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Diagnosis of Kidney Diseases Using an Expert System Designed Based on the Forward Method

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Abstract- In this study we evaluate the forward method which could be used for an expert system in a Python environment to diagnose kidney disease; initially, we need the tree diagram of the expert system which has been mentioned in this study. Furthermore, we design our expert system due to overall architecture which includes an Inference engine, Knowledge base, describing conclusions, working memory, foreign applications and Builder and user interfaces in addition it should be based on the planned expert system.

Keywords- *Kidney Disease, Expert System, Python Enviroment, Inference Engine, Network Architecture*

I. INTRODUCTION

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A. Kidney, related diseases and methods of diagnosis and treatments

Every human has two kidneys and each of them is as big as a fist. Also, each is placed on one side of the spinal cord and in the lowest level of the chest. Each kidney approximately has a hundred functional units that are named Nephron. The nephron is made of a purifier capillary unit which is called Glomeruli and it is connected with a tubule. Blood is purified after entering glomeruli and then the remained liquid goes through the tubule. Water and chemicals will be added or removed from this purified liquid by considering the needs of the body. Eventually, the product of this process is named urine which should be urinated [1] (Figure 1).

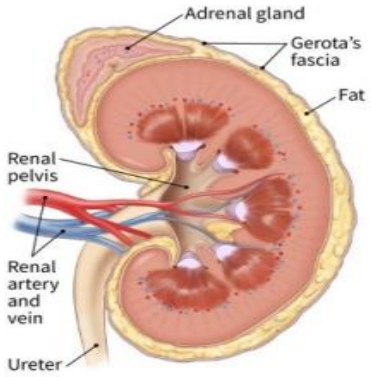

Figure 1. A view of the anatomy of the human body: kidney [2]

The main function of the kidney is to excrete the body waste and extra liquids which are done through urine. Urine production has very complex stages such as secretion and absorption. Indeed, this process seems essential for keeping the balance between chemicals stable. The vital hemostasis of potassium, acid materials and the amount of salt in the body is done by kidneys. In addition, kidneys produce different hormones or vitamins which have a significant impact on the function of other organs. For instance, one of the hormones which are made by kidneys can motivate and boost the production of red blood cells. Moreover, some other hormones secreted by kidneys can regulate blood pressure and the rest control calcium metabolism [1].

The majority of kidney illnesses attack nephrons hence it may cause some disorders in the excretion system in which kidneys are unable to excrete the body waste. Genetic problems, getting injured or using drugs could be some reasons for kidney illnesses. Moreover, diabetes, hypertension or different severity of kidney disease in close relatives may increase the possibility of disorder in the kidney. Chronic kidney diseases and kidney failure could hurt nephrons slightly and through several years [2].

Other kidney disorders could be mentioned: cancer, kidney stone, cyst and infection. The pain of the kidneys is caused by kidney infection. Perhaps you consider the pain in your waist associated with kidneys. Albeit it is not related to the most of the time. Indeed most people are amazed when they understand kidneys are approximately above their waist and accurately below the lower ribs (posterior space). How should we know the reasons for pain in kidneys or whether the pain is relevant to kidneys or not? There is not any obvious solution although the possibility of its association with the kidney will decrease regarding other signs and symptoms also the results of experiments [1], [3].

Kidney diseases are disorders that hurt kidneys. Kidneys are two organs with the production of specific hormones and regulating the number of chemicals in the blood.

Mostly both of the kidneys will be damaged by kidney disease. In the case of making kidney disabled by the illness in excreting and regulating water and chemicals, accumulation of extra fluid and body waste and leads to oedema and uremia (kidney failure). Kidney diseases have different kinds and etiologies. They could be divided into three groups: Hereditary, Congenital, and Adventitious [4].

Transferring inherited disorders is possible among female and male gender. This kind of kidney disease is demonstrated by clinical symptoms and signs that appear in teenage to adulthood. Polycystic kidney is the most widespread inherited kidney disease. In addition, concerning other inherited kidney diseases we can mention Alport syndrome, inherited nephrite (kidney inflammation), primary hyperoxaluria and cystinuria [5].

