Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Electronic Health File System based on Fingerprint Sensor Technology

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ARTICLE INFO

Article history:
Received 20 June 2023
Received in revised form 5 October 2023
Accepted 17 October 2023
Available online 2 November 2023

Keywords:
Electronic health file; unconscious; electronic fingerprint; health file system

ABSTRACT

In medical sector, the use of computers and information technology helps in diagnosis, especially the computer-based patient record (CPR). As the traditional method of storing patient files is not feasible to obtain the health file, especially those who are in critical conditions, such as accidents, loss of consciousness and memory at times, due to the consumption of a lot of time and effort in the process of manual searching in traditional files. In order to help health care centers quickly identify patient personal data and make accurate decisions, an automated electronic system for patient health files based on a fingerprint sensor was built using special methods and technologies such as Content-Based Image Retrieval (CBIR) system, which is a retrieval technology based on the similarity of the images has the potential to facilitate identification and diagnosis of the patient's condition when he or she is unconscious. This study aims to integrate different technologies and discuss issues related to the electronic health file system based on the patient's fingerprint data, the use of (fingerprint sensor) technology, linking to the patient file data system, storage in fingerprint databases, and health data for each. sick.; To help critical cases, in addition to applying this technology and employing it in the ambulance and diagnostic system in order to improve the level of medical services and reach the desired results. The results showed that the electronic health profile was successfully built, designed and implemented for its intended purpose, the system and the destinations that connect users to the system as well as the fingerprint sensor. Finally, the system is efficient and gives reliable results with up to 100% tested accuracy based on the states it was stored.

1. Introduction

Similarity measurement is the basis for any information retrieval, management, or data mining system. Both in the industry and scientific community including the medical sector, similarity detection is extremely useful when applied to different use cases.

Nowadays, the information available on the internet has been growing at an increasing rate, making it difficult to analyze and use without the help of information retrieval systems or filtering tools. As a result, a health file term appeared where health and patient records and health files are

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https://doi.org/10.37934/araset.33.2.209224

the systematic documentation of patient care and medical history. The term 'medical record' is used both for the physical folder each patient and for the body of information each comprises, the total of each patient health history.

In addition, health files are intensely personal documents with some issues related to the degree of third-party access and appropriate disposal and storage methods.

Undoubtedly, there is an important role of general automation in the global economy and in daily life; so, the patient information management system (PIMS) is an automated system that is used to manage patient information, and meant to provide the administration and staff, with information in real-time to make their work more interesting and less stressing [1-4].

And because of this, technological advances are making life easier and offering solutions to many problems. It was necessary to employ these techniques in the medical aspect to help different patients in general and some cases in particular, such as a state of unconsciousness [5,6].

Since most of the Libyan hospitals currently using the traditional medical files as Patient information record, and whereas medical files, or the patient files are one of the focal points on which the process of providing health care within hospitals and between various types of medical institutions depends. And due to the importance of preserving all patient information from the key and comprehensive medical data for all the tests, diagnoses, treatment, follow-up reports, and most important medical decisions, so this paper presents an electronic health file (using fingerprint), which is a technology that adopts.

According to Jalal-Karim [7] and Barua *et al.,* [8], who reported that electronic health care data is a different term used in literature, such as electronic health record (ERH), electronic patient record (EPR), electronic medical record (EMR), computer patient record (CPR), and computerized medical record (CMR) and medical record keeping practices in a tertiary level hospital. Sometimes these names are given in different healthcare environments and other nations. While Tsai *et al.,* [9], and Garrett and Seidman [10] argued that an electronic medical record (EMR) is different from electronic health record (EHR). That is not the site is patient care software while electronic patient records or electronic medical records are health providers centers [11]. In general, an EHF will go wherever the patient goes, and it is used in different providers or specialists to make informed treatment decisions.

Nurses and doctors value bottom-up communication and IT department support for implementation outcomes, and nurses respond with an open and innovative organizational culture [12-15]. According to evaluation studies of the EHR systems by Salleh *et al.,* [16] and Alanazi [17], The results indicated that electronic health file systems support clinical functions and health care workflow, and also indicated that the quality and accuracy of knowledge have a high rating for predicting performance, which positively affected the size, while system compatibility was the most original component of system quality.

There are attracted increasing interests in technics of similar image/shape retrieval in existing retrieval algorithms. In this context, methods proposed a simple yet effective retrieval method based on exploring the image-to-class similarity, which is use as an iterative framework where the size of the query class is progressively enlarge according to the previous retrieval results [18-22]. In addition, rank list is generated according to the similarities between the query class and the images in the database.

An overview of the Content-based image retrieval (CBIR) framework and surveys, analyses, and compares the current state-of-the-art methodologies over the last six years in the CBIR field have carried by Hameed *et al.,* [23], Chaithra and Sunitha [24], Somnathe *et al.,* [25], Latif *et al.,* [26], and Shukran *et al.,* [27]. They also addressed that the semantic gap between the high-level meaning of the image and the visual features as the challenge of any CBIR algorithm, at the last, they highlight on very important four aspects to consider when designing an algorithm that elevates the semantic gap: First, the feature extraction as well as similarity measure as they influence the performance of the CBIR. Secondly, it can extract more features to enhance the accuracy of the CBIR and maintain the computational cost as it is considered an important factor in real-time applications. Thirdly, merging local and global features will lead to a balanced design because of the differences. And lastly, it can use machine learning algorithms in different stages of CBIR to increase system accuracy but need more attention to be paid to their computation cost.

