DESIGN AND IMPLEMENTATION OF AN EXPERT DECISION SUPPORT SYSTEM FOR DIAGNOSIS OF KIDNEY STONE DISEASE

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ABSTRACT
A Decision Support System (DSS) is an algorithmic computer application program that gathers analyses and presents data to users for decision making purposes within an organization. This research aims at the design and implementation of a Decision Support System modelled by a rule based Expert System for the diagnosis of kidney stone to assist Physicians' make better decisions. The proposed system collects comprehensive information about kidney stone diseases from a group of experts. To this aim, a cross-sectional study is conducted by asking Physicians' expertise on all symptoms relevant to the disease. A rule based system is then formed based on this information which contains a set of significant symptoms. The medical diagnosis rules were formulated and applied by developing a new system using Visual Basic.Net. Sets of symptoms related to the set of considered diseases were defined. The input of the system is the severity level of each symptom reported by patients. We used the Object-Oriented analysis and design methodology and Visual Basic.Net as a language of implementation. A group of patients were used to validate the effectiveness of the system. The results show that the expert system is capable of diagnosing disease with a high degree of accuracy and precision and is fully compatible with those of medical experts. The developed system decreases the effort of initial physical checking and manual feeding of the input system.

Keyword: Prognosis, Diagnosis, Kidney Stone, Expert System, Decision Support System.

INTRODUCTION

An Expert system (ES) is a computer system that emulates the decision-making ability of a human expert. ES are designed to solve complex problems by reasoning through bodies of knowledge, represented mainly as IF-THEN rules rather than through conventional procedural code.

Decision Support System (DSS) is a computer-based information system that supports business or organizational decision-making activities. It is an interactive system that helps decision-makers utilize data and models to solve unstructured or semi-structured problems. The concept of Expert Decision Support systems is based on the integration of Decision Support Systems and Expert Systems, providing the decision maker with features from both types of systems.

The kidneys are a pair of bean-shaped organs on either side of the spine, below the ribs and behind the belly. Each kidney is about 4 or 5 inches long, roughly the size of a large fist. The kidneys' job is to filter the blood. Kidney stone is a disorder that occurs as a result of the formation of crystalline aggregates ('kidney stone') that can grow anywhere along the urinary tract (or lower down in the urinary tract). Kidney stone often causes blood in the urine and pain in the abdomen, flank or groin. It is observed that there are increasing cases of this nature, especially in Nigeria due to the climatic condition (Saigal, Joyce & Timilsina, 2005). Passing kidney stone can be quite painful, but the stone usually causes no permanent damage. However, stone diseases are among the most painful and prevalent urological disorders. Fortunately, most stones pass out of the body without any intervention, there are considerably fewer specialist in the field of Nephrolithiasis, called Urologist, and they are not usually available in all hospitals. Treatment of Kidney stone is a gradual process because it is a chronic kidney condition; it requires regular visit to the hospital to enable the specialist monitor the patient's records which need to be up to date in order to be used in making vital decisions.

Kidney disease is a very complex disease having higher rate of mortality. There are several causes of kidney disease. Diseases such as high blood pressure or diabetes lead to kidney disease (Robert et al., 2013). Also, kidney disease itself results in a number of complications. All these factors must be considered for the diagnosis and treatment of kidney diseases. Also, large numbers of disorders are associated with kidneys. Most of them show similar symptoms and it is difficult to differentiate and diagnose them correctly. General physicians or practicing doctors often seek an expert's advice to arrive at accurate diagnosis and to plan appropriate treatment. In remote areas where human experts are not easily available, physicians always find it difficult to get expert advice. Accurate and timely diagnosis is essential to reduce the mortality rate and improve the quality of life. The natural development of different diseases, the unclear nature of medical data and the intrinsic vagueness of medical problems lead to a need for a reliable framework that can deal with the ambiguity via permitting variable and facilitating approximate reasoning. This unavoidably causes the rule-based system to be a valuable tool for describing medical concepts (Steiman, 2001). Medical diagnosis and prognosis problems are the prime examples of decision making in the face of uncertainty. Dealing with uncertainties is a common problem in pattern recognition and the use of rule-based theory has given rise to a lot of new methods of pattern recognition for medical diagnosis. The diagnosis of a disease is a problem in medicine since some patients may have similar symptoms, but the doctor may diagnose different diseases. This research work introduces a simple and efficient method to create an expert system for medical diagnosis. The methodology is general and can be applied in diagnosing a wide range of diseases. However, to demonstrate the concept, in this thesis, we developed a decision support system that helps in the diagnosis of kidney stone using rule-based system that can infer accurate diagnostic decisions based on patient's data. The main problems this paper is set to solve include:

1. Limited observation and subjectivity of the specialist,
2. Uncertainties and incompleteness in medical knowledge of some of the medical personnel and
3. Inadequate time during diagnosis for appropriate treatment, i.e. poor time effect in diagnosis.

