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Original Article

Implementation of a Web-Based Expert System Model for Detecting Urinary Tract Infections

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Abstract *- Different information systems have been developed for different purposes, especially in the health field. Many diseases are known locally and worldwide; however, the specificity of the research is based on urinary infections that occur constantly in different patients of all ages. To avoid the collapse of the high demand for patients in public health centres, an expert web system has been implemented to predict urological infections using the programming language SWI-PROLOG to diagnose these urinary infections, and this predicts what type of urinary infection the patient who uses it has through its symptoms. In this research, the Buchanan methodology was used, which consists of 4 phases that allowed the development of each phase to implement the web expert system. To validate the system, a survey of users - patients who use the system - was carried out with a questionnaire of 15 questions grouped into 3 dimensions, the result of which was an acceptance rate of 90%. In conclusion, this web expert system has been developed successfully, benefiting many people with the problem of long waiting times in health centres and preventing and providing the appropriate treatment to patients.*

Keywords *- Buchanan Methodology, Expert web system, Health centre, Treatment, Urinary tract infections.*

1. Introduction

Today, the use of mobile applications has generated a high impact on society. Different developments based on apps are launched to the market continuously. However, few applications have been reflected in the medical field, especially in the speciality of urology; urological diseases are a great source of information because certain anomalies related to the urinary system in both men and women are affected by such diseases.

Expert systems based on artificial intelligence have the function of solving problems as a human being would do, looking for a way to solve it with a reasoning simulatable to that of a human being [1]. Software using expert systems is based on training models and automatic learning by applying rules to process knowledge correctly, opting for algorithms capable of making decisions as a thinking human being would. The applications implemented with expert systems are used in the health field due to the fact that the experts, who are the doctors, offer accessible knowledge to the users through these systems in the diagnosis of dangerous diseases for human beings [2]. ICTs offer a high percentage of use in individuals participating in society; in the field of medicine, diagnosed diseases are predicted thanks to technological advances. According to the advances that occur with the passage of time in medicine has been implemented certain AI algorithms. In the field of urology, research has been carried out on the prognosis and diagnosis of urological diseases, analyzing clinical data on certain diseases and classifying them according to their dangerousness [3]. Urinary tract infections are also a major health problem in urology. They are very common in urinary tract diseases, as expert systems are used to detect and diagnose certain infections caused by microbes [4].

Urinary Tract Infections (UTIs) are a major health problem worldwide, and the urology speciality generates great demand in patients with this problem; however, we are talking about detecting urological infections using expert systems through AI.

Diagnosing certain urinary tract infections goes hand in hand with numerous urine tests located in healthcare facilities to determine certain infectious agents that cause certain infections. With the use of artificial intelligence using Natural Language Processing (NLP) was used for the purpose of large-scale pathogen identification, for which the results found that 84% of patients stored 2 or more pathogens in females, and NLP showed 97% had fewer. One pathogen demonstrated that the study gave good diagnoses in both females and males [5]. Chronic kidney diseases are associated with renal failure; in

this procedure, the expert systems influenced as assistants and helpers based on an interactive graphical interface for the patients in order for the system to diagnose certain anomalies of the patients and to assist as a physician based on established rules. Patients from various districts of Lima and the province with different health cases come daily, causing the service to collapse and causing discomfort to waiting patients [6]. According to some research, a web expert system can make accurate diagnoses of various health diseases; the predictions made by these systems have the ability to diagnose accurately according to the information that is introduced to the system to perform its work [7].

The analysis of urological diseases reduced the risk of urinary tract diseases by 27%, with prostate cancer accounting for 30% and other diseases such as incontinence in women and erectile dysfunction by 41% in the urology department [8].

2. Literature Review

2.1. Related Work

In the course of time, computer sciences have evolved over the years; one of the most common technologies growing is artificial intelligence, which has as a strength the contribution to health sciences. A clear example is the contribution to prostate cancer in men, especially to detecting more accurate diagnoses when implementing expert systems [9]. The large amount of clinical data in healthcare facilities is becoming increasingly tedious for a skilled clinician to manage the data and provide appropriate treatments for patients using Machine Learning (ML) to create algorithms to predict outcomes for patient users [10].

On the other hand, the research aims to provide a repeatability analysis for radiomics derived from prostate DWI by implementing Machine Learning for prostate cancer features. For this research, a total of 112 patients were diagnosed with the disease and underwent two prostate MRI scans (Scan1 and Scan2) [11].

In that sense, decision-making about infectious urinary tract stones has been shown to be a serious complication in the diagnosis of stones, which is why, in view of this problem, it was proposed to be developed [12]. In this research, we talk about the benefits of artificial intelligence but focus on what it is. Machine Learning, as this technology, offers different means by which positive results can be obtained for problems in the field of health [13].

According to doctors who have used this technology, the research aims to introduce the concept of a Machine Learning (ML) system because the prediction of the results lacks transparency. Therefore, the objective of this research is to use different ML-based classification models to make accurate predictions about urinary tract infections in men with prostate cancer by testing over the course of 1 to 2 years of treatment and analyzing their accuracy and explainability [14]. For urologists, videourodynamics is important in identifying patients with neurogenic bladder anomalies resulting in upper urinary tract injury. Therefore, this research aims to use a Deep Learning technology-oriented model of video-urodynamic study models to analyze bladder severity. The materials and methods used for this research are based on a cross-sectional model study with patients aged 2 months to 28 years with spina bifida analyzed with videourodynamic technology [15]. The topic is the application of a machine learning algorithm to assess Detrusor Overactivity (DO) for Urodynamic Studies (UDS) with spina bifida. For this purpose, in paediatric urology, between May 2012 and September 2020, an orientation related to machine learning was constituted by applying data windowing, dimensionality reduction and vector machine [16].

According to the study on Overactive Bladder (OAB), which affects the lives of patients who contract this disease, takes into account the mental health of patients who contract this anomaly; in order to find an efficient solution to this problem, they seek to relate the treatment of this disease to urinary microecology [17]. The present research takes as a concept that the efficiency of the treatment suggested by the experts goes hand in hand with its diversity and microbial composition. Machine Learning based algorithms were used to create predictive models to obtain results in terms of the treatment of OAB related to urinary microbiota. This article discusses the interstitial disease Hunner cystitis (ICH), which has pelvic pain symptoms, interrupted urine storage, or Hunner's lesions on cystoscopy. For the research presentation, we use Machine Learning dominated CIBERSORT programs to obtain the measurement of immune cell subset infiltration and possible biomarkers for ICH [18].

2.2 Theoretical Basis

2.2.1. Web System

Web software systems are programme hosted on the internet by means of a hosting and identified with a peculiar URL; the main advantage of web systems is the ease of use without the need to install the created programme [19]. According to other authors, a web system or web application is a computer programme that is hosted on the network or locally on a desktop computer, with a user-friendly interface and is easy to use as it can be executed in different web browsers [20].

2.2.2. Features of a Web Application

One of the basic characteristics of a web application is that it uses the client-server model, i.e. the user makes a request through the web system components, which performs a programmed query on the server and returns a response to the interface with the answer [21] Figure 1 shows how a client-server system model for web pages works and how a request is made to a database.

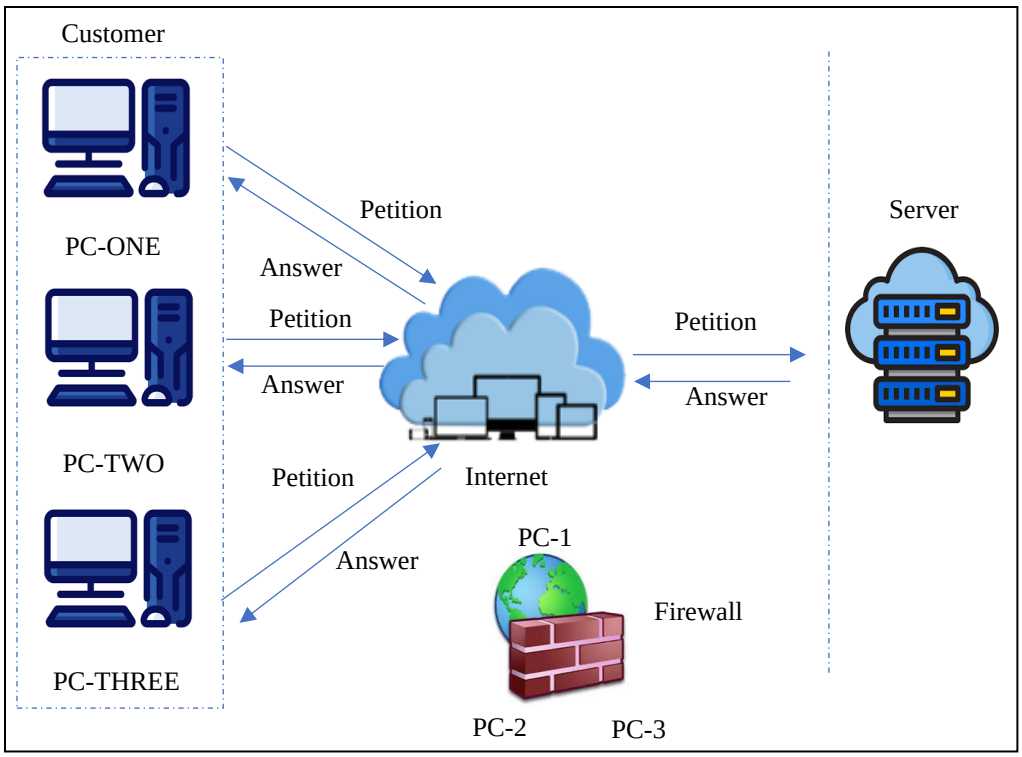

Fig. 1 Client-Server

2.2.3. Object–Oriented Programming

This classification of programming offers the ability to read a more orderly and understandable code for programmers among other advantages is the easy reuse of the same code in other development processes; many programming languages follow these rules either in the development environment, among them are Smaltalk, C++, Java, PHP and others available on the market [22].