Congenital kidney disease usually causes abnormalities and deformities of the genitourinary tract to some extent. Moreover, a kind of obstruction which was made by it may lead to inflammation or destruction of kidney tissue. In this way, the improvement in kidney tissue begets chronic kidney failure. There are several kidney diseases which are named nephrite or kidney inflammation overall. The most prevalent kind of nephritis is glomeruli nephrite and it is relevant to several causes.

Nevertheless, a lot of kidney diseases do not demonstrate any considerable signs or symptoms until they reach the advanced stages of the disease, there are six symptoms to the least which illustrate kidney disease:

1. Urinary incontinence or a painful bladder
2. Frequent urination
3. Bloody urine
4. The puffiness around the eyes or swelling in hands and feet
5. Pain in some little area of the back that is accurately placed under the ribs
6. Hypertension

Physician studies the patient history thoroughly and checkup the patient precisely for diagnosing. Furthermore, physicians prescribe blood and urine examinations to receive more information about the function of the kidney. Essentially some of the kidney illnesses could be cured successfully whilst improvement of the others will lead to kidney failure and dialyzing and a kidney transplant is required for treatment. Chronic inflammation of glomeruli is the most prevalent kidney illness. It develops steadily and is followed by kidney failure. In this case, the physician prescribes special medicine or advice on special diets [6-7].

II. EXPERT SYSTEM

A. The basic description of an expert system

Scientists have always had this ambitious idea of inventing "Artificial Intelligence" since the early 1970s and the time when the first digital computers were invented. Simply, artificial intelligence is known as a machine that can think and analyze. Thus the tremendous dream of artificial intelligence may come true one day if scientists become able to create a machine that can simulate the algorithms and function of the human's brain digitally by using substantial progress in the world of computers. In the 1970s Edward Feign Bam was looking for a solution that should not be general or general-purpose. Researchers discovered a fact and it became a beginning for the creation of the expert system. They found out each scientist has his tricks and techniques know-hows for their responsibilities. Indeed, they use some conducive and salutary self-made ways to get their things done efficiently [8].

The expert system collects these conducive ways and changes them into computer applications. In other words, it exerts scientist's process of argumentation and deciding to convert them to computer applications. Therefore, the description of the expert system could be mentioned as follows "Expert systems are computer applications which solve problems in a special subject by exerting the salutary ways used by scientists." A lot of people think much of computers before facing and using them initially since they believe computers are thinker machines with high Intel legacy.

Furthermore, they are believed to be able to solve all the problems even the complicated and unsolved ones. Whereas after getting acquainted with them for a while all of us will understand that the new users of computers were living in a dream world. Notwithstanding expert systems has brought their dreams into reality to some extent.

Using argumentations that are based on deduction and inference by expert systems is the main difference between them and other practical applications. Essentially ordinary practical applications use some fixed algorithms and solving methods however more complicated problems will be solved and more appreciable answers will be gotten if we use intuitive methods along with trial and error [9].

B. The second description of an expert system

For the most part, expert systems could be described as computer applications that can simulate a scientist's way of contemplating a specific subject. Indeed, firstly this software identifies the logical patterns by which an expert make a decision and after that, they decide on something based on those patterns as do humans.

Basically simulation of human intelligence by computer applications to comprehend it is one of the aims of artificial

intelligence. Though intelligence could be generalized to a lot of understanding-based skills such as the ability for making a decision, learning and understanding language hence it is known as a general word.

The main subject of the expert system includes the majority of achievements of artificial intelligence which were in making decisions and resolving fields. Expert systems are kinds of artificial intelligence applications and they reached a high level of expertise therefore they can decide in a specific field.

These systems are soft wares that can be used for deciding on a particular field based on the information in their knowledge base. We have to take into consideration none of the designed or programed expert systems was hitherto general-purposes and they are only able to simulate decision making in limited fields.