The Objectives of the Study are to:

a) apply rule-based techniques in the development of decision support system using Multiple Inputs Single Output (MISO)
b) use frequency distribution and mean to do feature extraction and selection respectively
c) provide real time, effective, efficient and accurate service delivery by clinicians in line with global medical health standards

Literature Review

Decision support systems have significantly evolved and turned into essential tools. As it is noted in Carlsson and Turban (2002) research work, modern institutions and corporations tend to become more widespread and to lose rigidness of their organizational structures. On the other hand, the larger numbers of senior and medium executives consult with DSS and have daily hands-on experience with them. Thus, a DSS has become a crucial part of organization and not just a stand-alone application (Fernández-Caballero & Sokolova, 2009).

As it is reported in the work of Scholten et al. (2007), agent technology has emerged as a promising solution to meet the requirements in order to provide decision support for complex domains. As a rule, agents within the decision support systems must carry out the following functions: to search for valuable information and to retrieve it; for multiple scaling in case of heterogeneous sources of income and outcome information; to provide intercommunication between the system and the external information sources (e.g. sensors, remote equipment); to check input data for consistency and to preprocess it; to execute data mining procedures; to experiment with different alternatives and to make recommendations; to organize human-computer interactions.

Modern “decision support systems” and “expert systems” (ES) are commonly based on intelligent agents, and the concepts of DSS as well as those of ES have also been modified (Lussier *et al*.,2007). For example, medicine is a traditional field of DSS application, and some recent academic reports deal with examples of novel usage of agent-based DSS for home and hospital care, pre-hospital emergency care and health monitoring and surveillance (Annicchiarico *et al.*,2012).

One of such applications is a distributed DSS for brain tumor diagnosis and prognosis, where agents use both data mining methods and decision-making techniques (Spargue & Carlson, 2010). An application of remote control of patients via clinical DSS is created on the basis of multi-agent methodology, and results in the creation of the SAPHIRE multi-agent system. There are many reasons to apply the agent paradigm: the necessity to interact in heterogeneous distributed environments, the need to provide instantaneous communication of autonomous components in a reactive manner, or the possibility to dynamically create and eliminate agents. It this application, the agents provide all the vital functions of the system.

Foster *et al.* (2011) provides a survey of intelligent-based system for decision support which supports clinical management and research. The author gives a brief introduction into DSS and agent-based DSS and gives an example of a Neonatal Intensive Care Unit system. In the high-level diagram of the proposal there is the solution manager service, which represents an Intelligent DSS (IDSS). The Analytical Processor of the IDSS joins different types of agents: functional, processing, human and sub-agents, and this processor is aimed to detect trends and patterns the data of interest.

Chen and Bell (2002) outlines the MAS “Instrumented City Data Base Analyst”, which is aimed to reveal correlations between human health and environmental stress factors (traffic activity, meteorological data, noise monitoring information and health statistics) by using a wide range of DM methods, including regression analysis, neural networks, ANOVA and others. The architecture of the system counts a number of modules placed within four levels. The multi agent structure includes specific modeling agents, which create models for the environmental stress factors, and are then harmonized by the model co-ordination agent. The Data Abstractor is an agent that gets information from sensors, fuses it and preprocesses it. Interaction with humans is provided by the Reception agent. In Li *et al*. (2015) work, a clinical DSS interface for displaying glycemic, lipid and renal function results, in an integrated form based on local clinical practice guidelines was done. The clinical DSS included a dashboard feature that graphically summarized all relevant laboratory results and displayed them in a colour coded system that allowed quick interpretation of the metabolic control of the patients.

