ISSN 2007-9737

Medical Assistant: A Mobile Application for Medication Prescription

S. Pérez-Cáceres, A. Reyes-Ramírez, E. Morales-Mendoza, C. Rodríguez-Flores, N. Morales-Ramírez

Universidad Veracruzana, Facultad de Ingeniería en Electrónica y Comunicaciones, Poza Rica, Veracruz, Mexico

{sperez, efmorales, carodriguez}@uv.mx, {abner.reyes03,nayely0199}@gmail.com

Abstract. The use of a software application, designed to support medical specialists in the selection of the drug to be prescribed, is presented and evaluated. The “Medical Assistant” application evaluates the patient's data and through a decision tree, obtained from the administering of this data mining technique on the information of successful cases in the prescription of medicines, suggests the most appropriate medication according to the patient's data. In this initial version only the information of patients with Allergic Rhinitis was considered; Surveys were conducted to know the opinion of the specialists regarding the use of the application, which results revealed that specialists evaluated the use of the Medical Assistant in a range from regular to good.

Keywords. Data mining, allergic rhinitis, decision tree, prescription of drugs.

1 Introduction

The prescription of drugs to a patient is a process of vital importance for the health and integrity of the patient. Although it is known that every disease has a wide variety of medicines to be chosen from, which vary in its components, presentation and price, it is important to take them into account when starting medical treatment for a given disease.

The medical diagnosis is the procedure by which a disease can be identified. Interrogation is the first medical act that leads to a diagnosis. It is based on interpersonal contact, carried out by the patient who suffers and by the doctor who is trying to cure or alleviate his/her ailments. Some -points to keep in mind when making a query are the following [18:]

- Let the patient freely expose his/her discomfort.
- Intervention by the doctor with a hardly explicit patient.
- Listen carefully.
- Ask for family history in case the patient does not report it.

The so-called "clinical history" is generated through the examination process, which includes patient's information, such as: Name, age, sex, marital status, and occupation, among others. It is well known that there is a large amount of drugs for the treatment of every disease; this is where doctors face the selecting procedure of the existing medications for the disease they are trying to cure.

"Allergic Rhinitis" disease is presented here to exemplify this process. Rhinitis is defined as the inflammatory process of the nasal mucosa, which occur with two or more of the symptoms: nasal obstruction, nasal or nasopharyngeal pruritus, rhinorrhoea before or after and/or sneezing, for more than one hour or two or more consecutive days [3].

Allergic Rhinitis occurs when something that the person is allergic to, such as dust, dandruff, insect venom or pollen, is breathed [8].There are several procedures to diagnose a disease, one of which is presented in figure 1: After making the diagnosis, the medical specialist has a wide range of medicines, which are usually selected from according to their experience or the most commonly used ones in the market, some of which are shown in table 1. They are available in Mexico, some with other names (Source: Pharmacotherapeutic Follow-up Guide on Allergic Rhinitis. Baena, University of Granada, Spain). As in any treatment of diseases, it is always necessary to consider its cost, since its economic impact is substantial [12]. The cost of some medicines for

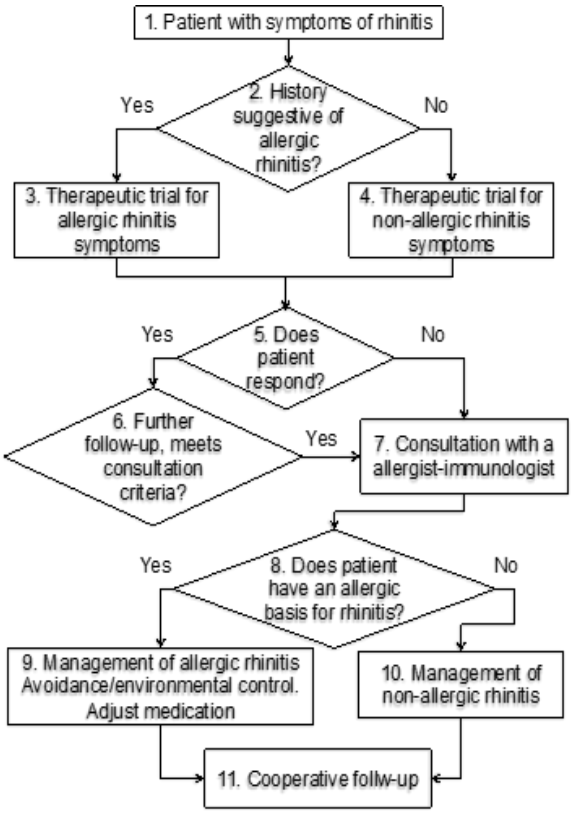

Fig. 1. Algorithm for the diagnosis of Allergic Rhinitis based on the patient's symptoms and allergic tests. Source: Journal of Allergy and Clinical Immunology (Wallace, 2008)