Classes

Within the classes, different types of codes fulfil certain functions, such as objects, which have properties called attributes. Another important component of the classes is the methods in which the functions of the objects are managed; a class can call the methods and objects of another class to reuse them by a means called instance [23].

Constructors

A constructor refers to a method that is executed automatically when an object is created; if it does not exist, the default constructor is created on the other hand. However, if this constructor is not implemented, a constructor is created for the class with characteristics created by the programmer [24].

Potting

Encapsulation is the hiding of certain attributes of the objects and the functionality of the methods inside them; the essential of Encapsulation is to hide the information and give certain restrictions to access the hidden information; for this, different reserved words are used [25].

Polymorphism

Polymorphism is the ability of certain programming languages to invoke different methods from different objects.

Inheritance

Inheritance is the action of inheriting characteristics and behaviours (methods and attributes) from another class called the parent class to use them in another class, executing the same actions, reusing other derived classes, and even changing the behaviour of those inherited classes; it also allows the definition of new objects from other classes for this to happen both classes must have certain similarities in their attributes and methods to perform a certain task. [26].

2.2.4. Programming Languages

For the development of web applications, HTML tag codes are introduced, which are used to realize the structure of a web page, taking into account HTML tags to realize an orderly website structure, while CSS allows adding the design to the web pages, creating user-friendly content. Current JavaScript, to give dynamism to the content, also acts as a mediator to send data through XMLHttpRequest code or other APIS that perform this task to send data from the FrontEnd to the BackEnd. These are processed and receive the response from the server. This programming language acts on the server side, with the main task of performing queries to a database management system through this language, supporting big

data and performing queries displayed in the web application interface. This programming language acts on the server side to create queries that allow interaction with the database through this language, supporting most of the major databases and performing queries displayed in the web application interface.

2.2.5. Security Mechanisms

SQL injection attacks are malicious attacks that affect the processes of the database management system concerning a computer programme by breaching the data by means of certain tricks in the URL or introducing certain insecure malicious codes [27]. Security mechanisms take into account the communication between the client and the server to exchange information; for this purpose, codes are used to manage sessions and give certain permissions to users or administrators [28].

2.2.6. Expert System

Definition of Expert System

The field of Artificial Intelligence (AI) has many derived disciplines, one of them being expert systems that are oriented towards the analysis of human expert knowledge transferred to machines [29]. According to another definition, an expert system is defined as an intelligent computer programme that uses knowledge and inference processes with the ability to solve complicated problems by emulating the decision-making capacity of an expert specialist [30].

Decision Tree Algorithms

One of the best-known algorithms in expert systems is decision trees because they are used to solve classification problems, easily giving results [31].

Algoritmos K Vecinos Más Cercanos

This algorithm aims to give a classification of an unknown object to its nearest neighbour class according to its distance by using the knowledge stored in the training model to determine which class belongs to the sample, taking into account the nearest neighbour [32].

2.2.7. Types of Expert Systems

Bayesian Networks

Bayesian networks are used to calculate a posteriori probabilistic data when there is little data on the subject; however, when there is a large amount of information, which is always the case, methods of propagation of evidence or uncertainty are required [33].

Determinists

They are mostly rule-based systems, solving deterministic problems expressed in certain rules by drawing conclusions through logical reasoning [34].

Stochastics

Stochastic ES are probability-oriented, i.e. they aim to solve problems of a stochastic nature which require the introduction of certain means of determining uncertainty.

Figure 2 shows the architecture of an expert system with all the components that communicate with each other to perform the prediction process.

2.2.8. Urinary System

Infections

Infections represent those phenomena characterized by microbial presence, giving rise to an inflammatory response of sterile host tissues by microorganisms [35].

Urinary Tract Infections

Infections represent those phenomena characterized by microbial presence, giving rise to an inflammatory response of sterile host tissues by microorganisms [36].

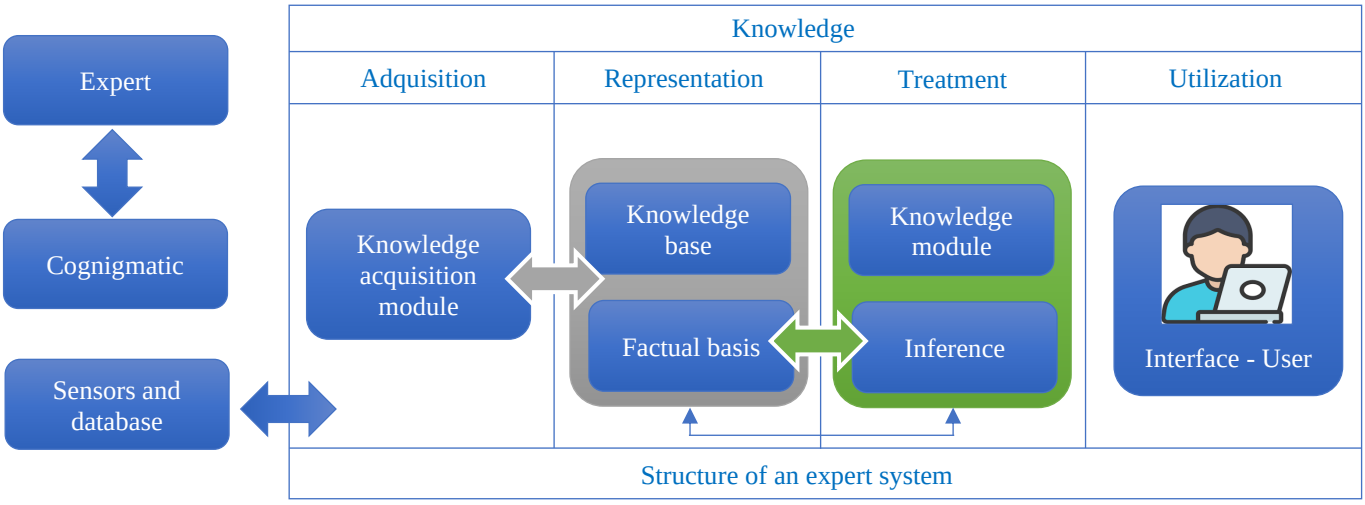

Fig. 2 Expert system

Types of Urinary Tract Infections

a) Urethritis

Urethritis is an inflammatory symptom of the distal urethra; this disease is differentiated between acute and chronic. An important fact is that this anomaly should be considered a sexually transmitted disease; in that sense, the specific clinical picture of this disease has characteristic dysuria of varying degrees of intensity, spontaneous urethral pain and urethral discharge associated with symptoms [37].

b) Prostate Cancer

It is a disease where certain regular inflammations generated in the prostate are detected; according to the symptom duration, it is classified as acute bacterial prostatitis or chronic if these symptoms persist for at least 3 months in complicated symptoms.

The most common symptoms of this disease occur in various parts of the urinary system, and this disease commonly manifests itself in men; the reference on chronic prostatic inflammation leads to prostate cancer if not treated in time to perform different studies such as quantum cultures of bacteriological location, microscopic examinations of urine and prostatic secretion squeezed [38].

c) Bacterial Vaginosis

Bacterial vaginosis is classified as a superficial infection of the vagina, the main cause being the spread of anaerobic flora without the need for inflammation. This disease is caused by the excessive proliferation of different types of bacteria; in that sense, the cause of the excessive proliferation of bacteria in the woman's intimate parts is unknown. That is why the main cases of this disease have been detected in women with recurrent sexual activity or homosexual relations that lead to contracting the disease [39].

d) Pyonephrosis

This anomaly is an infection located in the kidneys causing a persistent dilatation of the kidney due to different consequences, either due to stones, tumours or other complications of pyelonephritis.

The most common microorganism in these diseases is Escherichia coli, which is why 15% of patients who contract this disease are patients with known urinary tract obstructions accompanied by fever and flank pain [40].

Diagnostic Tests

Also, tests such as leukocyte esterase are related to 80%, and microscopic investigation of urine tests aims to find certain bacteriological leukocytes [41]. On the other hand, the tests performed on patients who have symptoms of urinary tract infections will depend on the area of discomfort where the infection is present; some tests are shown below [42].

a) Antibiotic Therapy

Adequate treatment for uncomplicated urinary tract infections is the first treatment choice[43].

- Nitrofurantoin for 5 days
- Trimethoprim-sulfamethoxazole for 3 days (taking into account local resistance of no more than 20% of bacteria sensitive to this drug).
- Fosfomycin-tromethamine: 3 grams as a single dose in the evening and when the bladder is empty.
- Fluoroquinolones: Due to their side effects, they should be considered an alternative to beta-lactams.

Figure 3 shows an image of the anatomy of a male urinary system, in which the different organs can be seen, each of which has a specific function to carry out its function as a whole, which is to expel toxic waste found in the urine.