Athanasiadis and Mitkas (2012) presented the outcome of the construction and usage of an agent-based environmental monitoring system. It is aimed to provide measurements of meteorological information and air pollution, to analyze them and to generate alarm signals. The system is created by means of the intelligent platform “Agent Academy”. The system has a three-leveled organizational structure where data preprocessing, its manipulation and distribution are carried out. The necessary steps for data transformation are executed by the following types of intelligent agents: Diagnosis agents, Alarm agents, Database agents and Distribution agents. In another article, the authors report about the application of the agent paradigm for the evaluation of socially oriented advertising campaigns aimed to affect consumers’ behavior (Athanasiadis & Mitkas, 2005). The authors create social communication models to simulate a public response to mass-media influence and introduce a social grid populated with autonomous consumer agents. This grid is also used to evaluate possible outcomes of the public campaign on water demand control. Another situation assessment is carried out by an agent-based system created with the MASDK tool (Gorodetski *et al*.,2010). The authors present their approach in situation assessment and explain its possible application in different problem areas. Another approach to complex situation assessment has been presented (Ly *et al*.,2003). The authors have accepted the Joint Directors of Laboratories (JDL) model as a basis for situation awareness. Their new approach to situation assessment learning is described and the structure of the MAS is presented as well. The agents act within the four levels of the hierarchical JDL-model.

In another reference Urbani and Delhom (2008), the authors presented the framework of a decision support system for water management in the Mediterranean islands, coupling a multi-agents system with a geographic information system. The platform developed made it possible for users to understand better the current operation of the system, apprehend the evolution of the situation, and simulate different scenarios according to the selected water policies and the climatic changes hypothesis. Recently, the development and experimental evaluation of an Internet-enabled multiagent prototype called AgentStra (Li, 2009), for developing marketing strategies, competitive strategies and associated e-commerce strategies has been introduced.

On the other hand, specialists working with environmental sciences and public health store huge volumes of relevant information about pollutants and human health. Continuous processing and maintenance of the information requires substantial efforts from the practitioners and professionals, not only while handling and storing data, but also when interpreting it. Actually, it seems very hard to handle all the data without using data mining (DM) methods, which can autonomously dig out all the valuable knowledge that is embedded in a database without human supervision, providing a full life-cycle support of data analysis. Using such techniques as clustering, classification, logical and association rule-based reasoning, and other methods, which are highly demanded for comprehensive environmental data analysis. For instance, DM techniques for knowledge discovery and early diagnostics are utilized for early intervention in developmentally- delayed children (Chang, 2007).

Shortliffe *et al*. (1975) developed the first expert system (MYCIN). Since then, expert system in the field of medicine became an important issue. There are some medical diagnostic systems based on Back Propagation Network (BPN): “The expert system for dermatology diagnosis” (Yoon *et al*., 1990), “The diagnosis for acute coronary occlusion” (Baxt, 1990) and “The early diagnosis of heart attack” (Harrison *et al*., 1991). Beside above systems, there are also some Chinese medical diagnostic systems based on BPN: “zhaosong-quan Chinese medical expert system of infertility” (Beijing obstetrics and gynecology hospital), “Composite international diagnostic system” (Beijinghui-guan hospital), “The program of Chinese medical liver compliant diagnosis” (Beijing Chinese medical hospital).

Androuchko et al. (2010) proposed an expert system called Medoctor which is a web – based system and has a powerful engine to perform all necessary operations. The system architecture provided by them is highly scalable, modular, and accountable and most importantly enables the incorporation of new features to be economically installed in feature versions. The user interface module of that system presents a series of questions in layman’s language for knowledge acquisition and also to show the top three possible diseases or conditions. However, this system lacks accuracy in decisions and also it is not following the coding of diseases as per the standards. Hence, there is need for proposing a system with increased accuracy and standard.

Shusaku and Tsumoto (2011) proposed a web based medical expert system in which the web server provides an interface between hospital information systems and home doctors. According to them, the recent advances in computer resources have strengthened the performance of decision-making process and the implementation of knowledge base (Shusaku & Tsumoto, 2011) operations. Moreover, the recent advances in web technologies are used in many medical expert systems for providing efficient interface to such systems. Moreover, many such systems are put on the internet to provide an intelligent decision support in telemedicine and are now being evaluated by regional medical home doctors.