the treatment of Allergic Rhinitis is presented on table 2.Source: Consumer Reports 2014. Monthly costs reflect nationwide retail average prices for February 2013, rounded to the nearest dollar.

It can be deduced from the above information that the inadequate selection of the medicine for the treatment of Allergic Rhinitis, can cause some inconveniences, including economic ones, as seen on table 2, the medicine selection can vary from $18 to $201, hence the importance of succeeding in the first choice of the drug. As with this disease, there are others for which a variety of specialized medications for the treatment of symptoms are available.

This assertion is based on what the World Health Organization says in its Guide to Good Prescription: "Bad prescription habits are the source of ineffective and unsafe treatments, exacerbation or lengthening of the disease, stress and damage to the patient and of higher costs. They also contribute to the prescriber vulnerability to influences that can cause an irrational prescription, such as patient pressure, bad examples from other colleagues and information from laboratory representatives" [20].

In this sense, the National Consensus on Allergic Rhinitis in children [16] states "We must be careful when using first generation antihistamines sedating because they produce depression of the central nervous system with drowsiness and also a decrease in work and intellectual performance, which may further affect the quality of life" and concludes that the proportioned use of laboratory techniques for proper and rational treatment is indispensable to successful paediatric operation on children suffering from this disease.

In relation to this problem, applications to support medicines prescription, such as: Portable

Table 1. Medications for the treatment of allergic rhinitis

Non-sedating antihistamines	Sedative antihistamines
Acrivastine	Clemastine
Levocetirizine	Diphenhydramine
Cetirizine	Alimemazine
Ebastine	Promethazine
Fexofenadine	Oxatomide
Loratadine	Cyproheptadine
Mizolastine	Azatadine
Terfenadine	Triprolidine
Desloratadine	Dexchlorpheniramine
Rupatadine	
Mequitazine	

Drug Companion [13] have been developed (now featuring applications that check possible interactions between the drug-drug combinations, drug-herbs and drug-nutrient and makes cross-reference of patient's food or drug allergies to their current medications and foods); epocrates [4], which presents lists of possible drugs from diagnosis, verifies the possible reactions to the drugs combination and uses decision trees to suggest the drug from some patient data, but is not specific, for example, the Diabetes

Type Predictor TreeCalc only mentions insulin as a treatment for diabetes, when there are at least 20 types of insulin [2]; With some other applications, such as Figure 1 [6], it is possible to explore and discuss real clinical cases worldwide between professionals and students of health.Derived from the above, the following question is defined to guide the investigation: How can technology provide physicians with a support tool for the selection of the most appropriate medication?

To respond to this issue, it is proposed to generate a software tool that based on the information of the new patient and applying data mining techniques to a database of patients who have received successful treatment. The software selects the most appropriate medication to be prescribed to this new patient at the very first selection of the medicine, and therefore contribute to decrease both physical disorders, and the impact on the economy of the patient having to buy two, three or more drugs that ultimately will not use.

One of the techniques used in data mining is decision trees, which allows generating conditions for decision making.

A decision tree is a prediction model used in the field of artificial intelligence, presented through diagrams of logical constructs built from a database [14].

These diagrams represent a set of conditions organized in a hierarchical structure in such a way that the final decision to be made can be determined by following the conditions that are fulfilled from the root of the tree to some of its leaves and are especially appropriate to express medical, legal, commercial, strategic, mathematical and logical procedures [9].

The general objective of the data mining process [11] is to extract information from a data set and transform it into a comprehensible structure, discovering valuable results [15] and reducing costs by avoiding repeated errors [5]. Therefore, the information discovered must be presented in a comprehensible manner, for example, using graphs, rules in natural language or data visualization techniques [9].

