design of the environmental analyzer connects the Particle firmware to the iOS app through Amazon Web Services (AWS). The application programming interface (API) gateway endpoint, Lambda function, and DynamoDB database are all linked via AWS in this project. A JSON payload is delivered by the API gateway endpoint, and the Lambda function is used to read it. The information is then saved in a database for future use. The AWS Lambda function is used to retrieve and migrate data to the DynamoDB database through a mobile backend. The firmware will read data from the sensors on the Particle board and send it to the cloud using this method. If the data has been uploaded to the cloud, it can be accessed using a web hook, which enables data to be transmitted from one computer to another over the internet. For data transmission, a link is formed between the Particle web hook and AWS. Data is sent to the database using the Lambda function, which determines when data should be read and sent. The iOS application will be able to read the database and interpret migraines in terms of environmental data once it has been submitted.

ii. Health monitoring application

- **Cloud Integration with AWS**

A web hook is used to link the Particle Cloud to AWS. The web hook used in this project allows data from the Photon board to be accessed and stored into a database, which can then be accessed and visualized in an iOS app. Web hooks do this by listening for an event published by a computer and then sending a request to a web URL. When the Photon publishes the room data read on the computer, the web hook is enabled, and the AWS API is used to access a Lambda Function. The data is then formatted and loaded into a DynamoDB database using this Lambda Function. A web hook was written to use this to access the AWS API gateway using an API Key for authentication. The application's final architecture is depicted in Figure 24, which divides the design into frontend and backend elements. The Particle firmware and iOS framework make up the front end modules. Both the Particle cloud and the AWS cloud and API make up the backend elements.

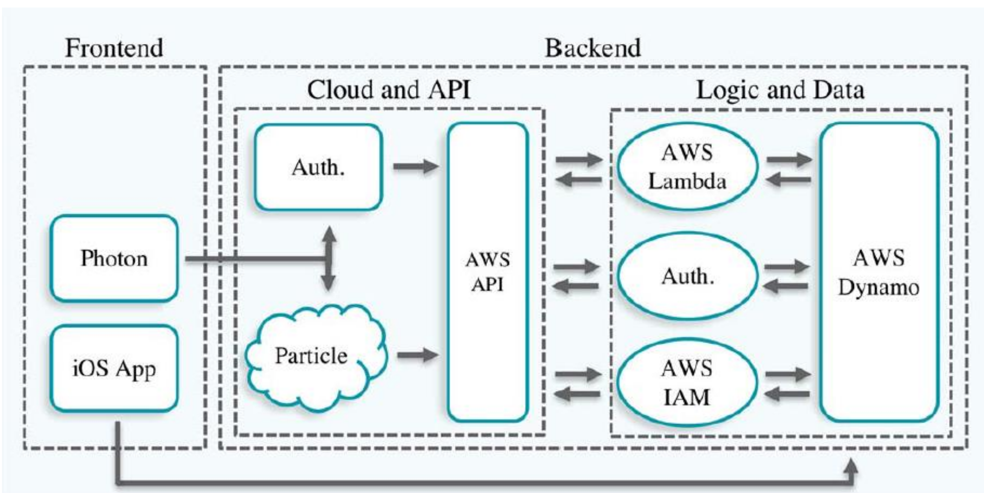


Figure 24-System architecture for the front and backend of the application using AWS.

1.2.4. IoT Enabled Prescription Reading Smart Medicine Dispenser Implementing Maximally Stable Extremal Regions and OCR

In this study, which focuses on the needs of senior citizens, we proposed an IoT-powered smart medication box with a camera for scanning the prescription. After the computer scans the drug with the camera, it is subjected to a variety of preprocessing techniques to extract additional information. The method of Maximally Stable Extremal Regions was then used (MSER). Before being uploaded to the database, the extracted text is subjected to string manipulation. The data is then used by our medicine box to warn the patient via buzzer and show medication information on the LCD display. A patient's fingerprint is used to verify his identity before he can take medicine. Finally, the medicine box dispenses individual drugs and records the use period in the database. If the dispenser runs out of medication, our system will show a message on the monitor to alert the patient[21].

- **Proposed methodology**

To retrieve details, the smart medication dispenser scans the given prescription and uses image processing algorithms. Only the information necessary for the device to function is submitted to the database. The patient will fill the tubes with the prescribed medication one at a time, following the directions on the device's LCD, and will be told when it's time to eat by the dispenser's in-built buzzer. The doctor will also be able to keep track on whether or not the patient is taking his medication on time. In a flow diagram, Figure 25 depicts the entire technique.