Proposed system and Implementation

Pre-Diagnostic Phase

This phase of diagnosis is to ascertain the presence of kidney stone. Patients that exhibit three or more of the selected symptoms is ascertained to be suffering from kidney stone and can then delve into the post diagnostic (advanced) phase.

Post Diagnostic Phase

The post diagnostic phase encompasses the major component of an expert system. It includes;

Stage 1: Rule Generation

The linguistic model of a process is commonly made of a series of IF…THEN rules. These rules use the measured state of the process (the rule antecedents) to estimate the extent of control action (the rule consequents). It describes the local input-output relations using the rules with consequent that are usually linear combinations of the inputs. The rules generated cover every possible combination of the input values.

The rule base was formulated using Multiple Inputs Single Output (MISO) technique (Alavala, 2012) based on the AND logical connective to form a logical function.

$R_1: If\ X_1\ is\ A_1\ and\ X_2\ is\ A_2\ and\ \cdots and\ X_n\ is\ A_n\ then\ y_1\ is\ c_1,$

$R_2: If\ X_1\ is\ A_1\ and\ X_2\ is\ A_2\ and\ \cdots and\ X_n\ is\ A_n\ then\ y_2\ is\ c_2,$

$R_i: If\ X_1\ is\ A_!\ and\ X_2\ is\ A_2\ and\ \cdots and\ X_n\ is\ A_n\ then\ y_i\ is\ c_i$

$R_i$is the ithrule, $X = [X_1, \cdots, X_n]^T$is the vector of inputs, y_i is the rule output,$A = A_1, \cdots, A_n$ are the known facts (values) defined in the antecedent space and $c_i$is the action to be taken. Specificity (the one with the most condition attached) was the conflict resolution strategy used in deciding the action to be taken.

Stage 2: Working Data Memory (WDM)

This holds the items of data (Known facts). The system checks whether the data matches any rules in the rule base. Their presence or absence causes the inference engine to trigger certain rules.

Stage 3: Knowledge Base (KB)

The KB contains the rules (production rules) generated. Rules fire if and only if when data in the WDM matches the condition of one of the rules in the system.

Stage 4: Inference Engine

The Inference Engine method used was Forward Chaining. This is as result of not exploring no specific goal. It is guided by the given data, that is, the Knowledge (which is also, the rules) contained in the rule based as well as the known facts concerning the problem at hand, and thus, called Data-Driven Reasoning.

$If\ X\ and\ Y\ Then\ Z$

Here, rules to reason is forwarded based on the known facts in the WDM to establish new conclusion (that is, facts) to add to the WDM. The result obtained from the inference engine is sent to the user interface.

System Implementation

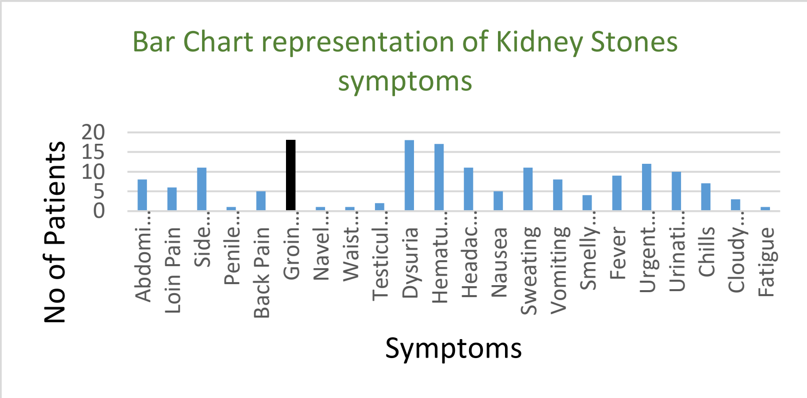
This is the process of defining how the information system should be built, ensuring that the information system is operational and used and ensuring that the information system meets quality standard.