Based on the physiological or behavioral characteristics, it can be (uniquely) identifier the Biometrics to a person. It relies on something, which he/she makes personal identification and, therefore, it can inherently differentiate between an authorized person and a fraudulent person. The development board is a printed electronic circuit that includes a microcontroller or processor in a way that allows amateurs and developers to program it easily, and connect it with other electronic devices, which contributes to accelerating the process of modeling designs and experimenting the project ideas, or even using to implement a project or an application.

The sensor senses the systolic and diastolic pressure along with the heartbeat and sends it to the Arduino. The temperature sensor senses the temperature of the surrounding environment, so when this sensor is in close proximity to the user, it reports the user's body temperature. Any inputs to the Arduino are values from sensor readings, and an LCD screen is used to display this information, and if the system detects any sudden changes in a patient's heartbeat or blood pressure, the system automatically alerts the paramedic and doctor to the patient's status via IoT and also displays details of heart rate and temperature, Humidity and blood pressure of the patient online.

The clinician can access this vital patient health information via a web interface from anywhere in the world. Thus, the IOT-based patient health tracking system effectively uses the internet to monitor the patient's health status, saving lives on time [28,29]. This system recommends the type of first aid that should be given in an emergency setting such as the scene of an accident or an ambulance. The paramedic or doctor can also easily suggest or give the types of assistance that should be provided at that moment, and among the results reached, the IoT technology monitors the patient's health, and the data file is in the cloud. When the patient needs emergency care, the proposed system alerts users pre-defined, and also finds nearby emergency contacts such as: an ambulance. IoT technology uses the Internet to constantly transmit patient medical data, and transactions can be made from anywhere, anytime as long as you have an Internet connection [30,31].

On different methods and techniques used in health applications, an electronic health file system is a programmatic integration of the programming language (PL), operating system (OS), and image processing technologies to process the fingerprint sensor data and deal with it (health file system) [32-34]. Because of this, the based database programs, where the automated electronic system for patient health files with fingerprint sensor helps the medical staff to identify the patient's data in many cases, the most important of which are cases (fainting/unconscious). And because of this, the confidentiality and medical history of the patient become available to access anytime and anywhere.

One of these boards is the Arduino board. A study by Pavithra *et al.,* [31] that used this technology, aimed to provide a fingerprint-based medical system in an effective way to store the patient's clinical files, and it is used to determine the previous health file to the patient quickly and easily using fingerprint recognition technology.

This system replaces the traditional paper medical files with the electronic medical file system; Where the fingerprint is used for the option of retrieval of medical data to avoid the identity card of the problem of losing it, and the previous file is considered and medical data is provided to emergency people, and patient information is collected with the help of sensors, so it takes the current health details of patients such as temperature, respiratory rate and heart rate with the push of a button.

2. Methodology

In this section, the chosen methods are addressed the achieved objectives of the system and described the technique of data collection employed in this research. The electronic health file system is a system that depends on different methods and techniques used in health applications, the electronic health file system is a software integration of the programming language (PL), operating system (OS), and image processing techniques of the fingerprint sensor with the health file system based on database programs, where the Automated electronic patient health file system based on fingerprint sensor was applied to help the health sector for identify the patient's data, especially in the unconscious or speechless through his fingerprint as illustrated in Figure 1. The methods applied to achieve the specific objectives such as literature review, oral interviews, system analysis, system design, data modeling using different diagrams, implementation, and testing. Overall, the system can be implemented based on the following three steps:

i. The first step: finger print extraction and EHF system data entry.
ii. The second step: storing fingerprint and patient EHF system data in two different databases.
iii. The third step: linking between the patient's file data and the finger print data and the other system's components as well.
iv. Finally, testing the system in order to let the health sector for identify the patient's data and then make decision.