20 surveys were applied to general practitioners, specialists and medical career students, in order to investigate the feasibility of carrying out the proposed tool in the medical community (75% mentioned that they had no knowledge of any computer tool). 65% mentioned that they would be willing to use an application and contribute to the creation of a database with the information of their patients and 80% would evaluate the application developed for the selection of medicines.

The design of the system will be based on software engineering [17], under the client-server model, where the client part will be performed by the mobile application that will be developed and implemented in the Android operating system, which will interact with the web server. The mobile application has been called "Medical Assistant", which in its first version will only consider the disease of Allergic Rhinitis.

2 Design of the Computer System

This system of drug selection is seen as a support tool for otorhinolaryngologists, and is not and

cannot be a replacement for such doctors. This system is available on devices with the Android operating system, in which users can generate a query about the medication for the patient. Among the possibilities of use of the system, users have the following options:

1. Consultation of medication. By entering the patient's data, the user can consult the system about the most appropriate medication based on the data previously entered.
2. Join the system. The system has a registration and login process for each of the doctors who use the system.

2.1 Conceptual Design

Using UML (Unified Modeling Language) [1], the use cases were represented, as well as the sequence diagrams for the processes "Start session", "Register user", "Consult" and "Close session"; figures 2 and 3 show the diagrams of the use case and the sequence for the "Consult" process.

Once the use cases of the system are established, the conceptual design of the system is followed; in figure 4 the process by which the client interacts with the server is presented, this shows of the information sent by the clients. Once the data are sent, the server receives them and includes them in the system database.

3 Materials and Methods

The computer system was implemented in the 19th version of the API of the Android operating system, which supports devices with versions of the Android system greater than version 4.4.4 (Kitkat). The decision tree that is used in the system is generated with the help of the Weka software. The storage part of the information of the consultations, the data of the patient, as well as the results of the medicines to be prescribed are stored in a database of Firebase [7], which acts as an unrelated database manager.

This system to achieve was developed following the client-server model. Figure 5 shows the architecture of the system, which has six layers of software to meet the fundamental requirements

Fig. 4. Conceptual design of the system for the selection of medicines

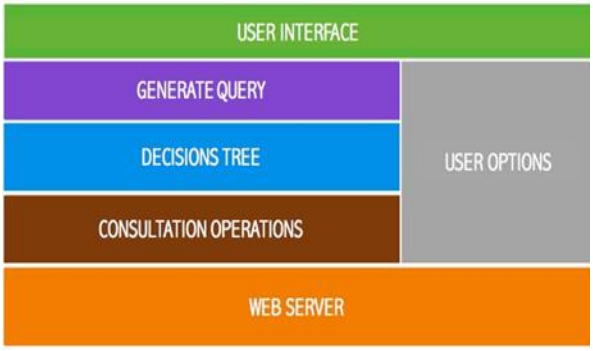

Fig. 5. Computational system architecture

of the system. The description of each one of the layers of the system is presented below:

Web server. This layer is responsible for the administration of the information that is presented, entered and stored in the computer system.

Consultation operations. The operations related to the query, update and saving of system data are managed in this layer.

User options. The user can have access to the different options presented by the system for the administration of his personal account here.

Decision tree. In this layer the system receives the patient data entered by the user which the tree uses to evaluate in order to identify and select the appropriate medication.

Generate query. Layer where the system receives the information from the patient which is processed and sent to the corresponding layer of the decision tree. User interface. This layer is the graphical interface where system users can enter patient data through a form.

3.1 Data Collection

The information used for the development of the application based on the decision tree was taken from a public database, which contains a total of 400 patient records to which a medication for the treatment of Allergic Rhinitis was successfully administered. The database contains the following patient data: age, sex, blood pressure, cholesterol, sodium, potassium and the medication prescribed successfully.

According to the information in the database shown in table 3, the frequency of success would indicate that, regularly, the specialist doctor prescribes the medicine "Y" to the new patient, since it has the highest frequency of success. However, this medication would not necessarily provide the best results for all new patients, as discussed above, the treatment may be ineffective, cause the disease to lengthen, cause tension and damage to the patient and even raise its own cost.

That justifies the importance of providing an option to the specialist doctor for the adequate administering of medications, according to the profile of the new patient and based on the success cases in the treatment of the disease.