Features Extracted and Selected

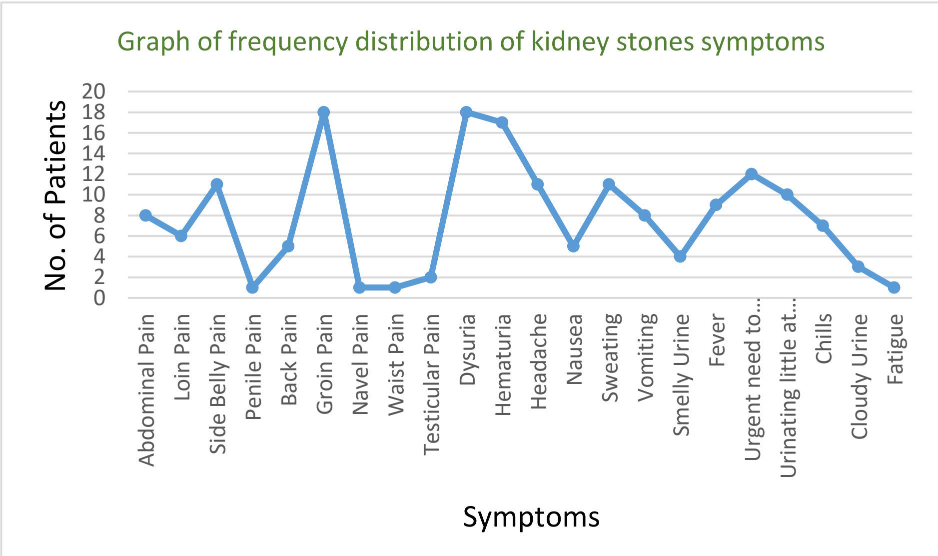
Twenty-two symptoms names' and the number of patients were collected as presented on Tables below, The bar chart and graph of frequency distribution of the data presented also respectively.

Frequency Distribution for the Kidney Stones Symptoms

S/N	Symptoms	Number of Patients
1.	Abdominal Pain	8
2.	Loin Pain	6
3.	Side Belly Pain	11
4.	Penile Pain	1
5.	Back Pain	5
6.	Groin Pain	18
7.	Navel Pain	1
8.	Waist Pain	1
9.	Testicular Pain	2
10.	Dysuria	18
11.	Hematuria	17
12.	Headache	11
13.	Nausea	5
14.	Sweating	11
15.	Vomiting	8
16.	Smelly Urine	4
17.	Fever	9
18.	Urgent need to urinate	12
19.	Urinating little at a time	10
20.	Chills	7
21.	Cloudy Urine	3
22.	Fatigue	1



Bar Chart representation of the Kidney Stones Symptoms



Graph of frequency distribution of kidney stones symptoms

From Equ. (3.1) and (3.2);

$\overline{X} = 7.681818$……………………………………………………………………….…… (4.1)

($where\ \sum x = 169$ and $N = 22$ as the working parameters)

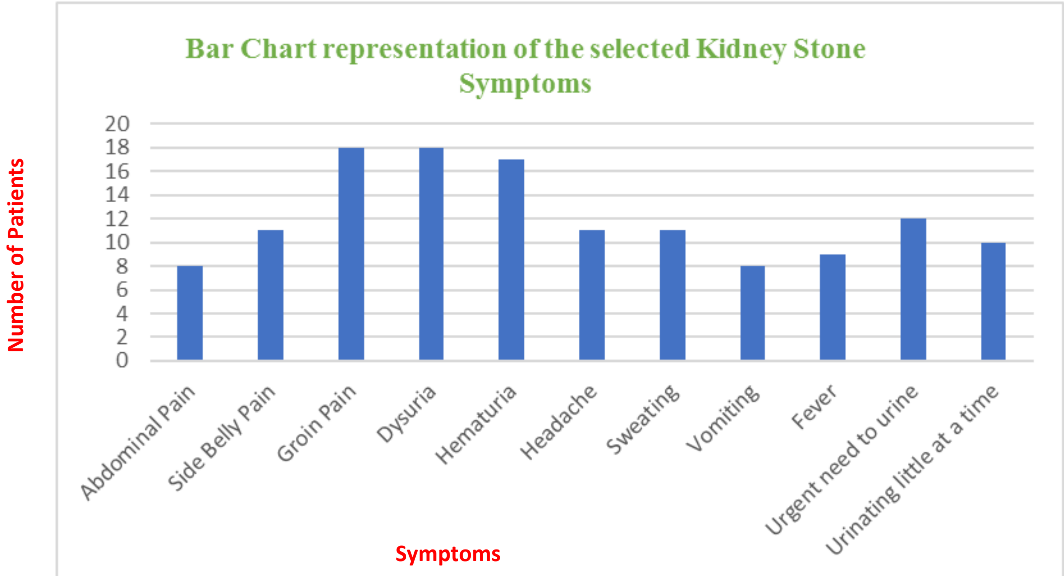
Therefore,

$Total\ S_s$ = 11 symptoms ………………………………………………...……….... (4.2)