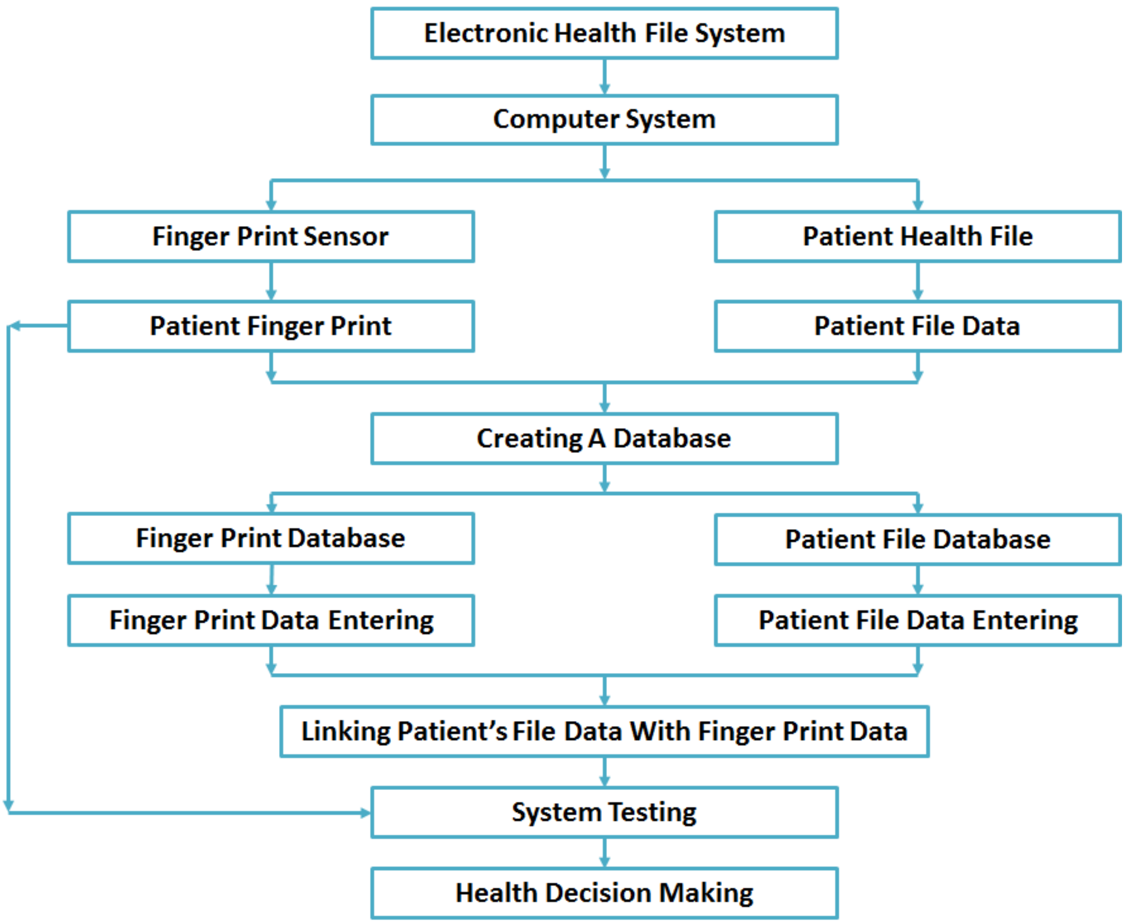

Fig. 1. Master plan for designing an electronic health file system based fingerprint sensor

2.1 Hardware and Software Requirements

The hardware used to implementation of the system is:

i. Computer system: Acer Aspire 5 A515-51G Windows 10 home edition 15.6-inch computer, Intel® Core™ i5-7200U processor, 8GB DDR4 RAM, NVIDIA® GeForce® MX150 graphics, 64-bit operating system, this device has been used in the construction, design and implementation of the system.

ii. Arduino board: the Arduino board is an electronic development board consisting of an open-source electronic circuit with a computer-programmed microcontroller, which is using in this project to connect them with the fingerprint sensor. The arduino model has the following technical specification:
   (a) Microcontroller: Microchip ATmega328P [9].
   (b) Operating voltage: 5 volts.
   (c) Input voltage: from 7 to 20 volts.
   (d) Digital I/O Ports: 14 (of which 6 can provide PWM output).
   (e) UART: 1.
   (f) I2C: 1.
   (g) SPPI: 1.
   (h) Analog input ports: 6.
   (i) DC Current per I/O Pin: 20 mA.
   (j) DC port for 3.3V: 50 mA.
   (k) Flash memory: 32 KB of which 0.5 KB is used by the bootloader.
   (l) SRAM: 2 kilobytes.
   (m) EEPROM: 1 kilobyte.
   (n) Clock speed: 16 megahertz.
   (o) Length: 68.6 mm.
   (p) Width: 53.4 mm.
   (q) Weight: 25 grams.

iii. Fingerprint sensor: the fingerprint reader sensor is a sensor that scans the fingerprint data and saves it, in order to compares it leather on with other inquiry fingerprint data. It is one of the sensors concerned with privacy and security. It is suitable for projects that need to make security systems and make an entry system for a place or a specific database. The fingerprint sensor's role is to take an image from the edges of our fingers, and then it will apply certain algorithm to match it with the stored data in order to displays the matched result, which is used in this system to store Patients' fingerprints and retrieval. The used sensor is R307 fingerprint recognition sensor module, which has following technical specification:
   (a) Type: optical.
   (b) Backlight: Blue.
   (c) Interface: USB2.0 / UART (TTL Logical Level).
   (d) Baud rate for RS232 communication: 9600BPS~115200BPS changeable.
   (e) Verification speed: 0.1 seconds.
   (f) Scanning speed: 0.2 seconds.
   (g) Character file size: 256 bytes.
   (h) Template size: 512 bytes.
   (i) Security level: 5 (1,2,3,4,5 (highest).
   (j) FRR (false rejection ratio): ≤1%.