To reach this goal, the database was subjected to a decision tree generation algorithm, Weka J48 [19], using a cross-validation of 10 folds. The result of the data processing is shown in Table 4.

The decision tree is presented in figure 6, which will be used in the Medical Assistant application to predict the medication to be prescribed to the new patient, depending on his/her data; the different trajectories of the tree indicate that any of the drugs A, B, C, X or Y can be administered.

3.2 Mobile Application Design

Once the project architecture was established, as well as the process of obtaining data, the next step was to develop the system in a mobile application. As shown in figure 7, the application consists of a form by means of which the specialist doctor enters the information of the new patients.

3.3 System Test Scenarios

In this scenario the system receives patient data: *name, age, sex, disease, blood pressure,*

```
K <= 0.050179
|   K <= 0.036393: drugY (108.0)
|   K > 0.036393
|   |   Na <= 0.672501
|   |   |   BP = HIGH
|   |   |   |   Age <= 47: drugA (7.0/1.0)
|   |   |   |   Age > 47: drugB (6.0)
|   |   |   BP = LOW
|   |   |   |   Cholesterol = HIGH: drugC (6.0)
|   |   |   |   Cholesterol = NORMAL
|   |   |   |   |   Na <= 0.614841: drugX (6.0)
|   |   |   |   |   Na > 0.614841: drugY (3.0/1.0)
|   |   |   BP = NORMAL: drugX (9.0)
|   |   Na > 0.672501: drugY (49.0/2.0)
K > 0.050179
|   BP = HIGH
|   |   Age <= 52
|   |   |   Na <= 0.847403: drugA (24.0)
|   |   |   Na > 0.847403
|   |   |   |   K <= 0.059023: drugY (4.0)
|   |   |   |   K > 0.059023: drugA (5.0)
|   |   Age > 52: drugB (25.0)
|   BP = LOW
|   |   Cholesterol = HIGH: drugC (40.0)
|   |   Cholesterol = NORMAL: drugX (36.0/2.0)
|   BP = NORMAL
|   |   Na <= 0.816508: drugX (54.0)
|   |   Na > 0.816508
|   |   |   K <= 0.057854: drugY (6.0)
|   |   |   K > 0.057854: drugX (12.0)
```

Fig. 6. Decision tree generated in Weka

Table 3. Frequencies of success in medications prescription

Prescribed medication	Success rate
Y	170
X	117
C	47
B	35
A	31
Total	400

Table 4. Results of classification using J48

Concept	Value
Number of Leaves	17
Size of the tree	31
Correctly Classified Instances	93%
Incorrectly Classified Instances	7%
Kappa statistic	0.9019
Mean absolute error	0.0315
Root mean squared error	0.1646

cholesterol, sodium and potassium, which are processed and sent to the decision tree to evaluate each of them within themselves and decide which medication is appropriate based on the input data.

Once the result is obtained, it is presented in the user interface to inform the specialist the result, which includes the name of the disease and the suggested medication to be prescribed, as shown in figure 8. As a result of the tests, the data and results for three patients are shown in table 5. It can be observed that for both patient 2, and patient 3, the results differ from the most frequent medication (see table 3).

It is convenient to point out that in this first version only the process for Allergic Rhinitis is included, but in the design it is foreseen the integration of processes for the suggestion of medicines for the treatment of other diseases into the application.

4 Evaluation

In order to evaluate the application, as well as its acceptance among the population of otorhinolaryngologists, we performed the approach that it is described in sections 4.1 to 4.4.

4.1 Research Design

The quantitative approach was selected, since the data collection based on the measurement and analysis was proposed to test the hypothesis. The non-experimental exploratory design was selected, among which are opinion polls or surveys [10].

4.2 Participants

According to the National Institute of Statistics and Geography, in 2011 a total of 624 people who were part of the medical staff worked in the municipality of Poza Rica de Hidalgo, Veracruz. Within this population, the population of otorhinolaryngologists was searched, and ten were found. Proportional sampling for this population with a probability of 95% yielded a sample size of 4 specialists.