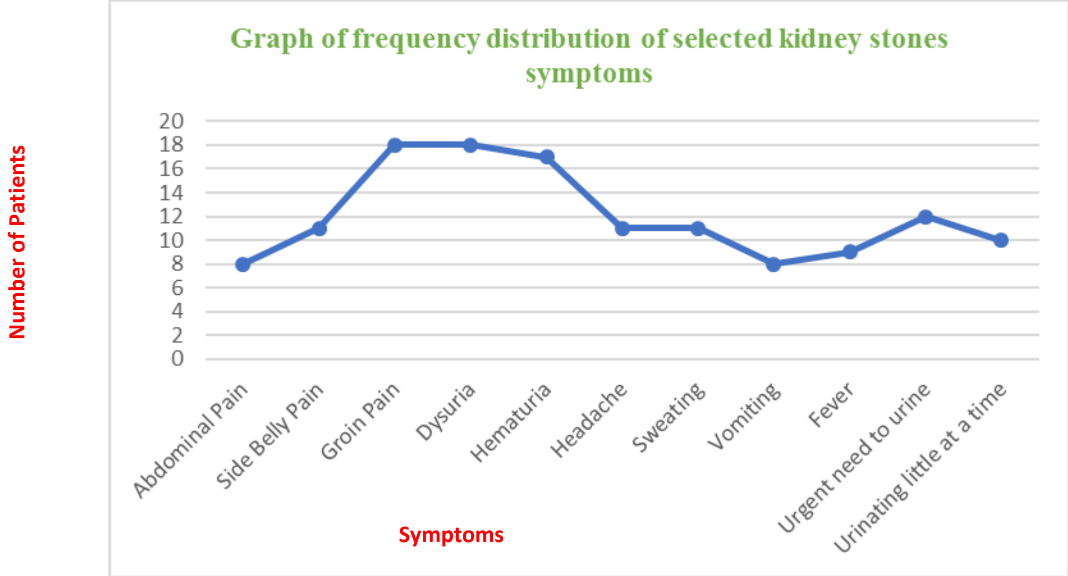
The eleven symptoms that were selected are depicted on Table below

Kidney Stones Selected Symptoms

Symptoms
Abdominal Pain
Side Belly Pain
Groin Pain
Dysuria
Hematuria
Headache
Sweating
Vomiting
Fever
Urgent need to urine
Urinating little at a time



Bar Chart representation of the selected kidney stones symptoms



Graph of frequency distribution of selected kidney stones symptoms

Rules Generated

Here, the advanced diagnosis treatment parameters (Blood, X-ray, T-Scan and Urine) were used as the inputs (Prentzas & Ioannis, n.d). These numbers of rules were generated based on the ranking of the input parameters as depicted on Table below. Eighty-one (81) MISO production rules were generated.

Ranking of Advanced Diagnosis Treatment Parameters

Parameter	Scaling		
	Low (l_s)	Medium (m_s)	High (h_s)
Blood	$0 < l_s < 30$	$30 < m_s < 70$	$70 < h_s < 100$
X-ray	$2mm < l_s \leq 4mm$	$4.1 < m_s \leq 6mm$	$6.1mm < h_s \leq 8mm$
CT-Scan	$2mm < l_s \leq 4mm$	$4.1 < m_s \leq 6mm$	$6.1mm < h_s \leq 8mm$
Urine	$0 < l_s < 30$	$30 < m_s < 70$	$70 < h_s < 100$

1. If blood is high and urine is high and x-ray is high and CT scan is high, then this patient must undergo a surgery
2. If blood is high and urine is high and x-ray is high and CT scan is moderate, then this patient must undergo a surgery
3. If blood is high and urine is high and x-ray is high and CT scan is low, then this patient is likely to undergo a surgery
4. If blood is high and urine is high and x-ray is moderate and CT scan is high, then Patient is likely to undergo a surgery
5. If blood is high and urine is high and x-ray is moderate and CT scan is moderate, then Place the patient on drugs
6. If blood is high and urine is high and x-ray is moderate and CT scan is low, then Place this patient on drugs
7. If blood is high and urine is high and x-ray is low and CT scan is high, then this patient is likely to undergo a surgery
8. If blood is high and urine is high and x-ray is low and CT scan is moderate, then Place this patient on drugs