Task domain is the range of information concerning the patterns of human expertise which is transferred to an expert system. This range clarifies the level of expertise and also demonstrates the responsibilities it has been designed for. The expert system can use these tasks with the aim of scheduling, timetabling and designing in a special field. Knowledge engineering is the process of creating an expert system. A knowledge engineer must be sure about the designed expert system to have all the required knowledge for solving a problem or else decisions of the expert system will certainly not be trustworthy anymore [10].

C. The third description of expert system

Computer soft wares are some particular kinds of soft wares which show an effort for helping out the scientists and exerts or working in their place for some of their duties partially. Essentially these systems are the primitive and simpler version of improved technology named knowledge base systems and they can conclude and resolve problems in situations in which the attitude and point of view of a skillful expert are required. These systems save information in form of facts and principles in a database which is known as a Knowledge base in an organized way and then the required results are achieved due to the utilization of specific ways for inferencing data [11].

D. The fourth description of expert system

Expert systems are soft wares that imitate the thoughts of an expert in particular fields. This application exerts user-saved data to announce an attitude in a specific subject hence they continue asking you questions and by the time expert systems can find a subject with accurate corresponding to your answers [12].

E. The fifth description of an expert system

Expertise in knowledge is a specialty that needs to study specialist meanings or pass specific courses.

Expert system is one of the subcategories of arterial intelligence. Expert systems are computer software with a high level of inelegancy in a particular field moreover it could be used in making decisions or helping an expert to decide with more facile. Expert systems are used for solving problems in which:

There is not a particular algorithm for these problems, or it is not conducive or possible to solve them algorithmically.

There is an apparent and evidential knowledge for designing or implementation a knowledge system based on that.

For instance, a system will not be categorized in classical and traditional fields of expert system, if it predicts the temperature of tomorrow based on statistical methods. Whereas if a system uses the fact that temperature is fixed in this time of the year up to a point and considering current temperature which is 25° and finally concluding the temperature of tomorrow that must be 45° it can be placed in the classical field.

At any rate, expert systems should not be expected to have some results better than the expert without fail. The conclusion of an expert system and an expert individual may have the same level at best. Computer expert systems are not always able to find an answer successfully as do expert individuals.

As regards different kinds of sciences, expertise can be discussed in different branches of science. An expert is a person who has lucrative skills in a particular field. For example, doctors, mechanics and civil engineers are expert individuals. This fact illustrates the extensive function of expert systems also it may be possible to design and run it for all the specialist fields [13].

III. COMPONENTS OF AN EXPERT SYSTEM

Figure 2 declares the main components and the connection kind among components of an expert system. All the components are defined as follows:

A. Knowledge base

One of the most important components of an expert system is the knowledge base also known as a knowledge bank which is a place for saving coded and understandable expert knowledge. A knowledge rule base is a place for the representation of knowledge like a set of rules. Representation of knowledge leads to the creation of a knowledge base. A person who changes the expert knowledge in codes is called Engineer Knowledge. Knowledge is saved in the knowledge base traditionally and classically and with conditional phrases [15].

B. Inference engine

It means solving problems by using available knowledge and making connections among related knowledge. Inference engine uses logical rules and the knowledge in knowledge base and facts of working memory to get a particular thing done. This could be done by adding new facts to the knowledge base or as a result for announcing to a user or doing a specific work [16].

C. Working memory

It is a memory for storing the questioned answers by the system [17].