(k) FAR (false acceptance ratio): ≤0.0001%.
(l) Voltage: DC 4.2-6V.
(m) Current: 50mA (typical).
(n) Peak current: 75mA.
(o) Matching method: 1: N.
(p) Operating temperature: -20-50 degrees.
(q) Image capture surface: 1.5 x 1.1 mm.

The software that used for implementation of the system are: Microsoft Visual Studio, Microsoft SQL Server, Arduino IDE, Crystal Reports, Edraw Max, Endnote, Adobe Photoshop, Visual Basic.NET, Structured Query Language (SQL), Arduino c language, and an algorithm of the content-based image retrieval system in fingerprint.

2.2 Electronic Health File System

Figure 2 illustrated the used waterfall model methodology. The system conducted by gathering materials from different resources. One of the most valuable data sources was an oral interview, in which had conduct with staff of Zliten Specialist Hospital Zliten with the presence of doctors and nurses who assisted the work by providing some technical facts.

In addition, the method of collecting data through research and review of scientific papers and studies related to the establishment of an electronic health file system is used, and some websites related to systems related to the proposed system.

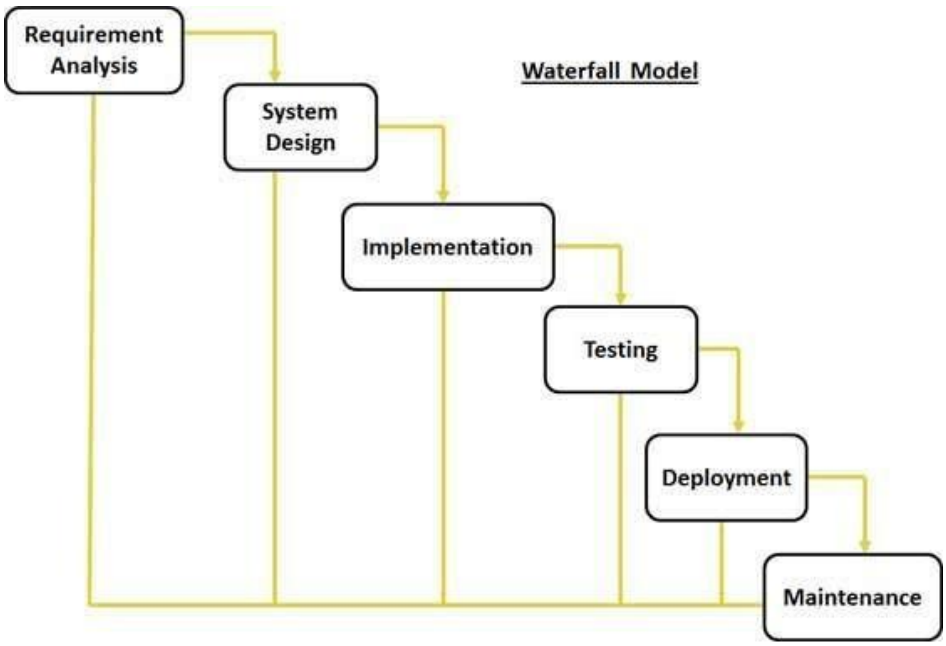

Fig. 2. Stages of the waterfall model

2.3 System Data Analysis

The data is arranged and organized in order to prepare and highlight it in the form of information. In this stage, the system requirements are determined, which aims to introduce a brief definition of the functional and non-functional requirements of the system based on the collected information.

The system functional requirements define what the system can do, as well as the inputs and outputs of the system as well. Table 1 illustrates the Functional requirements of the system.

Table 1
System Functional requirements

Requirement description	Requirement
Simple interface and good performance.	Usage requirements
only system administrator who has the right to give permissions and open accounts	Security and safety requirements
the fingerprint sensor is accurate in detecting previously stored patients	Accuracy Requirements
Depend on the speed and accuracy of the results, and the response time of the system should be short to give it the advantage of speed.	System efficiency

2.4 System Modeling and Designing

It is an approved method for developing systems that help in forming a preliminary picture of the total system and provides a set of solutions to design problems. Modeling provides the valuable advantage of allowing users to actively participate in the systems development process. One of them is Use Case Diagram that shown in Figure 3.

