

INCREASING THE EFFICIENCY OF ONLINE HEALTHCARE SERVICES SOFTWARE AND MOBILE APPLICATIONS USING ARTIFICIAL INTELLIGENCE TECHNOLOGY

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Abstract- The demand for online service applications related to our daily life increases greatly, especially those related to the field of healthcare services, and the importance of these applications during epidemic times rises significantly. This research deals with one of the inquiries correlated to making appointments in hospitals and health centers, as well as providing initial advice to the patient regarding the appropriate doctor, and the primary diagnosis of the disease using artificial intelligence techniques. All this by developing a software system and mobile application, therefore the users (the patients or who is responsible for them) can obtain these services as quickly as possible and in high quality and without even friction with anyone else. This leads to an increase in the effectiveness of these applications in times of epidemics and disease outbreaks. The proposed software system consists of two main components: The first one is responsible for searching for the right doctors and making an appointment with them, the right doctors are in the highest evaluation, with their best reputation and performance in their fields of competence. The second part is an expert system equipped with an inference engine that can, through a set of questions, provide diagnostic suggestions according to the patient's case, which will result in booking an appointment through the first part after the patient confirms the appropriate choice.

Keywords: Artificial Intelligence, Expert System, Knowledge Base, Mobile Application, and Healthcare Web Application.

1. INTRODUCTION

This paper is an extension of work "Medical patient appointments management using smart software system in UAE" originally presented in "International Arab Conference on Information Technology (ACIT'2019)" [1]. For instance, Information Technology and Online Services have become an essential part of our life, of course, this facilitates our it in normal and critical circumstances, especially in the epidemics crises, all of us will remember for a long time what happened with the spread of COVID 19, and how the IT and internet

technologies were the alternative tools for most of our activities such as e-learning, online shopping, and even in the medical sectors. Most of us as researchers, specialists, students, and developers are attempting to add new values and enhancements to the routine by implementing new applications and software systems. In this work, we are trying to provide online appointment system supported by an artificial intelligence tool (AIT) to help patients in searching for suitable doctors and medical centers, booking appointments, and evaluating their health problems according to the disease symptoms using AIT, this issue will helpful for reducing effort, time and even money. The proposed system merges between features of regular medical appointment systems and artificial intelligence medical systems.

1.1. Objectives

Comparing to the paper-based work in taking appointments, where patients and recipients staff in medical centers are spending a lot of time and effort for filling boring forms, online systems, and mobile applications provide many benefits. Online websites and mobile applications are used in all sectors of the daily routine, but their importance has been appeared in recent times, especially in the period of the spread of the Coronavirus (COVID19). Therefore, we are trying in this work to exploit the capabilities of artificial intelligence to support the healthcare services sector by achieving the following goals:

- Supporting our new lifestyle, where internet is used for everything.
- Saving time and effort for looking for needed doctors and suitable medical centers.
- An appointment booking.
- Avoiding contact with others, during epidemics time by using online health servicing software application.
- Providing general diagnosing suggestion for common and general diseases.

2. LECTRATURAL REVIEW

Normally solving problems can be implemented using any regular programming methodology, you need to understand the nature of the problem, design the

mathematic model, then implement it, but some cases when the nature of the problem can't be modeled using math or other methods, the expert systems become the adequate tool, especially when the problem referring to the simulating human behavior, "expert systems also used human knowledge to solve problems that normally would require human intelligence" [15]. In this section number of different systems will be provided which is related to three issues: first one system for managing medical appointments (searching for doctor, booking, canceling appointments, etc.), the second one is concerned about the diagnoses of diseases using Artificial Intelligence such as expert systems, neural networks, fuzzy systems and deep learning for detecting diseases (diabetes [18]), finally the online health care services system.

2.1. Medicus [2] and Mr. Doc

The systems "A Doctor Appointment Booking System" [2] and "A Doctor Appointment Application System" [3] are a good example of traditional systems for helping patients in facilitating their issues with managing appointments, "Life is becoming too busy to get medical appointments in person and to maintain a proper health care" [3]. They can help patients in decreasing the difficulties that patients face when visiting hospitals and health centers, both applications offer a different set of functions: medical appointment reminders, and location services for medical centers, clinics, and hospitals, and some other notifications features regarding the appointment. It does not use any AI tool.