9. If blood is high and urine is high and x-ray is low and CT scan is low, then No Presence of kidney stone
10. If blood is high and urine is moderate and x-ray is high and CT scan is high, then this patient must undergo a surgery
11. If blood is high and urine is moderate and x-ray is high and CT scan is moderate, then this patient is likely to undergo a surgery
12. If blood is high and urine is moderate and x-ray is high and CT scan is low, then this patient is likely to undergo a surgery
13. If blood is high and urine is moderate and x-ray is moderate and CT scan is high, then this patient is likely to undergo a surgery
14. If blood is high and urine is moderate and x-ray is moderate and CT scan is moderate, then Place this patient on drugs
15. If blood is high and urine is moderate and x-ray is moderate and CT scan is low, then Place this patient on drugs
16. If blood is high and moderate is high and x-ray is low and CT scan is high, then this patient is likely to undergo a surgery
17. If blood is high and urine is moderate and x-ray is low and CT scan is moderate, then Place this patient on drugs
18. If blood is high and urine is moderate and x-ray is low and CT scan is low, then No Presence of kidney stone
19. If blood is high and urine is low and x-ray is high and CT scan is high, then this patient must undergo a surgery
20. If blood is high and urine is low and x-ray is high and CT scan is moderate, then this patient is likely to undergo a surgery
21. If blood is high and urine is low and x-ray is high and CT scan is low, then this patient is likely to undergo a surgery
22. If blood is high and urine is low and x-ray is moderate and CT scan is high, then this patient is likely to undergo a surgery
23. If blood is high and urine is low and x-ray is moderate and CT scan is moderate, then Place this patient on drugs
24. If blood is high and urine is low and x-ray is moderate and CT scan is low, then Place this patient on drugs
25. If blood is high and urine is low and x-ray is low and CT scan is high, then this patient is likely to undergo a surgery
26. If blood is high and urine is low and x-ray is low and CT scan is moderate, then Place this patient on drugs
27. If blood is high and urine is low and x-ray is low and CT scan is low, then No Presence of kidney stone
28. If blood is moderate and urine is high and x-ray is high and CT scan is high, then this patient must undergo a surgery
29. If blood is moderate and urine is high and x-ray is high and CT scan is moderate, then this patient is likely to undergo a surgery
30. If blood is moderate and urine is high and x-ray is high and CT scan is low, thenthis patient is likely to undergo a surgery
31. If blood is moderate and urine is high and x-ray is moderate and CT scan is high, then this patient is likely to undergo a surgery
32. If blood is moderate and urine is high and x-ray is moderate and CT scan is moderate, then Place this patient on drugs

33. If blood is moderate and urine is high and x-ray is moderate and CT scan is low, then Place this patient on drugs
34. If blood is moderate and urine is high and x-ray is low and CT scan is high, then this patient is likely to undergo a surgery
35. If blood is moderate and urine is high and x-ray is low and CT scan is moderate, then Place this patient on drugs
36. If blood is moderate and urine is high and x-ray is low and CT scan is low, then No Presence of kidney stone
37. If blood is moderate and urine is moderate and x-ray is high and CT scan is high, then this patient must undergo a surgery
38. If blood is moderate and urine is moderate and x-ray is high and CT scan is moderate, then this patient is likely to undergo a surgery
39. If blood is moderate and urine is moderate and x-ray is high and CT scan is low, then this patient is likely to undergo a surgery
40. If blood is moderate and urine is moderate and x-ray is moderate and CT scan is high, then this patient is likely to undergo a surgery
41. If blood is moderate and urine is moderate and x-ray is moderate and CT scan is moderate, then Place this patient on drugs
42. If blood is moderate and urine is moderate and x-ray is moderate and CT scan is low, then Place this patient on drugs
43. If blood is moderate and urine is moderate and x-ray is low and CT scan is high, then this patient is likely to undergo a surgery
44. If blood is moderate and urine is moderate and x-ray is low and CT scan is moderate, then Place this patient on drugs
45. If blood is moderate and urine is moderate and x-ray is low and CT scan is low, then No Presence of kidney stone
46. If blood is moderate and urine is low and x-ray is high and CT scan is high, then this patient must undergo a surgery
47. If blood is moderate and urine is low and x-ray is high and CT scan is moderate, then this patient is likely to undergo a surgery
48. If blood is moderate and urine is low and x-ray is high and CT scan is low, then this patient is likely to undergo a surgery
49. If blood is moderate and urine is low and x-ray is moderate and CT scan is high, then this patient is likely to undergo a surgery
50. If blood is moderate and urine is low and x-ray is moderate and CT scan is moderate, then Place this patient on drugs
51. If blood is moderate and urine is low and x-ray is moderate and CT scan is low, then Place this patient on drugs
52. If blood is moderate and urine is low and x-ray is low and CT scan is high, then this patient is likely to undergo a surgery
53. If blood is moderate and urine is low and x-ray is low and CT scan is moderate, then Place this patient on drugs
54. If blood is moderate and urine is low and x-ray is low and CT scan is low, then No Presence of kidney stone
55. If blood is low and urine is high and x-ray is high and CT scan is high, then this patient must undergo a surgery
56. If blood is low and urine is high and x-ray is high and CT scan is moderate, then this patient is likely to undergo a surgery