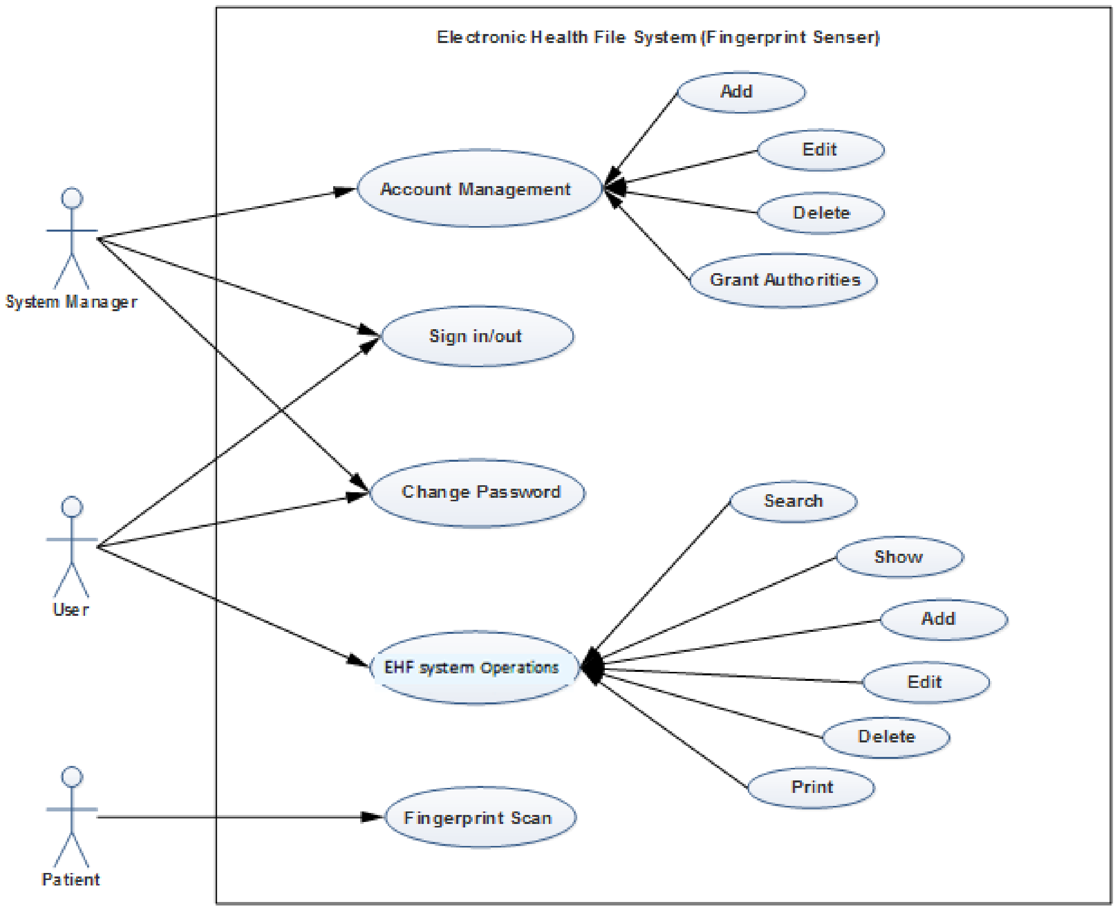

Fig. 3. Use case diagram of EHF system

At the stage of design, the system interfaces are designed to cover the user's needs so that become an easy to use and clear to the user to use the system under the names of; main interface, patient login interface, user login interface, patient personal data interface, diseases interface, general diseases interface, chronic diseases interface, interface Genetic diseases, previous surgeries interface, analysis interface design, radiology images interface design, schematics interface, sensitivities interface, vaccinations interface, vital rates interface, doctor data interface, user data interface and permissions, patient card interface.

As illustrated in in Figure 4. Basically, content-based image retrieval (CBIR) is a system try to retrieve images similar to a user-defined specification or pattern (e.g., shape sketch, image example). Their goal is to support image retrieval based on content properties (e.g., shape, color, texture), usually encoded into feature vectors. One of the main advantages of the CBIR approach is the possibility of an automatic retrieval process, instead of the traditional keyword-based approach. Indexing is responsible for extracting appropriate colors and texture features based on texture feature technology.

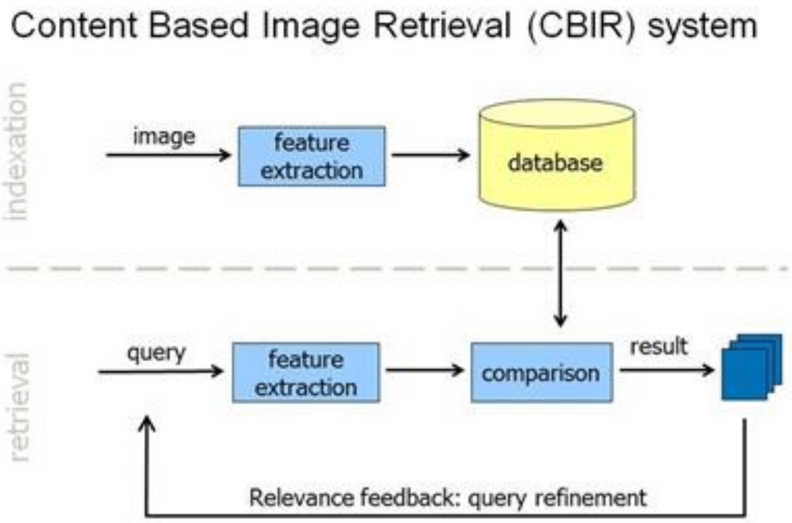

Fig. 4. The basic concept of the content-based image retrieval (CBIR) system

Generally, as illustrated in Figure 4, the image retrieval algorithm based on fingerprint sensor technology is retrieval regulates query processing where the interface allows the user to identify a query by query style and depict similar recovered images, and then extracts features from the style and applies the nearest neighbor algorithm (KNN) as a testing phase to assess the similarity between query images and database images. Afterwards, categorizes database images in order to reduce similarity to the query image and redirect the most similar images to the interface unit.