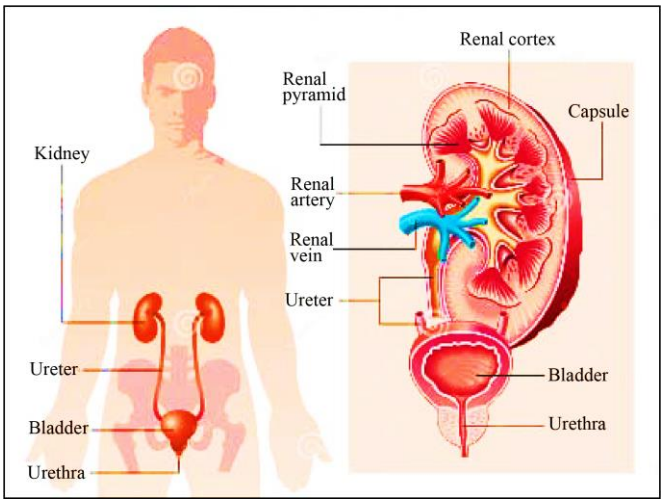

Fig. 3 Male urinary system

3. Methodology

3.1. Definition of the Buchanan Methodology

The Buchanan methodology consists of a procedure-oriented cascade life cycle of software engineering, thus ensuring that the construction of the development of an expert system is carried out according to the required procedures, making constant revisions according to its different phases in a hierarchical manner. On the other hand, according to the author, the Buchanan methodology consists of four important stages in which it is applied to Software Engineering applied to expert systems with rules and identification of stages for the construction of the expert system.

This methodology was integrated by Bruce G. Buchanan, whereby the main characteristic of this methodology is certain relationships that exist between the knowledge engineer and the human expert based on the knowledge itself, as shown in Figure 4 about the stages of the Buchanan methodology for consolidating information into an expert system.

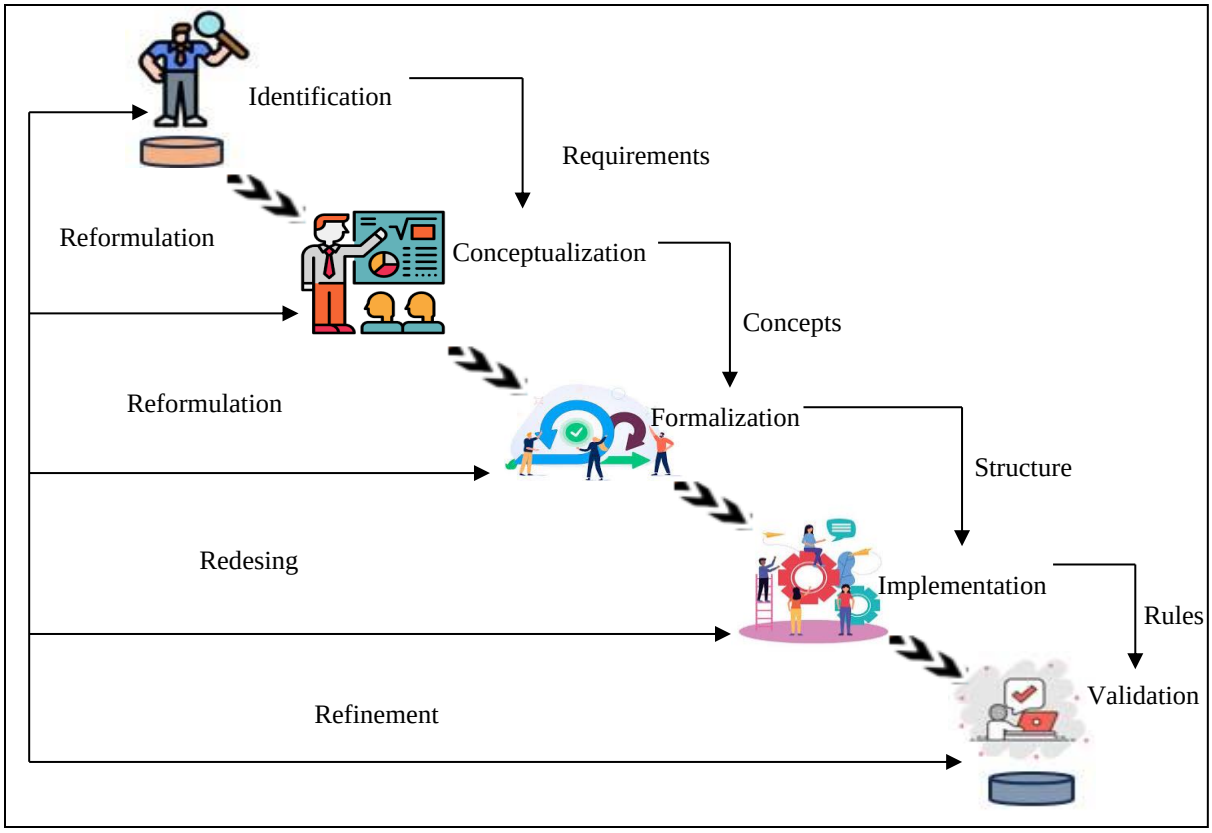

Fig. 4 Buchanan methodology

3.1.1. Identification

In this phase, different aspects are recognized in order to detect the particularities of the problem proposed for its solution; for this purpose, different parameters are included, such as the participants in the project as domain experts, knowledge engineers and future users who will use the system, as another important parameter are the characteristics of the problem where the available resources are taken into account including sources of knowledge, computational facilities, development time, financing among others, and finally the goals to be achieved based on formalizing the expert's knowledge, distribution of experience, help in the formation of new expert systems among others.

Phases of the Buchanan Methodology

In this first stage of the Buchanan methodology, certain important points of the identification stage will be determined, such as the clear and concise presentation of the problem to be investigated and giving clear references to familiarise ourselves with the business domain. Finally, the following will be developed that will act in the approach of the solution to the problem.

a) Problem

The problem in the investigation indicates the lack of a system to identify urological diseases in the urology speciality of the existing hospitals in our country, also complicated by the high demand that exists in the different health centres that force patients who are waiting for their appointment.

b) Solution

Implement a web-based expert system to identify urological diseases in patients in relation to the patient's presenting symptoms and other factors that facilitate the identification of the disease.

c) Reliable Sources of Information

The main lists of information will be consulted and will be sources of articles, books and theses that will provide us with concise information on the methodology used for this purpose.

Familiarization with the Domain

The project's domain is based on a set of rules expressed in an expert system for diagnosing urinary tract infections based on algorithms used by expert systems to make predictions about the disease.

In that sense, to begin with, the facts are acquired by the user, i.e. the information provided by the user, and then a strategy for identifying the preceding disease is followed.

Table 1. System activities

NRO	Person	Activity	System Response
A001	Patient	Allow the user to place the symptoms of the urological disease he/she suffers from in the system.	The system receives the necessary information from the symptoms.
A002	Patient	Provide results based on the diagnosis previously entered by the user-patient.	The system proceeds to give a concrete result on the information received from the user-patient.
A003	Patient	The system will provide recommendations on disease that has preceded the system with the information obtained.	The recommendations are based on certain criteria entered for each disease in the knowledge base.

Table 1 shows the main actor, which in this case is the patient who will use the system by listing the activities and answers the expert system will give him/her.

3.1.2. Conceptualization

According to the conceptualization phase, a precise knowledge organization according to a conceptual scheme is sought. This is why the expert who provides information about the subject matter and the knowledge engineer try to find concepts representative of the expert's knowledge. The work of both parties seeks to represent the flow of information during the process of solving the given problem. Table 2 shows some organs of the urinary system and the symptoms that occur in each urinary organ to contract a urinary tract infection.

3.1.3. Formalization

The formalization process is based on the translation of the key concepts, subproblems and the characteristics of the information obtained previously identified in previous phases represented in knowledge engineering tools or schemes; therefore, the formalization phase seeks to extract the knowledge considering consistent physical support to the information obtained in the identification and conceptualization process as shown in Figure 5, which deals with the components that will participate in the proposed system, are reflected in two sub-systems that belong to the expert system in general.

Table 2. Classification of symptoms related to urinary tract infections

Affected organ of the track urinarias	Signs and symptoms
Kidneys	Back or side pain
	High fever
	Shivering and shivering
	Nausea
	Vomiting
Bladder	Pressure on the pelvis
	Discomfort in the lower abdomen
	Micciones frecuentes y dolorosas
	Blood in urine
Urethra	Burning sensation in the urine
	Secretions

