A Proposed Model for Health Management and Expert Diagnosis System for the Prediction of Common Diseases for Ethiopia (East Africa)

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ABSTRACT
Many rural & pastoral communities in Ethiopia have extremely limited access to medical advice. People are traveling long distances to avail medical facilities, and there is a shortage of medical experts in most of the health institutions. This results in slow service, and ends up waiting long hours without receiving any attention for the patient. Expert on particular diseases is also not available at the health centers, in that case, patients are misdiagnosed and abused medically. Hence medical expert systems can play a significant role in such scenarios where medical experts are not readily available. This work presents the patients registration system and design of a knowledge-based expert system that aims to provide the prediction of the diseases to the patients and medical advisors to expedite their non-surgical diagnostic system.

Keywords: Expert Diagnosis system, Prediction system, Common diseases, Support Vector Machine, Symptoms and signs of diseases.

I. INTRODUCTION

Ethiopia is a land of cultural diversity. Eighty percent of the population are living in remote and rural areas (World Bank Report, 2014) [1]. Basic facilities and resources are very limited for daily needs. Peoples are traveling a long distance to avail the resources, especially in case of medical assistance. Medical experts and advisers are very less in numbers. So patients are waiting in long queue unattended. This pathetic situation will observe everywhere in rural and remote areas. This research is focusing especially for Ethiopia, East Africa. The area is covered with dry and unproductive land. Ninety percent populations are living in rural/remote areas and mostly belong to pastoral and agro pastoral community. The population of Ethiopia is more than 102.4 Million (on the basis of Ethiopian census) [2]. There are no well-equipped medical facility, primary and higher education system, lack of safe drinking water, lack of good transportation and other basic infrastructures. The literacy rate is very poor. Hospitals are located only at headquarters. These hospitals are difficult to approach by the pastoral community. Due to lack of medical experts in the rural area, medical diagnosis process is very slow. To expedite the system this research aims to develop a prototype knowledge-based system for the provision of medical advice on common diseases. The medical field needs appropriate facilities and medical experts for efficient service delivery. Deaths occur mostly in situations where patients' conditions are critical and yet no medical facilities and experts to handle those situations [3]. In expert diagnosis system, detection of diseases are readily available consultations can be taken online for the particular disease if medical expert is not available [8].

Shortages of medical experts, hospitals and equipment are some of the major problems confronting the health sector of most developing countries and thus responsible for misdiagnosis, poor diagnosis, self-medication, drug abuse, deaths and economic backwardness. It was also evident that the computer technology has been successfully utilized in the health sector in conjunction with medical experts to develop computer aided diagnostic systems.

Medical diagnosis system in Ethiopia is based on manual monitoring system. Due to lack of expert medical practitioners, it increases diagnosis time, cost of diagnosis and high probability that patients are abused medically

A. Expert Diagnosis System in Medical Field

The expert diagnosis system is a subfield of artificial intelligence; term Diagnosis is concerned with the development of algorithms and techniques that are able to determine whether the behavior of a system is correct. If the system is not functioning correctly, the algorithm should be able to determine, as accurately as possible, which part of the system is failing, and which kind of fault it is facing. In another way we can say that expert systems are the knowledge based system by the expert and future prediction is given on the basis of set of association rules which are extracted from the knowledge base shown in Figure 1.

Expert System for the medical science is a kind of software that runs in computer memory and works the same kind of interaction as a medical specialist work and gives prediction of diseases to the patient as a specialist. It is a kind of software that asks you about your symptoms and signs of disease and provide a prediction of the possible disease.

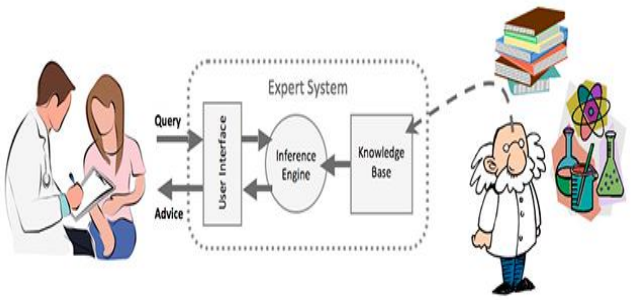

Fig.1 Expert Diagnosis System [26]

B. Medical System for Non-Surgical Treatment

Non-surgical medical procedures are used to diagnose, measure, monitor or treat problems such as diseases or injuries that don't require surgery. They are generally not highly invasive and don't involve cutting. Non-surgical procedures are carried out by a health professional such as a physician, general practitioner, diagnostician or nurse. Figure 2 shows the Non-surgical medical treatment procedure.