2.5 System Execution

There are stages to implement the system to become integrated and ready for use in both states (normal and urgent) as shown in Figure 5.

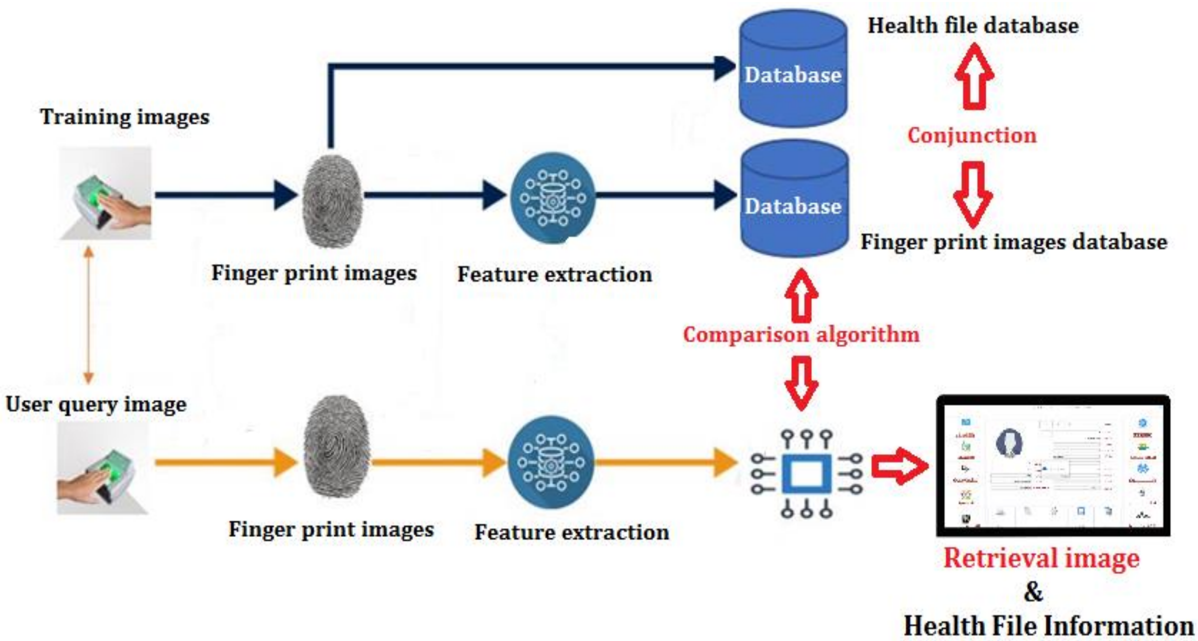

Fig. 5. Typical structure of the image retrieval algorithm based on fingerprint sensor technology

2.5.1 Designing and entering the system data

After the system was analyzed and designed using the methodology used (Waterfall model) as previously indicated, the researchers entered the personal and medical data of the files for each patient.

2.5.2 Entering the fingerprint data for each patient

Since the health's data files as well as the fingerprint data were entered and given (a digital address) to each patient who had a file stored in the system.

2.5.3 Linking the fingerprint data with the system data

Linking the patient's fingerprint data with the patient's electronic health file data, after programming it by connecting the system to the Arduino program through the port.

2.5.4 System reports

Where the system provides various reports for all the system data to be printed and used by the medical or paramedical personnel when needed or for use by decision makers in the Ministry of Health in particular, or in the Libyan state in general.

2.5.5 System backup

In this system, it was enabled to take a backup copy of all system data every time the user exits the system and store it in both external disks and spaces or in the cloud of the system in the future. It has the effectiveness and accuracy of diagnosis on which the lives of patients are built.

In summary, after completing the analysis and design phase, and since the data for the files was entered, the fingerprint data was entered and given (a digital address) to each patient with a file, and then stored in the system, so the image of the fingerprint was taken using the fingerprint device which uses the algorithm of the content-based image retrieval system in fingerprints and in data storage, where it tries to retrieve images similar to the specifications of the specified pattern as in Figure 5, with this algorithm two main functions are supported: indexing (inserting data) and retrieval (query processing), while retrieval regulates query processing where the interface allows the user to select a query-by-query style and visualize similar retrieved images, extracts feature from the styles and applies the nearest neighbor algorithm (KNN).