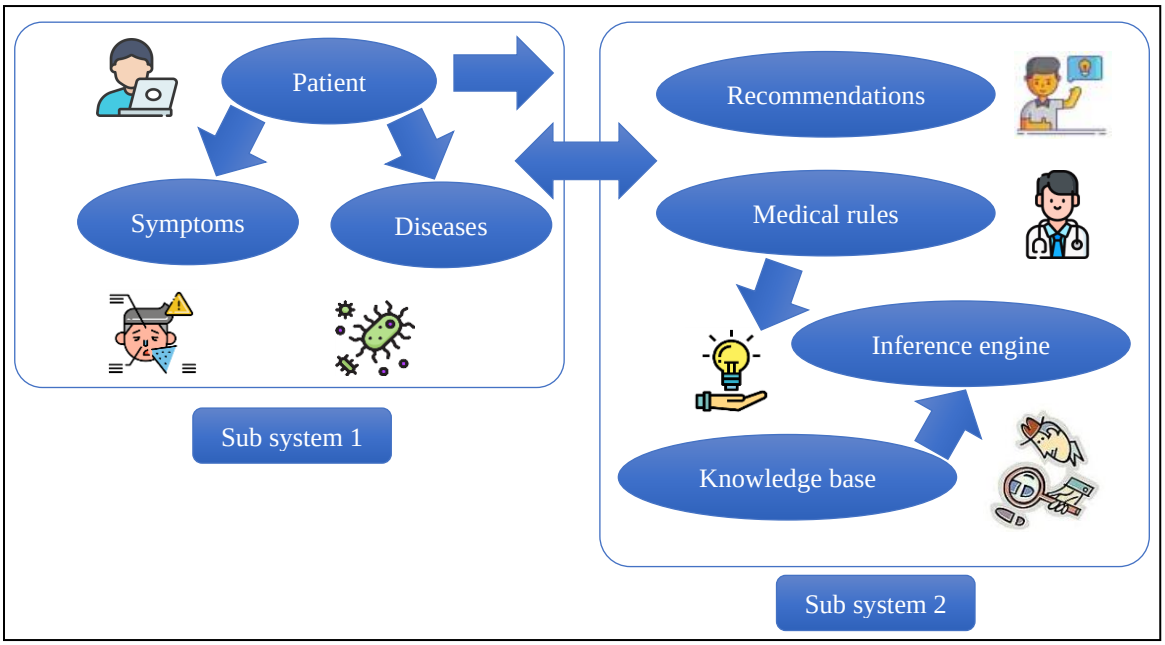

Fig. 5 Key components

- Patient: A person seeking medical consultation or advice from an expert urologist about the urinary tract infection he/she can get.
- Symptoms: Those complaints that patients have about a particular urinary tract infection.
- Diseases: List of possible urinary tract infections that trigger symptoms leading to disease.
- Medical Rules: Expert knowledge of the relationship between symptoms and diseases.
- Knowledge Base: Storage of medical information and symptom rules.
- Inference Engine: A logical model that allows reasoning used to infer diseases based on patients' symptoms.
- Medical Recommendations: Advice or suggestions proposed by the medical expert in an expert system suggested for diagnosis and treatment.

Definition of Formal Language

For the conceptualization of the processes of the expert system, different tools will be used to consolidate the information about the business, such as BPN Bizzagi Modeler to create the activities to be carried out, and also for the different diagrams, such as class diagrams, The IBM Rational Software Architect tool and programming languages such as HTML, CSS and JAVASCRIPT are used for the system design (Front-end) and PHP for the business logic (Back-end). Finally, for the prototyping of the system, the Figma tool is used to visualize the appearance and functionality of the system without the need to program it.

Factual Basis

Rules associated with the diseases described in the diagnosis and treatment of urological infections presented earlier in the conceptualization stage are shown according to the parameters that will be requested by the patient using the system.

H1. The patient presents with pain during urination and often for 3 to 4 days after symptom onset.

H2. If the patient develops a fever and pain in the abdominal area, he/she has the symptoms of an upper urinary tract infection, such as pyelonephritis.

H3. Sometimes, the patient experiences painful urination and cloudy urine when urinating, as a result of which he or she may have a urinary tract infection with the presence of bacterial microorganisms in the urinary tract.

H4. In females, if the patient has tenderness in the genital intimate areas or unpleasant pain during urination, then she may have a urinary tract infection due to cystitis.

H5. Suppose the patient has previously had recurrent urinary tract infections and flank or lower back pain. In that case, it means he/she may have a chronic urinary tract infection or recurrent kidney infection.

H6. If the male patient experiences difficulty urinating, pain in the genital area and fever, he may have a complicated urinary tract infection, such as prostatitis.

H7. If the patient has lower back pain and a high fever, consider the possibility of a kidney infection, such as acute pyelonephritis.

H8. If the patient has diabetes and presents with urinary symptoms such as increased thirst, frequent urination and fatigue, the possibility of a urinary tract infection associated with diabetes should be considered.

H9. If the patient has recently used a urinary catheter and presents with fever, chills and discomfort in the catheter area, a catheter-associated urinary tract infection (CA-UTI) should be considered.

H10. Suppose the patient has a history of kidney stones and presents with severe lower back pain and blood in the urine. In that case, the possibility of a urinary tract infection complicated by the presence of kidney stones should be considered.

H11. If the patient has recently been treated with broad-spectrum antibiotics and has persistent symptoms of urinary tract infection, the possibility of antibiotic-resistant urinary tract infection should be considered.

H12. If the patient has a history of chronic kidney disease and presents with fever, malaise and changes in micturition patterns, a possible complicated urinary tract infection should be considered in the context of kidney disease.

H13. Urinary tract infections in pregnant women are recurrent infections that can be diagnosed in the first trimester by developing symptomatic infections.

H14. During sexual activity, there is a risk of the penis entering the vaginal opening and colonizing the woman's private parts, causing cystitis.

H15. Experts believe that during sexual intercourse, the vagina is prone to physical trauma to the female urethral tract, weakening it to allow pathogenic microorganisms such as Escherichia coli to enter.

H16. Contraceptive drugs made up of hormones to prevent pregnancy and aimed at delaying the menstrual cycle result in the weakening of the bladder mucosa, which allows the entry of new bacterial microorganisms, such as Escherichia coli, causing repeated urinary tract infections or cystitis.

H17. Inadequate hygiene in women or men after sexual intercourse leads to urinary tract infections.

Table 3 shows the risk factors, the number of people surveyed and the percentage of the risk that creates danger for different people.

3.1.4. Implementation

The implementation phase consists of proposing rules and control structures to represent the knowledge obtained in previous phases, for which the result is reflected in a prototype that gives us the idea of checking whether the knowledge that the expert has investigated during the process has been conceptualized, as shown in Figure 6, which is intended to show the actors and components that participate in the consolidation of an expert system and its operation.

Table 3. Risk factors in UTI patients

RISK FACTORS	TOTAL	
	n	%
Use of disposable butts	34	40
Non-exclusive breastfeeding	31	36,5
Inadequate genital grooming	30	35,3
Constipation	16	18,8
Immersion baths	3	3,5
Low birth weight	2	2,4
Unprotected sex	2	2,4
Anatomical and functional alterations	1	1,2

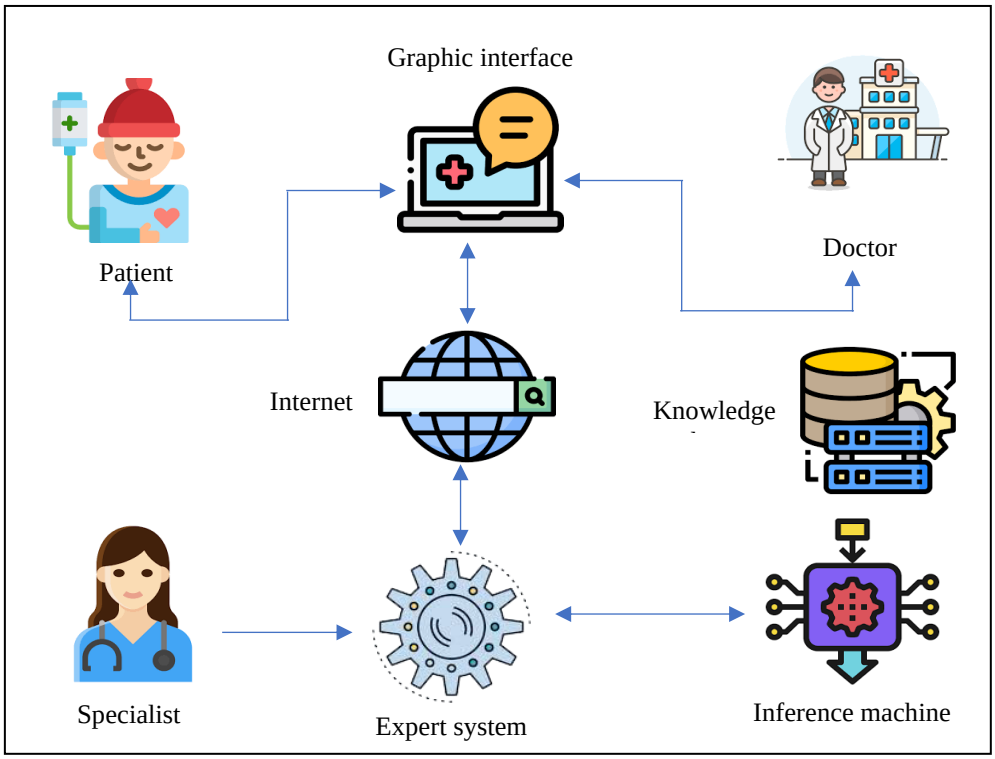

Fig. 6 Operation of an expert system

System Modelling

In this section, the different diagrams used for the analysis of the expert system are made, with the aim of consolidating all the information gathered in previous stages and verifying that all the procedures established by the patients who will use the system are complied with, thus gaining significant acceptance by the users.

Figure 7 shows the activity diagram of the system consisting of the actors and the functions performed by each actor in the operation of the expert system from its inception to the final use of the system.

Figure 8 shows the consolidation of the use case analysis, the interaction between a patient and the system, and each activity performed by each actor.

Table 4 shows about the problem we want to solve by implementing an expert web system; it serves as a reference to know about the problem.

Table 5 refers to the entities - objects and the requirements for each object that must be managed by the object in order for it to interact with the system.