57. If blood is low and urine is high and x-ray is high and CT scan is low, then this patient is likely to undergo a surgery
58. If blood is low and urine is high and x-ray is moderate and CT scan is high, then this patient is likely to undergo a surgery
59. If blood is low and urine is high and x-ray is moderate and CT scan is moderate, then Place this patient on drugs
60. If blood is low and urine is high and x-ray is moderate and CT scan is low, then Place this patient on drugs
61. If blood is low and urine is high and x-ray is low and CT scan is high, then this patient is likely to undergo a surgery
62. If blood is low and urine is high and x-ray is low and CT scan is moderate, then Place this patient on drugs
63. If blood is low and urine is high and x-ray is low and CT scan is low, then No Presence of kidney stone
64. If blood is low and urine is moderate and x-ray is high and CT scan is high, then this patient must undergo a surgery
65. If blood is low and urine is moderate and x-ray is high and CT scan is moderate, then this patient is likely to undergo a surgery
66. If blood is low and urine is moderate and x-ray is high and CT scan is low, then this patient is likely to undergo a surgery
67. If blood is low and urine is moderate and x-ray is moderate and CT scan is high, then this patient is likely to undergo a surgery
68. If blood is low and urine is moderate and x-ray is moderate and CT scan is moderate, then Place this patient on drugs
69. If blood is low and urine is moderate and x-ray is moderate and CT scan is low, then Place this patient on drugs
70. If blood is low and urine is moderate and x-ray is low and CT scan is high, then this patient is likely to undergo a surgery
71. If blood is low and urine is moderate and x-ray is low and CT scan is moderate, then Place this patient on drugs
72. If blood is low and urine is moderate and x-ray is low and CT scan is low, then No Presence of kidney stone in this patient
73. If blood is low and urine is low and x-ray is high and CT scan is high, then this patient must undergo a surgery
74. If blood is low and urine is low and x-ray is high and CT scan is moderate, then this patient is likely to undergo a surgery
75. If blood is low and urine is low and x-ray is high and CT scan is low, then this patient is likely to undergo a surgery
76. If blood is low and urine is low and x-ray is moderate and CT scan is high, then Place this patient is likely to undergo a surgery
77. If blood is low and urine is low and x-ray is moderate and CT scan is moderate, then Place the patient on drugs
78. If blood is low and urine is low and x-ray is moderate and CT scan is low, then Place the patient on drugs
79. If blood is low and urine is low and x-ray is low and CT scan is high, then this patient is likely to undergo a surgery
80. If blood is low and urine is low and x-ray is low and CT scan is moderate, then Place the patient on drugs

81. If blood is low and urine is low and x-ray is low and CT scan is low, then No Presence of kidney stone in this patient

CONCLUSION

In this thesis, the researchers designed a decision support system using rule base for diagnosis of kidney stone disease. This system can be effectively used to diagnose kidney stone and make intelligent decisions on related clinical issues. This system is not to rule out the job of the urologists, but to assist them in handling issues of clinical decision making. The experiments conducted shows that the system has very high accuracy in terms of decision making. This goes ahead to show that rule base works very well in decision support system.

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