2.6 System Testing

After executing the system and converting it into software commands, the final stage is testing. Software testing is a critical element in the issue of system quality assurance and represents the last review of the requirements, design, program writing, and error detection stages to ensure that results can be obtained without errors when opening and dealing with the system. The components of the system have been tested individually, i.e., the work of each software part (such as buttons, permissions, fingerprint scanner, etc.) has been tested. The test is in the following stages: the first is Functional testing It is the testing of the system after assembling all its components to ensure that it performs the function it should do, which are described in the requirements documents such as the fingerprint scanner, the add, modify, delete and print buttons, Testing the functions of the system and the appearance of alert messages in the event of an incorrect procedure, such as not filling in all the fields, entering text in the numbers field and vice versa. Where the second is Accuracy testing of the system that completion was tested using the method of retrieval and matching, that is, by calling the file that was previously stored using the same fingerprint whose data was stored and linked to the health file system, so statistical analysis used to calculate the percentage diseases that have been identified and successfully retrieved for the total number of cases previously entered and tested.

3. Results

This research is a project to create the Electronic Health File based on fingerprint sensor". This section explains the results and discussion of building, designing and implementing the electronic health file, the results of testing the system, and the destinations that join and link between the users and the system, the fingerprint sensor and the system, which can be divided as follows:

3.1 Software Results of the HFS

These results contain of system interfaces design and testing results, for example: Users login interface shown in Figure 6 demonstrates an alert message appears when the user enters an incorrect password, patient interface Figure 7 that shows an alert message appears when the user searches for a patient that is not previously stored, and Personal data interface Figure 8 which displays patient information and the alert messages when entering a number in the text field.

Fig. 6. Demonstrates the login interface test for users

Fig. 7. Illustrates Patient interface test

Fig. 8. Illustrates personal data interface test shows when writing letters in the number field

3.2 Data Collection Results of the HFS

These results contain: programming and joining hardware that concentrate on fingerprint extraction. For example, Figure 9 illustrates the process of displaying the patient's fingerprint in the form of a (digital address) after identifying him through his fingerprint that previously saved through the patient card based in Figure 10 that contains personal and medical information.

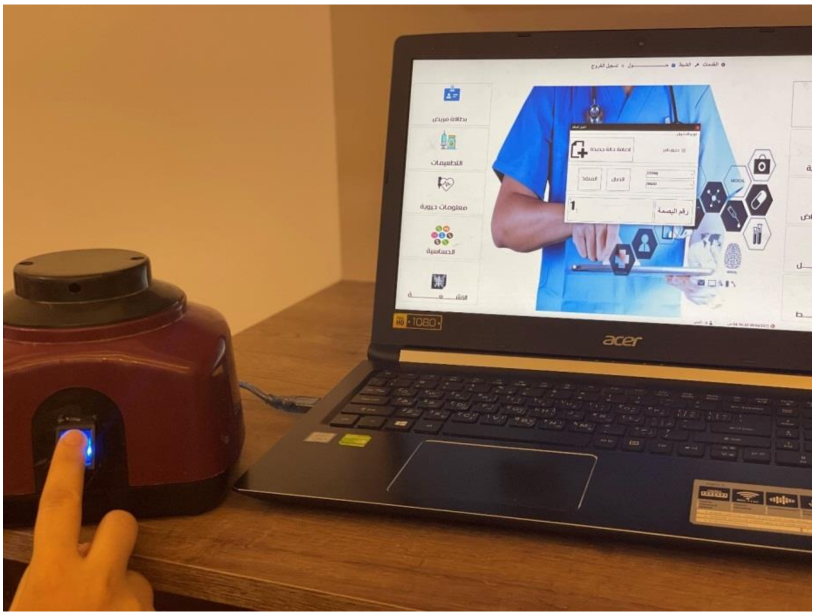

Fig. 9. Illustrates data collection results

Fig. 10. Illustrates patient card

3.3 System Accuracy Test Results

This section discussed the results obtained from the process of linking the fingerprint to the health file. The effects of the data obtained from the fingerprint verification process are discussed, the test configuration for this experiment in Eq. (1), the accuracy of the system's achievement was tested using (similarity based recovery) techniques; by calling the previously stored file using the same fingerprint whose data was stored and linked to the health file system, and to calculate the accuracy of the achievement were used (statistical analysis), By calculating the percentage of cases successfully identified and retrieved for the total number of cases previously entered and tested, the accuracy of the digital fingerprint scanner was calculated. Where 20 fingerprints scanned as a total of fingerprints entered in the test period and no fingerprints were rejected, and the database showed good results regarding the retrieval of their file data, where the accuracy of the system was calculated from Eq. (1) and Eq. (2).

$$Accuracy = \frac{Number\ of\ cases\ successfully\ matched}{Total\ number\ of\ cases} \times 100 \quad (1)$$

$$Accuracy = \frac{20}{20} 100 \times = \%100 \quad (2)$$

Thus, we obtained a 100% result as a system accuracy level and all the data of each patient's files were retrieved, this interface also illustrates, as in Figure 3, the process of displaying the patient's fingerprint in the form of (digital address) after identifying him through his fingerprint that was previously saved.

3.4 Electronic Health File System Based on Fingerprint Sensor

In this interface shown in Figure 11 the system as a whole is displayed, which consists; the system, the fingerprint sensor, the Arduino board, and connecting interfaces.