2.2. Online Polyclinic [4]

This online system was implemented by Maryam Tufail (2018), it supports the entire process of managing medical appointments by reducing time, efforts, and money. It has very simple features such as online booking and simple notifications [1, 4], also it does not provide any of AI functions.

2.3. Diagnosis using Classification Methods [19]

This research focused on methods of pattern recognition to classify objects, it presented a performance study of K Nearest Neighbor, Multiplayer Perceptron, Bayesian Algorithm, and Parzen Window [19] in classification the skin diseases into twelve classes to represent skin diseases types.

2.4. Diagnosis using Machine Learning [20]

The researchers in this work implemented a system to analyze laboratory data using a machine-learning technique to identify the most useful variables for proper and precise diagnosis, the machine-learning system will be very helpful for doctors for fast disease diagnosis [20].

2.5. Diagnosis using Medical Expert System [12]

The researchers in this review paper "Medical Expert Systems for Diagnosis of Various Diseases" [12] are trying to provide a study of all possible elements and aspects needed for diagnosing different diseases in medical expert systems, they presented a good idea to

implement intelligent ES capable of advising and recommendations for medical staff and patients to facilitate treatments and disease diagnosing [12].

2.6. Diagnosis using Fuzzy Logic [14]

The authors of the "Design and Implementation of Fuzzy expert System (FES) of Back Pain Diagnosis" [14] used fuzzy system rules depending on experimental examination symptoms for implementing ES using fuzzy logic concepts to exploring and treatment back pain diseases. The input for this system is a group of variables: symptoms of experimental tests, gender, age, BMI "Body Mass Index", and then based on this input the FES will estimate and evaluate the back pain disease and provides recommendation and suggestion in a good percentage of accuracy within 90% [14].

2.7. Diagnosis using Prolog [13]

This system "The Diagnosis of Some Lung Diseases in a Prolog Expert System" [13] is an expert system implemented in Prolog as an artificial intelligence tool; it uses the seen and felt symptoms to diagnose lung diseases. It is helpful to doctors and medical experts to explore and making the right decision of diagnosing patients.

2.8. Diagnosis Using Intelligent Tools in Real Time [7]

The system "An intelligent mobile-enabled expert system for tuberculosis disease diagnosis in real time" [7] was implemented in 2018 as one of the most important expert systems using image processing theory as artificial intelligent method; using this method, the researchers implemented a real-time intelligent mobile expert system to detect tuberculosis illness[1, 7]. It uses image processing to extract features of disease, then analyses them to provide the result.

2.9. Diagnosis using Neural Networks "Artificial Neural Networks in Medical Diagnosis" [11]

Neural networks as an important branch of Artificial intelligence were used as a powerful tool in medical matters to help and enable specialists in analyzing, modeling, and making sense of complex and big medical data. The feed-forward back propagation model can be used to learning, training, and using neural networks in classification, problem-solving, and forecasting [11], but for diagnosing in the medical sector the author of this work developed their system using feed-forward back propagation model [11].

2.10. Overall View

In the final stage of this section, we can say that really there are many different systems around the world concerning our topic, in each one, many advantages can be found, and in Table 1, a conclusion of their features is provided. By comparing the above-mentioned systems, we found that the idea of facilitating patients and provide intelligent service can be solved by combining online services, appointment management, and expert system together.

Table 1. Summary table of related works

Systems / Features	Online Services	Appointment Management	Artificial Intelligence tool
Proposed System	√	√	√
Diagnosis using Medical Expert System	x	x	√
Diagnosis using Fuzzy Logic	x	x	√
Diagnosis using Prolog	x	x	√
Diagnosis using Neural Networks	x	x	√
Midcus	√	√	x
Mr. Doc	√	√	x
Online polyclinic	√	√	x
Diagnosis using Classification	x	x	√
Diagnosis using Machine Learning	x	x	√

2.11. Advantages and Disadvantages

By comparing the proposed system with the other systems (Table 1), the following advantages can be listed:

- Providing a proportionate diagnosis.
- Preparing sensible explanations and recommendations.
- Succeed in dealing with human limitations
- Ability to the adaptation to new diseases.
- Having properties of both booking systems, and artificial intelligent diagnostic systems.

The disadvantages are:

- High cost on implementation.
- Difficulty in knowledge representation.
- Accuracy needed more samples and training.

3. PROPOSED WORK

The proposed work consists of web and mobile applications, expert system, and database system as shown in Figure 1, both of web and mobile applications are connected to the central database, and from the other side expert system can be called by both applications.