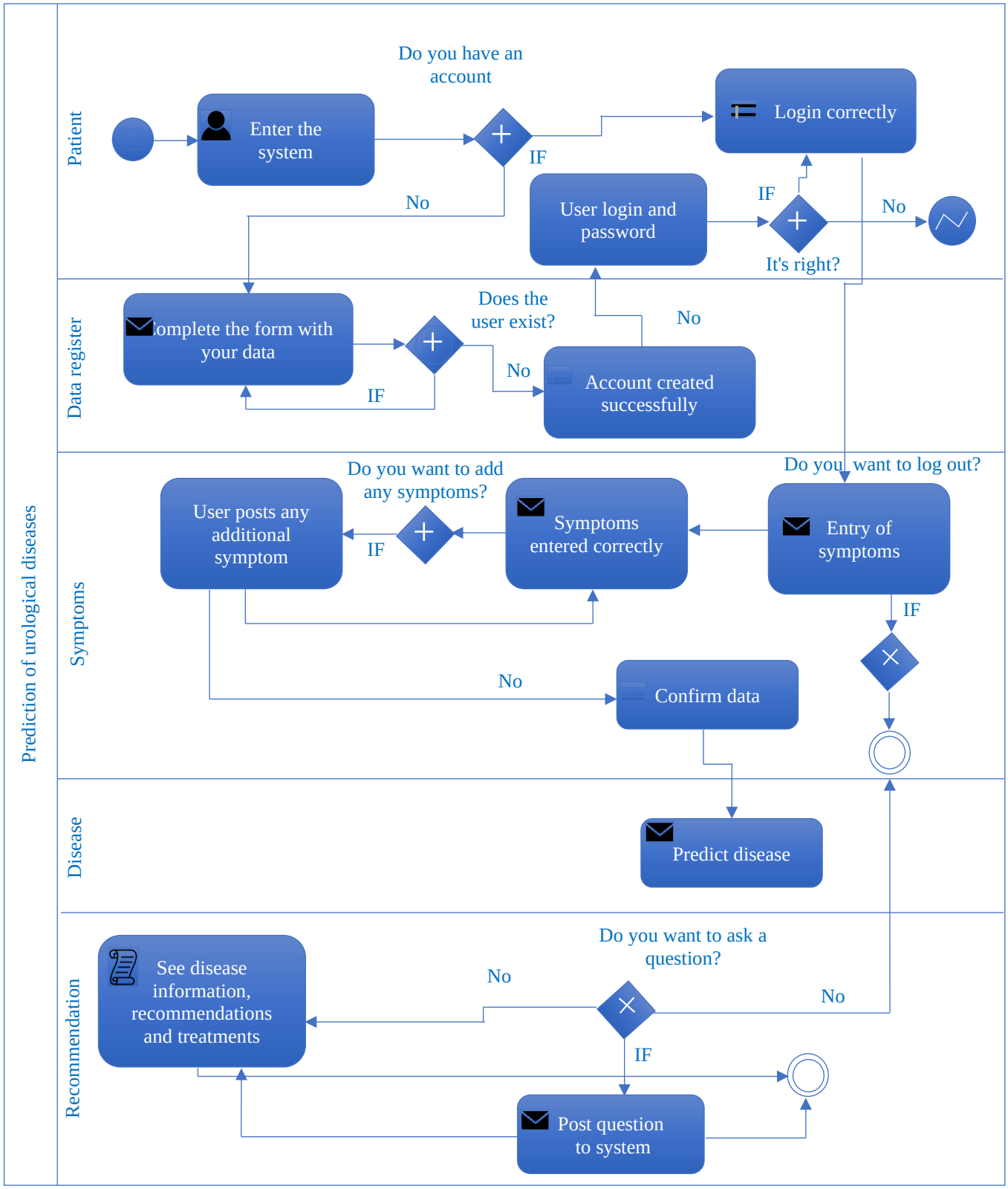

Fig. 7 Diagram of activities

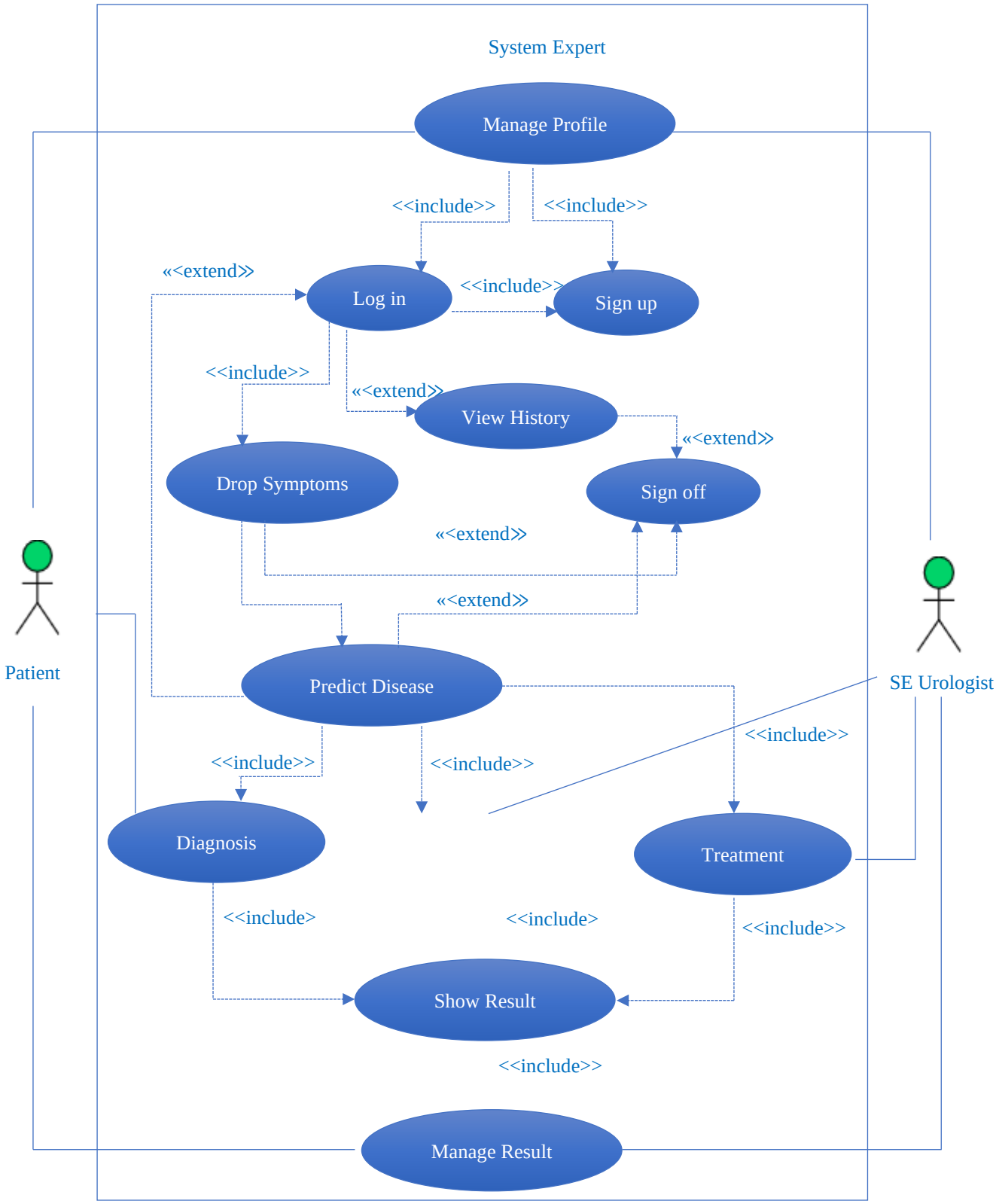

Fig. 8 Use case diagram

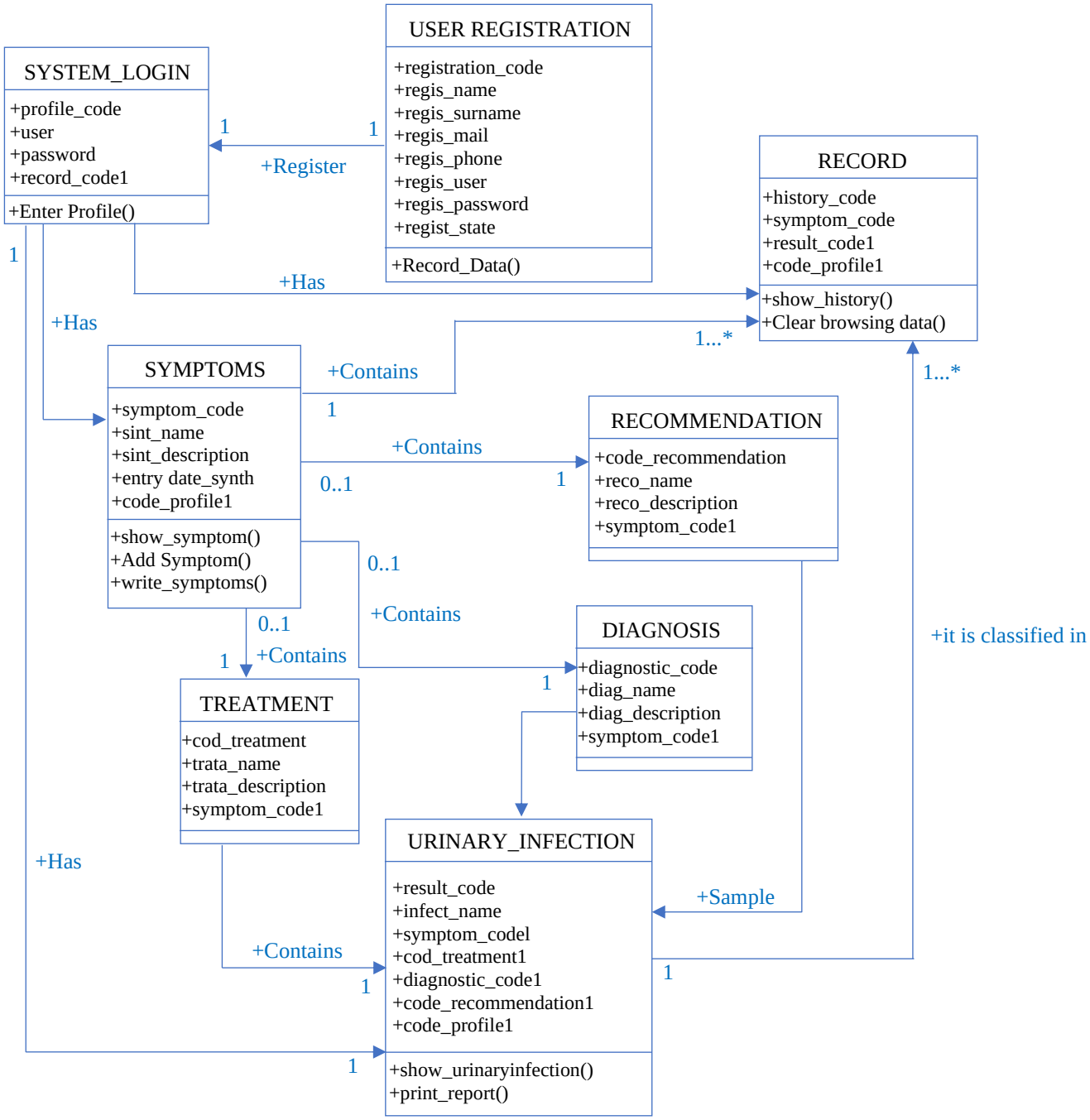

Fig. 9 Class diagram

Table 4. Identification of requirements

NRO	Problem	Business requirements
RN1	Medical care in the specialty of urology	Expert web system

Table 6 presents the functional requirements consisting of the functions that the different objects named in the table can perform.

Table 5. User requirements (Entity - Object)

NRO	Entity - Object	User Requirements
RU1	Patient	Manage profile
RU2	Symptoms	Symptom management
RU3	Disease	Managing illness
RU4	Recommendation	Manage recommendation
RU5	Treatment	Manage treatment
RU6	Diagnosis	Manage diagnosis
RU7	Result	Manage results

Table 6. Functional requirements

NRO	Entity - Object	User Requirements
RF1	Manage profile	Enter data
		User login
		Password entry
RF2	Managing symptoms	Placing symptoms
		Add symptom
RF3	Managing illness	Predicting disease
		Show illness
RF4	Manage recommendation	Predict recommendation
		Show recommendation
RF5	Manage treatment	Predict treatment
		Show treatment
RF6	Manage diagnosis	Predicting diagnosis
		Show diagnosis
RF7	Manage results	Consult expert
		Show result
		Add history

Figure 9 shows the architecture of the class diagram in which the different objects with their attributes, their primary and foreign keys, and their methods that communicate with each other are related to their respective cardinality and their keyword to relate them.

Figure 10 and Figure 11 shows a part of the swi-prolog code used to build the instructions that compose the expert system to perform the prediction appropriate to the proposed system.

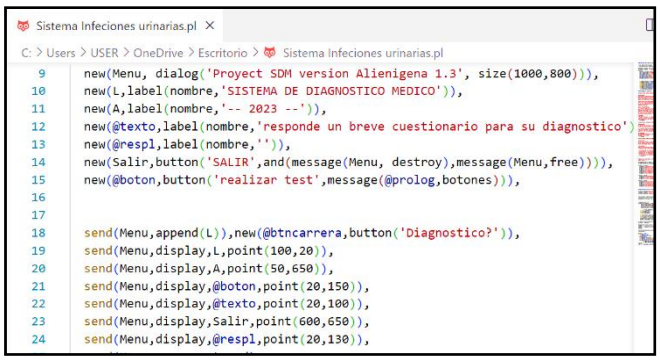

Fig. 10 Expert system code part 1

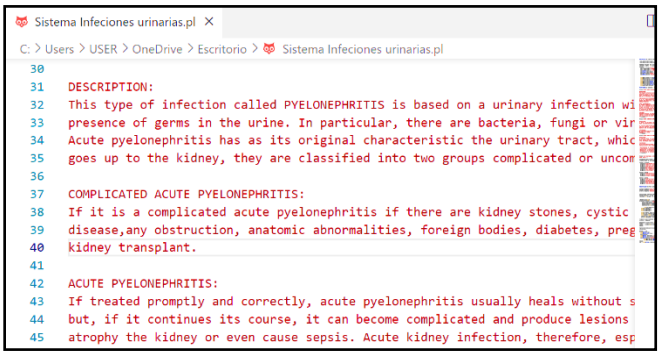

Fig. 11 Expert system code part 2

Table 7 shows the non-functional requirements involving their attributes, the tools used and the methods used to implement the system.

Table 7. Non-functional requirements

NRO	Attributes Quality	Non-functional requirements
RNF1	Hardware	Client/Server Technology.
RNF2	Software	HTML, CSS, JavaScript, PHP, G - Prolog, MY SQL (XAMP).
RNF3	Security	Queries with markers to protect data in PHP, regular expressions, and use of security methods in PHP.
RNF4	Security	Protection against possible malware attacks and monitoring of possible security vulnerabilities.
RNF5	Confidentiality	Transactions at 95% confidentiality.
RNF6	Confidentiality	Fault tolerance of 5% of transactions
RNF7	Availability	24 hours a day.
RNF8	Scalability	I make it easy to make changes to different components (version upgrades).