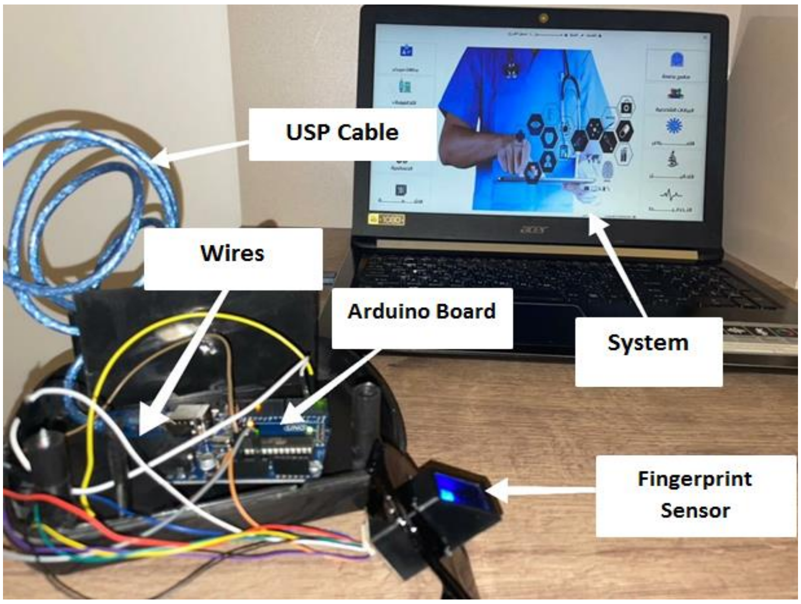

Fig. 11. Demonstrates the components of an electronic health file system "fingerprint sensor"

4. Discussion and Comparisons with the Literature

The Module of Fingerprint R 307 is good image processing capability of finger print reader can successfully capture images up to resolution 500 DPI. The Fingerprint Sensor R307 is designed to be compatible with Arduino and Raspberry Pi, making it easy to integrate into existing projects. it consists of the optical fingerprint sensor, high-speed DSP processor, high-performance fingerprint alignment algorithm, high-capacity FLASH chips, and other hardware and software composition, stable performance, simple structure, with fingerprint entry, image processing, fingerprint matching, search and template storage, Fingerprint image entry time: <0.1s, Acquisition window area: 14*18 mm, Template file: 512 bytes, Security level: 5 levels (low to high: 1, 2, 3, 4, 5) and other functions. It integrates fingerprint algorithm chip with functions such as fingerprint entry, image processing, feature extraction, template generation, template storage, fingerprint comparison (1:1) and fingerprint search (1:N).

The fingerprint readers can conduct secondary development and can be embedded into various products such as access control, attendance, safety deposit box, car door locks.

5. Conclusions

As work contribution an automated electronic system for patients' health files was built based on fingerprint sensor by using special methods and techniques such as Content-based image retrieval (CBIR) system, in order to help the health care centres quickly identifying the patient's personal data and precisely decision making, whereas, the traditional method of storing patient files is not feasible of obtaining the health file, especially those in critical conditions, such as accidents, loss of consciousness and memory at times, due to the consumption of a lot of time and effort in the process of manual searching in traditional files.

An electronic health file system (fingerprint sensor) is designed based on databases to store patient data such as database software (Microsoft SQL Server), a system for displaying data using the integrated development environment (Microsoft Visual Studio), a fingerprint recognition and preservation software such as Arduino, fingerprint sensor and image processing technologies. The system aims to ensure that patients are identified, especially in critical cases such as (unconscious/speechless) based on fingerprints, which uses the algorithm of the content-based image retrieval system in fingerprints and in data storage, where it tries to retrieve images similar to the specifications of the specified pattern.

The two main functions are identifying using this algorithm such as indexing (inserting data) and retrieval (query processing). Indexing is responsible for extracting appropriate colors and texture features based on texture feature technology, while retrieval regulates query processing where the interface allows the user to select a query-by-query style and visualize similar retrieved images, extracts feature from the styles and applies the nearest neighbor algorithm (KNN).

As a testing phase to assess the similarity between the query images and the database images afterwards, the database images are classified in the order in which the similarity of the query image is reduced and the most similar images are redirected to the interface unit. In short, after the data for the files was entered, the fingerprint data was entered and given (a digital address) to each patient with a file, and then stored in the system. In addition, the decision was made on the accuracy test of the system.

The accuracy of the system achievement was tested using the similarity technique based on retrieval؛ Where 20 fingerprints scanned as a total of fingerprints entered in the test period and no fingerprint were rejected, and the database showed a good result regarding the retrieval of their file data, where the simple mathematical equation was made to show the accuracy of the system, which was 100% accurate.

The importance of this research lies in eliminating the problem of the difficulty of identifying the personal and medical data of the unconscious and speechless patient, and solving the problem of the noticeable lack and loss of data in all health sectors as well as improving the management of medical conditions, especially chronic ones, and not having to fill out the same papers and data every time he visits the doctor.

Acknowledgement
This research work was supported by the Alasmarya Islamic University, Municipal Council of Zliten, as well as the Zliten teaching hospital.

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