The system architecture shown in Figure 2, displays that: The databases in hospitals and medical centers and clinics to the proposed system through the Database server, and all their data are isolated and secure, only a

few fields (ID, name, age, and non-sensitive data) of the patient’s record will be saved in the central system of the proposed system; this issue gives a guarantee for patients information.

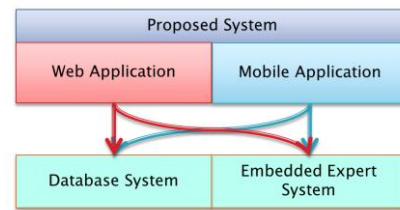


Figure 1. General overview of the proposed work

Each hospital or medical center and clinics should register to the system through the web server and system administration. A web and application server is used between the user (patient’s) device and a central database, this server helps to extract, search, and save data, in addition to process the AI algorithm used to diagnose general disease. To implement this system, we used ASP C# (Visual Studio including Xamarin) as main programming tool [17], and MySql to for the database.

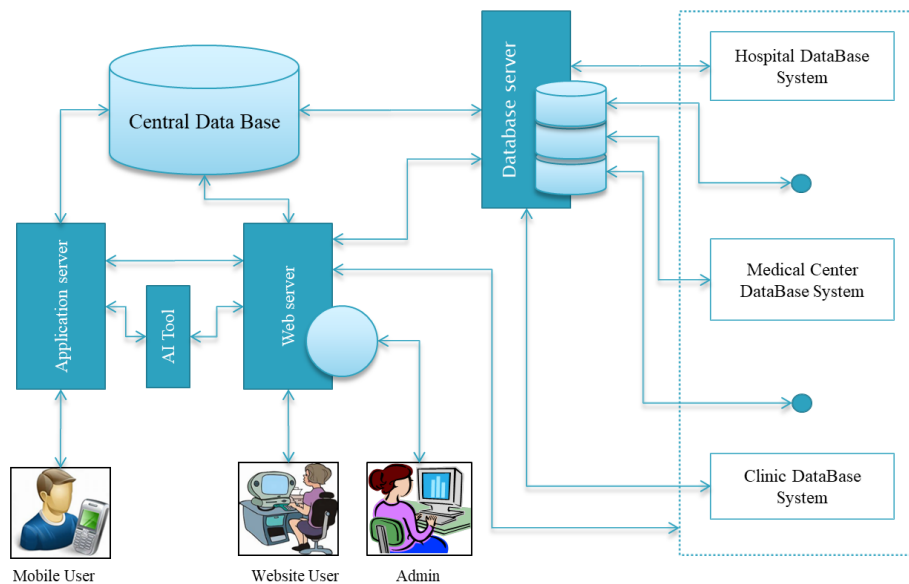


Figure 2. The Central Database System Architecture

There are many mobile applications that use this embedded expert system, for example "an investigation into the development of an intelligent mobile-enabled expert system to perform an automatic detection of tuberculosis disease in real-time" [7]. Another application "the ontology-based Medical Report Mapping Process" [8] was implemented to collaboration with medical and

computer experts to support the transformation of unstructured reports into a structured representation [8].

The general architectural view of an expert system, shown in Figure 3, consists of typical expert system components: user interface, inference engine, and knowledgebase modules. EES was developed as an assistant tool to help patients in diagnosing their most common health cases.

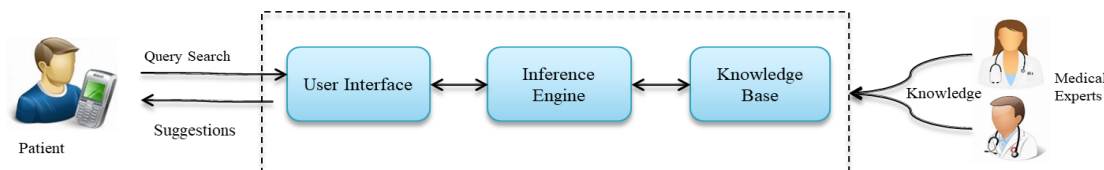


Figure 3. General View of Typical Expert System

ESS used as an interactive and reliable system to help the patient in decision making using facts and rules (heuristics) according to his/her disease symptom through the following functions:

- Collecting disease symptoms.
- Provide a simple diagnostic.
- Providing a list of doctors' names, medical centers, hospitals, and clinics suited to their diagnosed case.
- Suggesting alternative recommendations to the patient problems.