For its application, each of the otorhinolaryngologists was contacted, but only 4 of

Table 2. Antihistamines: Medicines Comparison Chart

Generic Name & Strength	Brand Name	Average Cost per Month
Desloratadine tablet 5 mg	Clarinex	$201
Desloratadine tablet 5 mg	Generic	$97
Fexofenadine tablet 180 mg	Allegra	$24
Fexofenadine tablet 180 mg	Generic	$18
Levocetirizine tablet 5 mg	Xyzal	$119
Levocetirizine tablet 5 mg	Generic	$59

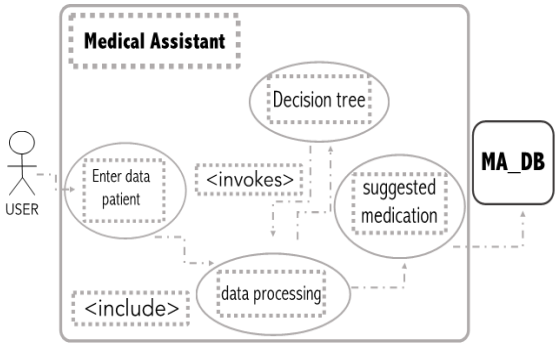

Fig. 2. Use case diagram for "Consult"

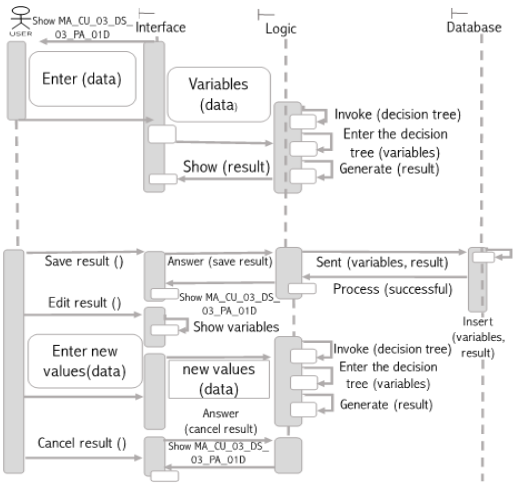

Fig. 3. Sequence diagram for "Consult" use case

the 10 accepted the interview, the rest did not participate for different reasons, among which are: lack of disposition, it was not possible to locate them and no availability of time.

4.3 Variables and Hypotheses

The variables selected to evaluate the application were the following:

Evaluation: The aim is to measure the evaluation given by the doctors to the Medical Assistant application in terms of the process performance of this application to select the most appropriate medication according to the patient's data. This variable will be measured in the following ranges: bad, good, regular, or excellent.

Acceptance: It is intended to measure the acceptance of the development of the Medical Assistant application. Here physicians will be questioned if they would be willing to use the application to prescribe medication. This variable will be measured with the following acceptance ranges: nothing, very little, little, or much.

The hypothesis proposed was the following:

"The Medical Assistant application provides physicians with a tool for the most appropriate prescription of the medication based on patient's data."

4.4 Administering of the Evaluation Instrument

Before the administering of the survey, the project, the software proposal that was made and its operation was presented to each of the doctors describing the problem by which the research was carried out. At the end of the presentation, the survey was applied.

The results obtained from the administering of the survey were organized graphically, as shown in figure 9. According to the results, 75% of the respondents found the process of drug selection proposed by the Medical Assistant system, “regular”. While 25% of respondents considered it “good”. It is worth mentioning that the parameters used to measure the evaluation of the system were the following: bad, regular, good, and excellent.

About the acceptance of the system it was found that 25% of the respondents consider that they would not be willing to use the Medical