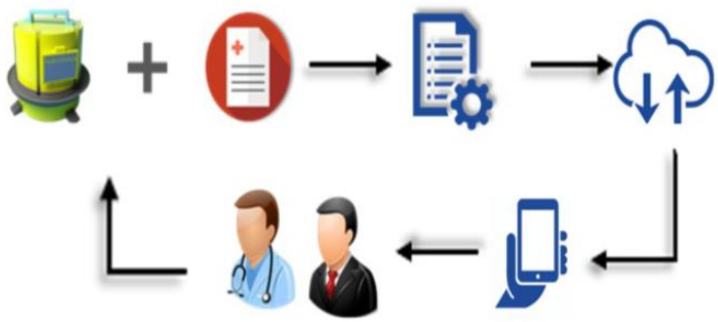


Figure 25- Workflow of proposed methodology

- **Hardware Calibration**

Six specially designed test tubes with medication dispensing holes in the bottom part of the tubes are included. The drugs are held in these tubes. The medicines or tablets are kept in place by a spring mechanism on a platform in the tubes. This spring mechanism also prevents medication from falling out of the dispensing hole by blocking it.

- **Information Extraction from Prescriptions**

After pre-processing the image produced by a pi-cam connected to the proposed device, the Optical Character Recognition and Tesseract methodologies were used to make the device prescription readable. Grayscale, noise cancellation, binarization, and adaptive thresholding were used to preprocess the captured image. After that, maximally stable extremal regions (MSER) are used to detect and bound text areas. Additionally, an OCR engine was used to extract the information in string format, and a Python library was used to submit the medication names and timing to the database. Pre-Processing of Images: Image preprocessing is essential for better text extraction because it reduces image complexity and allows texts to be read more easily.

- **Communication Process with IoT**

The Internet of Things allows for remote monitoring. Among the many notable contributions of IoT, the medical field is one of the areas where it has been extensively used. The primary aim of IoT in the medical field is to assist patients remotely by tracking, advising, and analyzing their condition without having to wait for doctors or nurses to arrive. This work concentrates on designing an IoT framework using the Raspberry Pi 3's built-in wifi protocol in this article. It uploads to the MySQL database records of patients' medication consumption reports, timetables, and scanned prescription results. The serial communication between the Arduino Nano and the Raspberry is done via USB, and the consumption timing is based on the fingerprint verification timing. Furthermore, a http custom formed connection with fixed domain or ip address is generated using all information, including fetched medicine data such as medicine name and dosage, medicine quantity from prescriptions, prescribed time and consuming time. Using Python's URLlib library, this now sends a http request with the following URL. A php backend framework is built to isolate the URLs and post them to MySQL's allocated data table to handle the HTTP request. As a result, both sides use IoT methodology to store and access data.

IV. Conclusion

A smart city is a platform for creating, deploying, and encouraging sustainable development practices in order to address the challenges of increasing urbanization. Information and communication technology make up the majority of it (ICT). An intelligent network of connected objects and machines (also known as a digital city) that transfer data using wireless technology and the cloud is a major part of this ICT architecture. Real-time data is received, analyzed, and managed by cloud-based IoT applications to assist municipalities, businesses, and residents in making informed decisions that enhance quality of life. The satellite industry, without a question, is one of the fastest-growing sectors in Smart Cities, owing to the high level of connectivity they require. Smart buildings, traffic management, parking spaces, street lights, and even smarter networks would all benefit from it. When looking for hybrid satellite solutions, some viable markets for M2M (machine to machine) focused on satellite applications are video surveillance, telemedicine, and industrial production. Satellites, as part of space technology, play a crucial role in the development of smart cities, particularly when it comes to applications such as smart healthcare, autonomous vehicles, and electric vehicle charging stations.

When IoT technical innovation is applied to one of the most conventional vital industries, healthcare, the outcomes are outstanding. In conclusion, smart healthcare has a bright future. Individual users can benefit from smart healthcare because it allows them to better control their own health. Medical services will be available when they are required, and the content of such services will be more personalized. It will also aid in assimilating data from tests in real time, monitoring the patient's condition, and communicating the knowledge to physicians and staff in real time, thus enhancing the overall efficacy of the healthcare system.

In terms of smart mobility, AVs are causing a shift in the transportation business model due to their characteristics. To stay up with those and future developments, we must fully embrace new technologies that are available and provide them with a conducive environment in terms of research and investment. Satellites would aid in the safe and efficient transportation of the populace. Autonomous cars would receive current information via monitoring and address assignment, avoiding traffic or an accident in road.

Regarding another application of IoT-based smart city which is EV charging stations what is concluded is that, with IoT technology, EV charging stations become more efficient and convenient not only for drivers, but also for service workers. By applying IoT, EV stations can be easily monitored and managed within one platform. It can also connect distributed EV stations, enabling drivers, charger vendors, local service companies, and station owners to collaborate more efficiently. The system developed is composed of two applications, a mobile one for the drivers of the EVs, and an application installed in a global aggregator, server, that is including the decision algorithm. Furthermore, the communication scenarios between the EVs, the server, and the CS should also be considered.

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