To achieve the above-mentioned goals, the mobile application provide a GUI represented as list of questions classified as a groups, they will appear on the applications depending on sequence of patient answers. These features help the user (the patient) with quick access to useful health information and finding the appropriate and most experienced doctor in the field of the pathological complaint, as well as in obtaining the best hospital or health center.

3.1. Knowledge Acquisition and Representation

Collecting medical proper data and converting them to form suitable for the proposed web and mobile applications was one of the most important challenges in

this project, this step was achieved by meeting with human experts (pharmacy and medicine students, reading books, and searching the internet) to be able to design and formulate appropriate questions for using in the next step in interviews with specialist doctors in medical sectors to collect information and experiences about symptoms and treatment of common diseases such as Flu and Cold, Diabetes, Obesity, etc. For example diagnosing diabetes by common symptoms [6] can be represented as shown in Tables 2 and 3, and then this representation can be converted to knowledgebase (Figure 3). Table 2 displays the common diabetes symptoms [6].

Table 2. Diabetes Symptoms [6]

#	Symptom	Fact No
1	Feeling thirsty	Fact 1
2	frequent urination	Fact 2
3	Feeling hungry: even through eating	Fact 3
4	Blurred vision	Fac 4
5	Slow healing of cuts and bruises	Fact 5
6	Extreme fatigue	Fact 6
7	losing weight - even though you are eating more	Fact 7
8	Numbness and pain in hands and feet tingling	Fact 8
9	Feeling tired	Fact 9

Table 3. Diabetes Symptoms [6]

Diabetes Type Symptoms (Facts)	Fact 1	Fact 2	Fact 3	Fact 4	Fact 5	Fact 6	Fact 7	Fact 8	Fact 9
Diabetes (no type)	√	√	√	√	√	√	√	√	√
Type1	√	√	√	√	√	√	√		√
Type2	√	√	√	√	√	√		√	√
Type1 (infant or child)	√	√					√		√
.....

This was an example; the general form for preparing facts and rules is a normal decision table that can be developed using common predicates formulas used in expert system development process as shown in Figure 5, some systems use "weighted numerical probabilities based upon the frequency of association of B given A"

[16] $(P(A \setminus B) = \frac{P(B \setminus A)P(A)}{P(B)})$, where A is the

diagnosis, and B the associated observations.

The mobile embedded expert system application was implemented using Microsoft Visual Studio Xamarin C# platform based on the Android mobile operating system. The concepts and ideas provided by "Artificial Intelligent Experts for developing Expert System Shell" [9], and "Medical expert project" [10] were used to develop proposed applications. The following script in Figure 4 provides an example of source code used for creating rule based statements for Inference Engine.

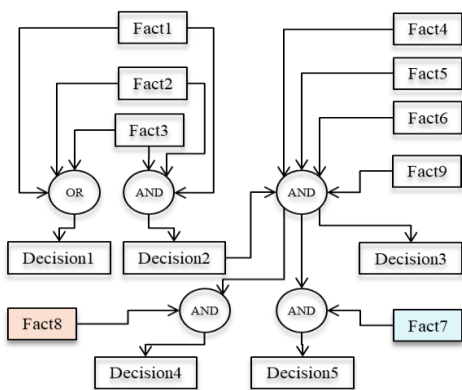


Figure 4. Diabetes logical representation

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RuleInferenceEngine Test = new RuleInferenceEngine();
Rule rule = new Rule("Diabetes");
rule.AddAntecedent(new IsClause("Feeling", "thirsty"));
rule.AddAntecedent(new IsClause(" Feeling ", "very hungry "));
rule.AddAntecedent(new IsClause(" vision ", " Blurry "));
rule.setConsequent(new IsClause(" Urinating ", "Often"));
rule.setConsequent(new IsClause(" Weight ", "Loss"));
rule.setConsequent(new IsClause(" numbness ", "hands "));
rule.setConsequent(new IsClause(" numbness ", "feet"));
Test.AddRule(rule);
    