RNF9	Reusability	Ease of reuse of system components.
RNF10	Integration	It can be easily integrated with other components.

Table 8. Login

Use case	**Login**	
Code	CU01	
Target	Allows users to log in to the system by entering their username and password in the text boxes.	
Preconditions	The user must create an account before logging into the system. Blank data cannot be entered.	
Postconditions	The user's data is recorded in the system.	
Actors	User	
Main flow	**Steps**	
	1.	The user enters their username and password.
	2.	System validation when entering data
	3.	The system displays a message if the user is correct or incorrect, or if there are empty fields.
Extensions	**Action**	
	4.	The system validates if your data is correct or incorrect or if there are blanks.
Frequency	Infrequent	
Performance	High	
Priority	High	

Table 8 shows the description of the login process presented as use case number 1, presenting the main characteristics of it.

Figure 12 shows the prototype of the developed system design, presenting the different components to access the system. The user will have to log in mainly with his username and password.

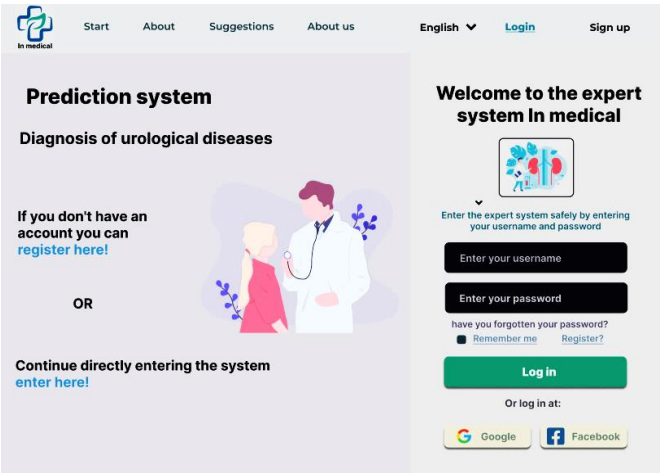

Fig. 12 Login prototype

Table 9 shows the table of use cases of the user registration process and its characteristics described for each one since if the user does not have a username and password, he/she will not be able to access the system and will have to create a username and password for him/herself.

Figure 13 shows the graphical interface of what the registration process will look like, showing certain text boxes to enter your data and buttons to click and register to log in to the system.

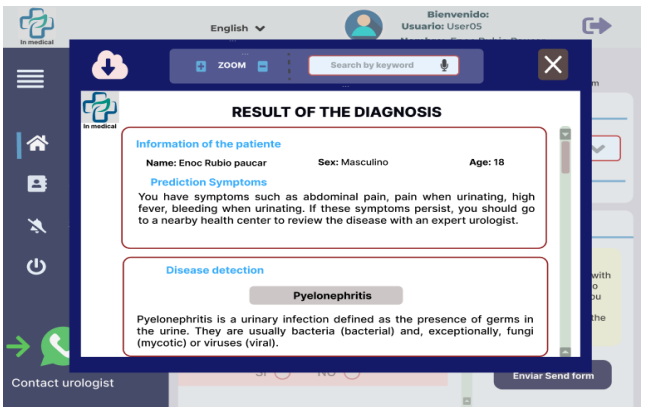

Fig. 13 Prototype user registration

Table 9. User registration

Use case	**User Registration**	
Código	CU02	
Target	Before logging into the system, the user will have to register his or her details to create a username and password.	
Preconditions	You must create one if you do not have a registered username and password. You must enter the data requested in the form.	
Postconditions	Successfully registered data	
Actors	User	
Main flow	**Steps**	
	1.	The user enters his or her data in the registration form.
	2.	Press the button to register the data, or there is also a button to cancel the process and return to the login form.
Extensions	**Action**	
	4.	The system validates if your data is correct or incorrect or if there are blanks.
Frequency	Infrequent	
Performance	High	
Priority	High	

Table 10 shows the characteristics and their description about the diagnosis of diseases, which are presented to interact with this process.