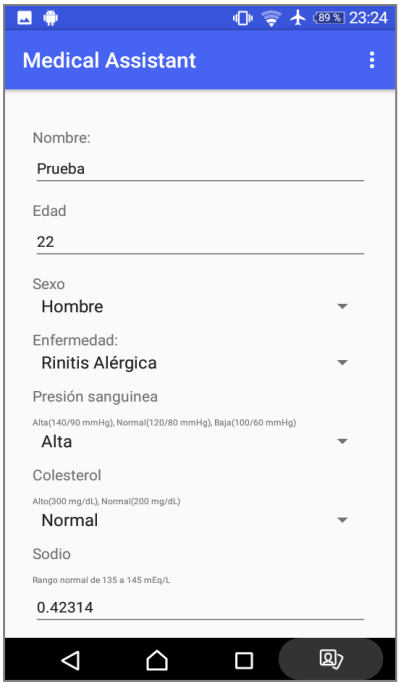

Fig. 7. Patient data entry form

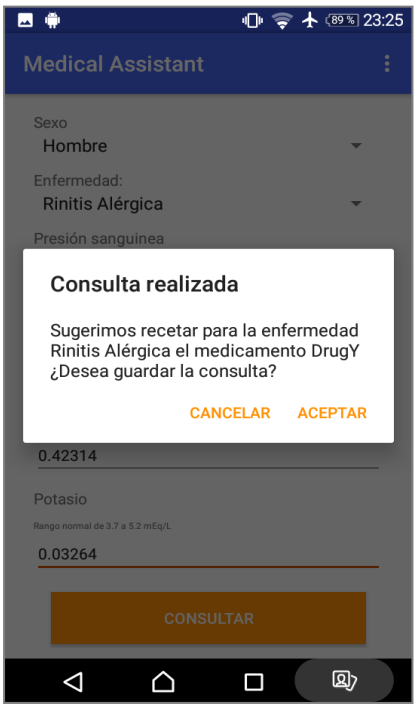

Fig. 8. System response using the decision tree

Table 5. Medical Assistant system testing

Patient's data	1	2	3
Name	Patient 1	Patient 2	Patient 3
Age	22	25	52
Sex	Man	Women	Man
Disease	Allergic Rhinitis	Allergic Rhinitis	Allergic Rhinitis
Blood pressure	High	Low	Low
Cholesterol	Normal	Normal	High
Sodium	0.42314	0.672501	0.614841
Potassium	0.03264	0.052000	0.053050
Suggestion	DrugY	DrugX	DrgC

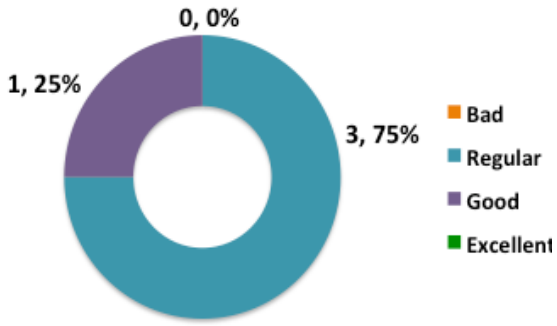

Fig. 9. Evaluation of the Medical Assistant system

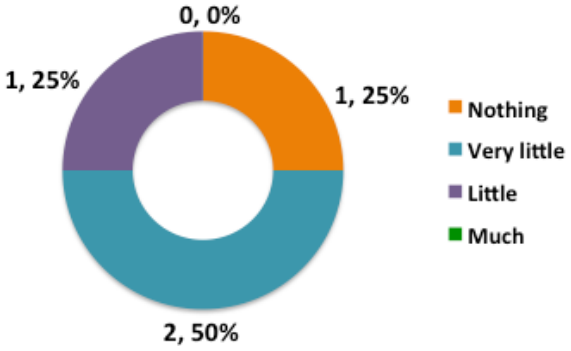

Fig. 10. Acceptance of the Medical Assistant system

Assistant application to prescribe medicines to their patients. However, 75% of the respondents mention that their willingness to use the Medical Assistant system to prescribe medication would be little or very little (fig. 10). It is worth mentioning that the parameters used to evaluate the acceptance of the system are the following: nothing, very little, little, and much.

It is important to mention that in the interview with the specialists they stated that one of the reasons why they evaluated the Application in that way was because of the characteristics of the patients that were selected to integrate the database, and pointed out that it is necessary to include some other symptoms, to have more elements that lead to a prescription of the right medication.

5 Conclusions

According to the results, the Medical Assistant application is a tool that helps physicians in the selection process of the medication to be prescribed, considering it as an adequate tool, which responds to the research question.

This application was a first approximation to the solution, which is why it is necessary to improve its processes by considering some data that provide more precise elements for prescribing medications based on the patient's profile, as well as the integration of a database with greater number of successful cases in the use of medications for different chronic diseases.

Acknowledgments

This work has been supported by the Faculty of Engineering in Electronics and Communications of the U.V. and the otorhinolaryngologists of the City of Poza Rica, Veracruz, Mexico.

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Article received on 12/05/2018; accepted on 15/07/2018.
Corresponding author is S. Pérez-Cáceres.