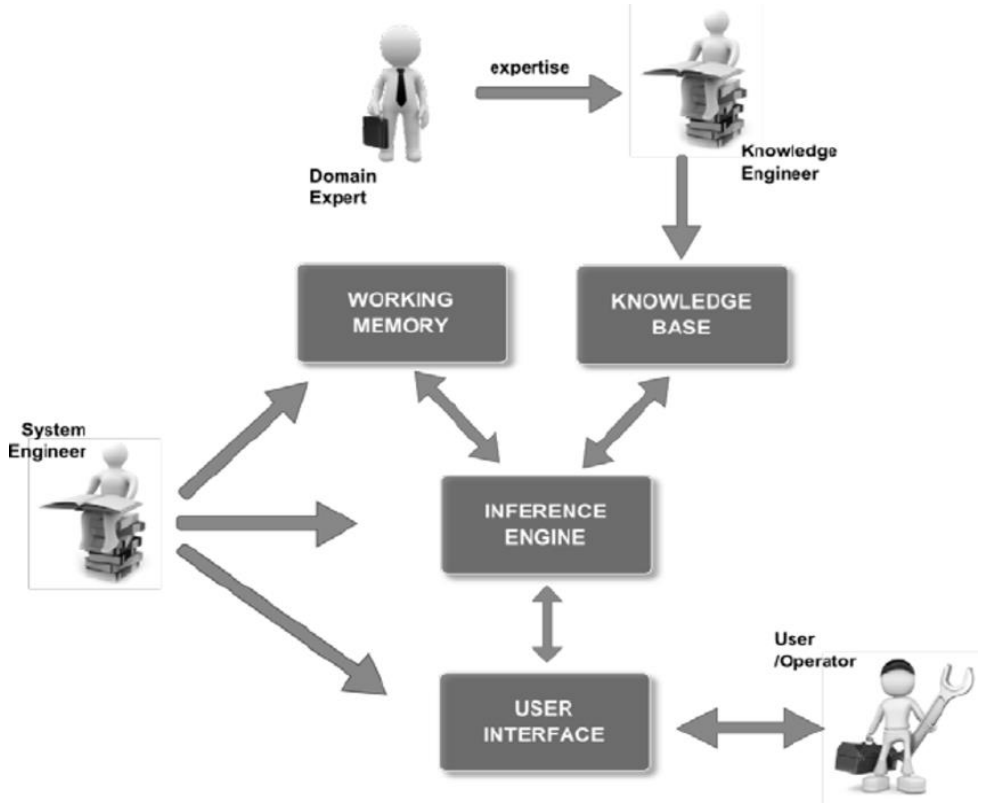

Figure 2. Expert system diagram

D. Facilities for knowledge achievement

These facilities are some approaches for creating and adding knowledge to the system and we must cross this step for once when we want to do these processes. Unless this knowledge is available in the system, it will be brought to the inference engine for purification and after that, it can be placed in the knowledge base [18].

E. Facilities for explaining

It is used for clarifying the steps of concluding by an expert system for a particular problem in an understandable way for users. In this way, users can trust more in the decision made by the system. Furthermore, the expert who has an entered science in knowledge base will be ensured about the correct representation and process of entering his science. User and system can be connected by some questions and answers and users will be advised to follow different approaches from the beginning of implementation till the end. During asking questions expert system have to explain the reason for asking this kind of question? Or how did it end up with this conclusion? If the user feels it is necessary thus this option is called Facilities for Explaining [19].

F. Connection with user step

It is relevant to the part which has an association with the user.

IV. METHODS FOR DESIGNING AN EXPERT SYSTEM

A. Forward chaining

Forward chaining is a reasoning method in artificial intelligence. In this method, inference rules are applied until achieving the last purpose for the extraction of extra data. In this chain inference engine starts its duty by assessment of facts, derivatives and existing conditions before new inference of data and eventually an aim will be reached through manipulating the available knowledge in the knowledge base (Figure 3) [20].

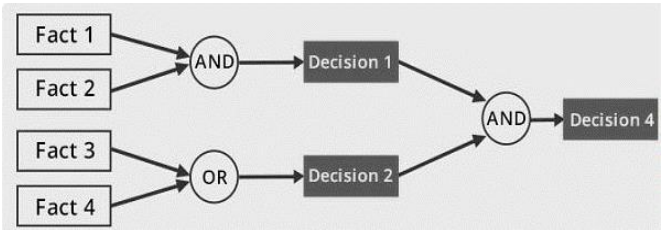

Figure 3. Forward chaining method

B. *Backward chaining*

Backward chaining is a concept in artificial intelligence and it includes going backwards from the final point or aims to the last section. This kind of chaining method starts with the aim and it continues with moving backwards to have a clear idea of the taken steps to achieve this aim. Moreover, moving backwards makes it possible to use logical steps for finding out other important solutions (Figure 4) [20].