Table 10. Diagnosis of disease

Use case	**Diagnosis of disease**	
Code	CU03	
Target	In this interface, it is possible to select the different symptoms that the patient has in order to detect urological disease.	
Preconditions	You will necessarily have to enter an answer (YES or NO); before that, you will have to fill in the requested data.	
Postconditions	To show the prediction result, you will have to answer the questions in advance.	
Actors	User	
Main flow	**Steps**	
	1.	The user enters the requested data in the text boxes to make the prediction.
	2.	The patient will then have to answer the questions so that the system can predict the disease.
Extensions	**Action**	
	4.	Once you have entered the requested data, you will have to click on the button to validate this information.
Frequency	High	
Performance	High	
Priority	High	

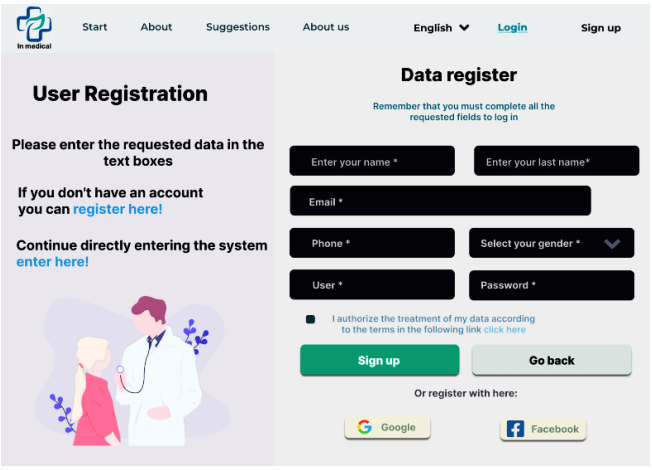

Fig. 14 Disease diagnosis prototype

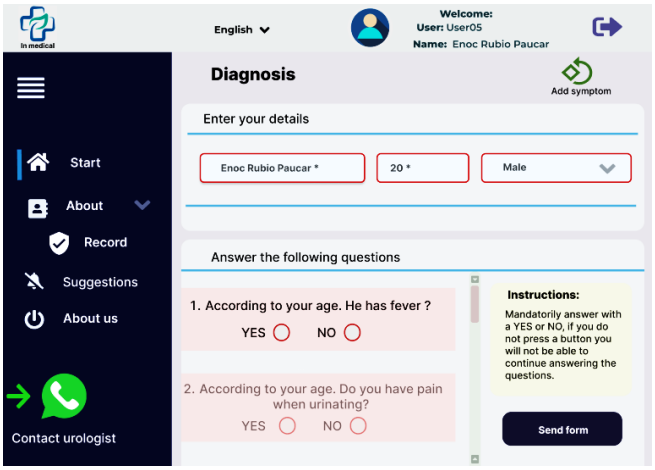

Fig. 15 Diagnostic prototype result

Table 11. Diagnostic result

Use case	**Diagnostic result**	
Code	CU04	
Target	By means of a modal, the result is displayed as the name of the urinary tract infection, its description and the treatment needed by the patient.	
Preconditions	Patient data must be displayed to target the results to the patient.	
Postconditions	Before displaying these results, the questions of the diagnostic interface will have to be answered.	
Actors	User	
Main flow	**Steps**	
	1.	Information related to the symptoms placed in the diagnostic interface shall be displayed.
	2.	The patient or the expert may print the result to manipulate this information.
Extensions	**Action**	
	4.	Only show the result of the diagnosis.
Frequency	High	
Performance	Half	
Priority	High	

Figure 14 shows the disease diagnosis interface characterized by a user form and a questionnaire of questions to be answered by the user to make the prediction.

Table 11 shows the diagnosis result use case, which presents the characteristics and description of each one to understand how this process works. The function of this process is to show the diagnosis of the predicted disease analyzed with the questionnaire of questions posed previously in the previous process.

Figure 15 shows the interface that displays the result of the diagnosis preceded by the questions posed in the previous interface; in this modal, the necessary information is displayed, such as the description of the disease and the patient's data, among others.

Table 12 presents the characteristics and their description of the process of adding symptoms to add their symptoms and diseases that are not registered in the system in order to make new predictions with diseases not found in the system.

Figure 16 shows the symptom and disease aggregation interface, in which an interactive section can be seen where the symptom can be added or removed; once the register button has been pressed, the changes are automatically saved.

Table 12. Adding symptoms

Use case	Adding symptoms	
Code	CU05	
Target	The user will enter an unknown infection and its symptoms that the user has and is not registered in the system.	
Preconditions	A disease must be entered first, and then the symptoms of the disease; the symptoms cannot be entered first as the system validates that the symptoms come first.	
Postconditions	The system will not be able to update empty data; you will have to enter the requested data first.	
Actors	User	
Main flow	**Steps**	
	1.	Enter urinary tract infection and its symptoms for update.
	2.	Once the data has been entered correctly, press the save symptoms and diseases button to store it in the DATABASE.
Extensions	**Action**	
	4.	Aggregation of symptoms and diseases that are not recorded in the system.
Frequency	Half	
Performance	Half	
Priority	Low	

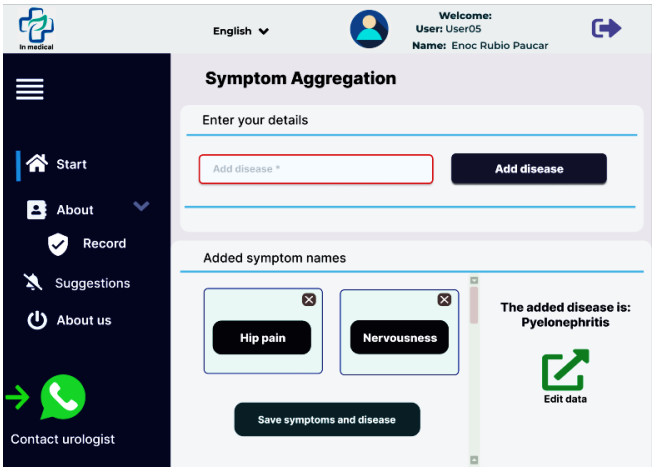

Fig. 16 Prototype adds symptoms and diseases

Table 13 shows about the characteristics of the disease registry use case with its logical description that exists for this process to add symptoms and diseases not found in the system.

Figure 17 shows the interface where the user's previously registered disease records are displayed, showing the data with their respective records and fields and a text component to add comments.

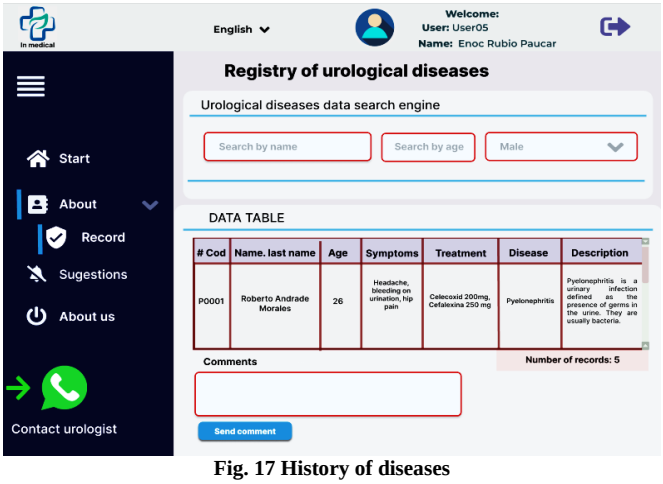

Fig. 17 History of diseases

Table 14 shows the characteristics and description of the use case of editing diseases or elimination, in which a modal is shown that allows these actions to be carried out.

Figure 18 shows a small modal with a table with the diseases and their symptoms that the user has added if they are not in the system, where the selected disease can be edited and deleted.

Table 13. History of diseases

Use case	**History of diseases**	
Code	CU06	
Target	Display a history of the system's predictions in a table of records.	
Preconditions	There are no preconditions for accessing this interface.	
Postconditions	There are no preconditions for accessing this interface.	
Actors	User or Expert	
Main flow	**Steps**	
	1.	Only disease information and registered patient data are displayed.
	2.	A box will contain the patient's suggestions for improvements to the system that are agreeable to the patient.
Extensions	**Action**	
	4.	There is no extension to be made.
Frequency	Half	
Performance	Low	
Priority	Low	

Table 14. Edit diseases

Use case	**Edit diseases**	
Code	CU07	
Target	Edit or delete the symptom added by the patient.	
Preconditions	You must press the edit data button in the symptom aggregation interface.	
Postconditions	You can only edit or delete the disease and symptoms added by the patient; you cannot edit the default symptoms and diseases.	
Actors	User or Expert	
Main flow	**Steps**	
	1.	Press the update data button located in the symptom aggregation interface.
	2.	Verify that it is in the table that you want to update or delete.
	3.	The system will ask if you are sure you want to delete or update the selected record.
Extensions	**Action**	
	4.	Press update or delete the record.
Frequency	Half	
Performance	Half	
Priority	Low	

Table 15 shows the characteristics and description of the use case of displaying information, which is irrelevant because, in this section, there is no manipulable information for the system; only static data is displayed.

Figure 19 shows the interface where only the information of the system's creator is displayed, showing his data and his professional and work environment description.