```

Figure 5. An example of Rule based statements written using C#

In this work we started building knowledge base for most general diseases, this process should be continued, and more facts means more rules and better results.

3.2. How to Use It

To use the proposed system, user needs to do:

- Registration hospitals and medical centers (by system administrator).
- Establishing connection between central database and hospitals and other medical centers databases (by system administrator).
- Creating an account.

For privacy and security reasons all patient records and data should be processed and saved locally in hospital and clinics database systems, the coordination between patients (end-user) and medical centers including med-clinics and hospitals is the most important function of the web application and central database by managing and processing their queries and searching local databases to retrieve the appropriate results (answers) bases on certain factors as shown in the general algorithm in Figure 6.

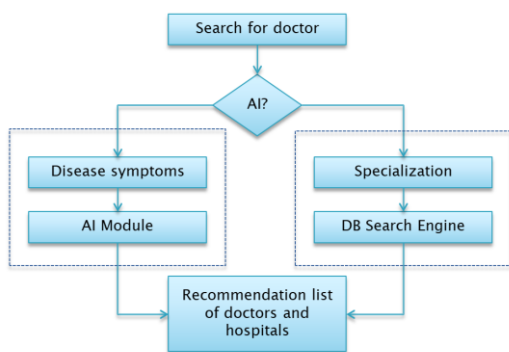


Figure 6. General data flow diagram

4. RESULTS

The general algorithm for the proposed system shown in Figure 6, the user can search for doctor, or can use it to get help in diagnosing his/her disease, this section focuses on using the proposed system as artificial intelligence tool for disease diagnoses.

The prototype implementation of the proposed web and mobile applications are ready, they were delivered, for testing and feedback purposes, to a group of users. For the first stage of testing, the behavior of the Inference Engine (IE) in diagnosing the correct results for common diseases was not very acceptable, this result improved by increasing the number of training samples and enhancement rule-based algorithms used for knowledge representation, the error of disease diagnoses process decreased as shown in Figure 7.

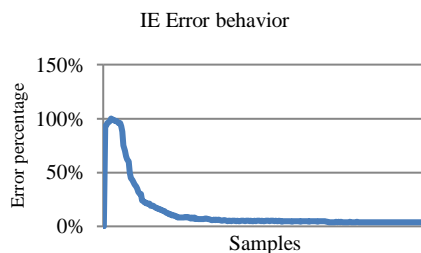


Figure 7. IE error behavior

To get feedback and assessment of the proposed applications, a questionnaire about using such type of application (medical ES for disease diagnosing) was distributed among 100 users (students) [1], the results of this questionnaire shown in Figure 8. Another survey was distributed during the Corona Virus crisis period; the main goal of this survey was to explore people's opinions about using online services and mobile applications for general disease diagnostics, the result of this survey shown in Figure 9.

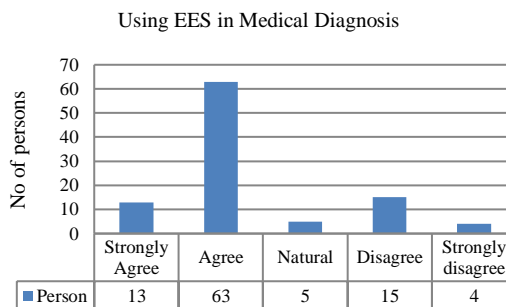


Figure 8. Statistical survey result

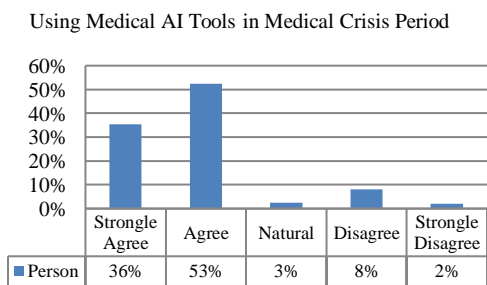


Figure 9. Survey result of using medical AI tools in medical crisis period

5. CONCLUSION

Nowadays and everywhere online software systems are required more than ever, exceptionally for the health care sector. In this work, an online web and mobile applications were proposed that facilitates the booking appointment process, searching for doctors and hospitals, and diagnoses for common disease. The proposed system keeps patients' information protected and isolated from any unauthorized access because the connection between its database and hospital databases is very limited to general information only. The result of the questionnaire was strongly supportive of the use of this type of application in the time of the Coronavirus pandemic because this can be used from home away from contact with others, but the idea of obtaining a preliminary diagnosis may not be desirable to many. This is normal because this type of application needs a long period of time in order to prove its validity and gain the confidence of patients and health experts, especially as it is directly related to health, it still in its beginnings and we are working to improve it.

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BIOGRAPHIES



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