C. *Methodology*

We exerted the Forward chaining method for creating our expert system which needed to fill out a tree diagram by the set of our knowledge and principles (Figure 5).

V. TREE DIAGRAM OF EXPERT SYSTEM

A. *How to run the project in python*

We availed the 15th rule in creating our knowledge base. The set of these rules are available in Figure 6.

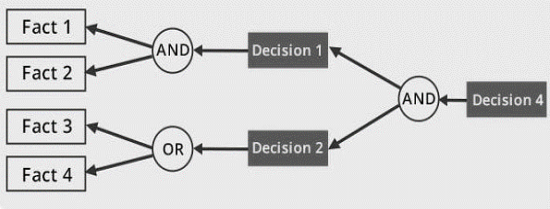

Figure 4. Backward chaining method

Figure 5. Expert knowledge system and rules tree for diagnosing kidney disease

```
Goal = "kidneydisease"

Knowledge_Base = {}
Knowledge_Base["Rule1"]=[["Diagnosis of the doctor"],["Suspect"],"kidneydisease"]
Knowledge_Base["Rule2"]=[["doctor checkup","Triage examination"],[],"Diagnosis of the doctor"]
Knowledge_Base["Rule3"]=[["Test Results"],["Patient Symptoms"],"Suspect"]
Knowledge_Base["Rule4"]=[["urine test","blood test","SG"],[],"Test Results"]
Knowledge_Base["Rule5"]=[["Anemia","low blood pressure"],[],"blood test"]
Knowledge_Base["Rule6"]=[["fainting"],["High fever"],"low blood pressure"]
Knowledge_Base["Rule7"]=[["Low blood sugar","Cough"],[],"fainting"]
Knowledge_Base["Rule8"]=[["Infection"],["Low urination"],"urine test"]
Knowledge_Base["Rule9"]=[["backache","Burning back"],[],"Infection"]
Knowledge_Base["Rule10"]=[["Kidney pain"],["kidney stone"],"SG"]
Knowledge_Base["Rule11"]=[["chronic disease","Abdominal pain"],[],"kidney stone"]
Knowledge_Base["Rule12"]=[["Diabetes","Obesity"],[],"chronic disease"]
Knowledge_Base["Rule13"]=[["Severe pain","Confusion","Nausea"],[],"Patient Symptoms"]
Knowledge_Base["Rule14"]=[["Shake your head"],["Lack of fluids"],"Confusion"]
Knowledge_Base["Rule15"]=[["Digestive problems"],["To be poisoned"],"Nausea"]
```

Figure 6. Collection of expert system rules

Indeed, these set of rules build up our inference engine and regarding asking questions we can diagnose whether an individual is patient or not that is based on this set of rules. Figure 7 provides information about diagnosing the illness based on asking some questions by running a code.

```
doctor checkup ----- is true or false
true
Triage examination ----- is true or false
true
Anemia ----- is true or false
true
----------The target is approved----------
```

Figure 7. Results of code execution in colab environment

VI. CONCLUSIONS

Results reveal expert systems have a variety of applications in different fields. The application of an expert system in the medical field could be used for a significant improvement in medical science. Diagnosing kidney diseases are somehow complicated thus there is an eventuality for a wrong diagnosis or treatment. This study advises an expert system for helping physicians or medical specialists to diagnose and cure chronic kidney disease.

Nevertheless, given the current situation, we cannot consider the replacement of medical specialists or their knowledge and admirable works with the developed expert system. Having said that it can be a helpful and practical tool for physicians in decision making hence they could be used in hospitals with a lack of specialized workforce and regions where there is more or less no access to the hospitals.

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