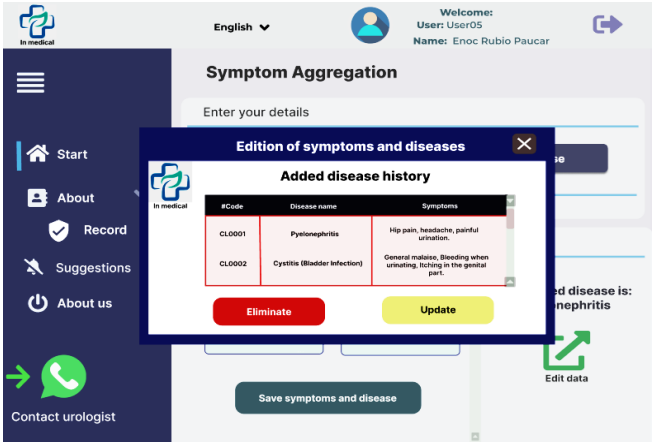

Fig. 18 Prototype disease history

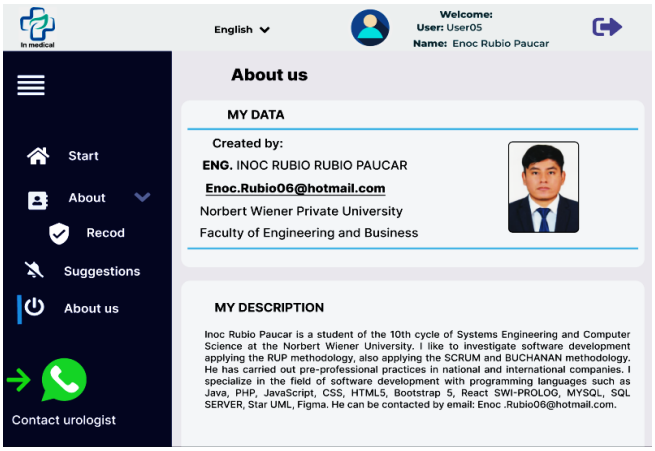

Fig. 19 Prototype disease history

Table 15. Display user information

Use case	Show creator information	
Code	CU07	
Target	Display information about the ING. Who created the system?	
Preconditions	Not specified.	
Postconditions	Not specified.	
Actors	Not specified.	
Main flow	**Pasos**	
	1.	Not specified
Extensions	**Acción**	
	4.	Not specified
Frequency	Low	
Performance	Low	
Priority	Low	

4. Results

4.1. About the Survey

In order to determine the results of the research, a questionnaire of questions for the users of the system was designed; the questions were asked according to the functionalities and the user's experience of using the system (see Table 16).

Table 16. Questionnaire of questions

Nro.	Questions
	Design
P-1	According to the design, is the interaction with the system comprehensible?
P-2	In terms of colours and design, do you find the system's appearance pleasing?
P-3	Does the web design meet the details required by users?
P-4	In your design, do you wish to add any additional components to the proposed design?
P-5	Does the interface meet your expectations?
	Functionality
P-6	According to the user registration, does filling in the requested data take a long time?
P-7	For you, does it cause you any inconvenience when the system corrects errors when entering data in text fields?
P-8	Are you provided with the necessary information for you and the expert in the resulting interface?
P-9	For you, is it essential to add a disease and its symptoms that you do not find in the system?
P-10	Do you have any difficulties interacting with the proposed system?
	Security
P-11	When registering your data, do you agree to your data being recorded in our system?
P-12	Do you believe that the information provided on diseases is truthful and accurate?
P-13	According to your login, have you had any problems logging in with your username and password?
P-14	Do you consider that the system complies with the correct security measures?
P-15	Do you agree that the diagnosis of predicted disease should be supervised by a specialist urologist?

After answering the questionnaire, the results were classified according to certain categories such as low, high and medium. These data were processed to determine the feasibility of the implemented project. To determine the feasibility, an analysis of the mean was established to determine different variables taken from the mean, such as median, mode, and variance, among others, as mentioned in Table 17.

On the other hand, it was classified in different answers between bad, regular, good, and very good to evaluate the system where the most outstanding results about the average calculation were regular and good, as mentioned in Table 18.

Table 17. Descriptive table

STATISTICAL		
DESCRIPTIVE		
N	Valid	**50**
	Missing	**0**
Media		2,84
Standard error of the mean		,052
Medium		3,00
Fashion		3
Desv. Deviation		,370
Variance		,137
Asymmetry		-1,913
Standard error of skewness		,337
Kurtosis		1,726
Standard error of kurtosis		,662
Range		1
Minimum		2
Maximum		3
Sum		142
Percentiles	25	3,00
	50	3,00
	75	3,00

Table 18. Grouped average sum

AVERAGE SUM (Grouped)				
Valid	**Frequency**	**Percentage**	**% valid**	**% Accumulated**
Regularly	8	16,0	16,0	16,0
Well	42	84,0	84,0	100,0
Full	50	100,0	100,0	

Table 19. Average results

Average Sum	Frequency	Percentage	% Valid	% Accumulated
1,85	2	4,0	4,0	4,0
1,90	1	2,0	2,0	6,0
1,95	1	2,0	2,0	8,0
2,00	4	8,0	8,0	16,0
2,05	2	4,0	4,0	20,0
2,10	4	8,0	8,0	28,0
2,15	1	2,0	2,0	30,0
2,20	6	12,0	12,0	42,0
2,25	4	8,0	8,0	50,0
2,30	3	6,0	6,0	56,0
2,35	5	10,0	10,0	66,0
2,40	3	6,0	6,0	72,0
2,45	2	4,0	4,0	76,0
2,50	3	6,0	6,0	82,0
2,55	4	8,0	8,0	90,0
2,60	2	4,0	4,0	94,0
2,70	2	4,0	4,0	98,0
2,80	1	2,0	2,0	100,0
Full	50	100,0	100,0	

Table 20. Results by dimensions

ANALYSIS BY DIMENSIONS				
		Design (D1)	**Functionality (D2)**	**Security (D3)**
N	Valid	50	50	50
	Missing	0	0	0
Half		14,540	15,260	15,900
Standard error of the mean		,3184	,3255	,28749
Medium		15,000	15,000	16,000
Fashion		14,000	14,00	17,00
Desv. Deviation		2,251	2,3018	2,032
Variance		5,070	5,298	4,133
Asymmetry		,602	,118	,466
Standard error of skewness		,337	,337	,337
Kurtosis		,076	-,410	-,085
Standard error of kurtosis		,662	,662	,662
Range		9,00	10,00	9,00
Minimum		9,00	10,00	11,00
Maximum		18,00	20,00	20,00
Sum		727,00	763,00	795,00
Percentiles	25	13,0000	14,0000	15,0000
	50	15,0000	15,0000	16,0000
	75	16,0000	17,0000	17,0000

Table 19 shows the average sum related to the survey of users who will use the expert web system, showing certain indicators such as frequency, percentage, percentage valid and cumulative percentage.

In order to maintain order among the questions, they were classified into three dimensions: design (d1), functionality (d2), and safety (d3), with the objective of calculating the average of the 15 questions grouped in 5 blocks, calculating different arguments such as Median, Mode, Variance among others to determine the results calculated according to each variable as mentioned in Table 20.

The tables shown with the corresponding results of the agreement concluded that the design, according to the variables raised, has an adequate acceptance with customers - patients who use the system for this evaluation aim to cause a very strong impact on users and strengthen the demand for the system in its use.

4.2. Comparison of Methodologies

Table 21 shows the comparison of three agile methodologies used in software development, for it shows key concepts about the three methodologies to be evaluated as the Buchanan methodology, which consists of 4 phases identification, conceptualization, formalization and implementation developing each phase according to the processes established in each phase while the Rup methodology also consists of 4 phases as analysis, design, coding and integration of tests conceptualizing the phases mentioned and finally the Scrum methodology also contains 4 phases as analysis, design, codification and integration of tests conceptualizing the phases mentioned above and lastly, the Scrum methodology contains 5 phases: initiation, planning and estimation, implementation, review and retrospective and launch, developing each phase according to the needs of each project, in this sense, it was classified in a table to make the necessary comparison.

Table 21. Comparison of methodologies

Buchanan	**Rup Methodology**	**Scrum Methodology**
This methodology is based on the cascading life cycle	Its approach is based on an interactive and incremental cycle.	It is based on very short iterations called Sprints, which usually last 1 to 4 weeks.
There must be cooperation between the expert and the engineer.	It is generally used in large team development projects.	It allows complex projects to be realized, which can be changed according to your requirements.

5. Discussion

For the research carried out, clinical data management was performed using Machine Learning (ML) to provide the appropriate treatment established for the patients using algorithms in the calculations. [11]. Another research is based on evaluating the repeatability of DWI-derived radiomics for prostate treatment with the implementation of Machine Learning in which 112 patients who were diagnosed with the disease as mentioned above participated. [12]. The present investigation refers to infectious urinary system diseases, including kidney stones. [13]. Finally, the research carried out is based on the benefits of Artificial Intelligence (AI) in the health field, which are implemented with beneficial results. [14].

6. Conclusion and Future Work

As a conclusion the implementation of this web application allowed us to predict which disease of the urinary system a person suffers from according to their symptoms, for this we determined the usability of our system by carrying out a check with the clients - patients verifying its benefit and effectiveness that satisfies the users that use it allowing to have a control in the problem that is the high demand of people in the health centres especially public that has collapsed due to the great affluence of people, the use of the Buchanan methodology developed in the project, This methodology was clearly selected because it fits the needs of the project concerning expert systems in comparison with the compared methodologies such as Rup and Scrum, that is why an expert system is recommended to solve various problems detected in society, to obtain satisfactory results to the problems in society is advisable to use artificial intelligence by applying technologies related to these concepts as there are not many systems on predictions about urinary tract infections in the urinary tract.

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