Nonsurgical Examination Procedure

Non-surgical procedures can be grouped into the following classes:

a) Physical examination (propaedeutic procedures)
b) Tests, x-rays and scans (diagnostic procedures)
c) Treatments to repair the effects of injury, disease or malfunctions, including medicines, physical and radiation therapies (therapeutic procedures)

Physical Examination

Commonly known as a physical examination, propaedeutic procedures are basic hands-on methods used by a doctor to get a general sense of a person's health and wellbeing. Some examples are included :

a) Looking at the person to check their appearance.
b) Touching areas of the person's body (palpation) to check for abnormalities such as pain, tenderness, swelling, masses or lumps.
c) Tapping areas of the person's body (percussion) to check for the absence or presence of air or liquid inside a body cavity.
d) Listening to internal body sounds with a stethoscope (auscultation), such as the sounds made by the heart, lungs or abdominal organs.
e) Taking note of the person's vital signs, such as temperature and blood pressure.

Tests, X-Rays and Scans

Diagnostic procedures are tests that a doctor uses to help diagnose a person's medical problem or to measure the severity of the problem. The results of diagnostic procedures also help a doctor or other health professional to plan the best course of treatment. Many diagnostic procedures are available. Some examples include:

a) **Body fluid tests** – such as blood tests and urine tests.
b) **Non-invasive scans** – such as x-ray examinations, magnetic resonance imaging (MRI), ultrasound and computed tomography (CT).
c) **Electrographs** – a graph made by measuring electrical activity within the body. Examples include electrocardiography or ECG (heart) and electroencephalography or EEG (brain).
d) **Angiograms** – a type of special x-ray that involves an injection of a contrast dye to better define the blood vessels. Examples include coronary (heart) angiogram, cerebral (brain) angiogram and pulmonary (lung) angiogram.
e) **Endoscopy** – a slender tube (endoscope) is inserted into the body, which allows the doctor to make a visual inspection. Examples of endoscopic procedures include colonoscopy (bowel), gastroscopy (stomach), cystoscopy (bladder), bronchoscopy (airways of the lung) and laparoscopy (abdomen).

C. How Expert Diagnosis System Will Help Non-Surgical Treatment

Even though the expert diagnosis system can design to help in all phases of medical treatment, but due to the sensitivity of the different medical cases, this research focuses in the first phase for the identification of accurate diseases. It can help the medical treatment system in following ways:-

a) Prediction of diseases accurately.
b) Recommendation to the needed lab tests only.
c) If the expert is not available for a specific disease, then medical practitioner can consult help for treatment from the expert practitioners.
d) Load shedding from the medical practitioners.
e) More patients can be consulted.
f) Reduction in medical abuse and misdiagnosis.

II. RATIONALE OF THE RESEARCH

Expert diagnosis systems are the backbone of the developed countries. Online systems as well as mobile apps are going viral and a large number of users are benefited. These systems are comparatively very cheap in comparison to visiting the medical practitioners. On the basis of symptoms they are advised to pathological test for confirmation and diagnosis of particular disease. These systems are also very helpful to the medical practitioners to expedite their services. These prediction systems are available everywhere in the medical field. Million dollars of revenue are generated by these systems in the developed countries. These prediction systems are not only applicable to the developed countries, but also in developing and underdeveloped countries where hospitals are few in numbers and lack of medical practitioners.

India is a developing nation, and they developed one of the most revolutionized medical device its name is **"Swasthya Slate"** (Health Tablet). It is a Bluetooth-enabled integrated diagnostic kit that works with an android based mobile system, to perform 33 diagnostics tests, and is equipped with various applications that are created strategically to increase

access to health care and health education in the country. Through a number of mobile applications, it is able to record a patient's medical history, basic medical indicators and even offer on-the-spot diagnosis on the basis of the information gathered. It offers health communication through its knowledge sharing apps, with an aim to break unhealthy behaviour patterns. It even covers decision support tools to enable users to deliver quality recommendations for achieving better health, and provides strategic information for data driven policy decisions. Policy Makers can get real time data from portals and enhance data driven policy making. It is an affordable system that has been tested and employed across the world by frontline health workers, doctors and policy makers. It can provide a means of delivering a national screening and diagnostic service which can allow targeted health analytics, delivery and communication.

In tropical countries, most of them are developing countries, medical personnel and facilities are inadequate for effective control of tropical diseases. Intelligent systems have become vital to the growth and survival of the healthcare sector. Recently much research efforts have been concentrated on designing intelligent systems [9], [10], [11], [12] and [13] for under developing countries.

III. LITERATURE REVIEW

The Medical diagnostic Systems comprise undergone lots of changes and are using innovative techniques to generate enhanced results. The complete detail is given in Table1, including the disease type and inputs to the system for prediction of the diseases.

Hossain, M.S, [13] design, development and application of an expert system for diagnosis of influenza under uncertainty. The recently developed general belief rule-based inference method by using the evidential reasoning (RIMER) approach is in use to develop this system, termed as Belief Rule Based Expert System (BRBES). This approach preserves handle different types of uncertainties, together in knowledge representation, plus in inference procedures. Symptoms of this disease are considered as inputs to the system are cough, fever, headache, bireme, nasal congestion, nasal polyps and sinusitis. The knowledge-base was constructed by using evidences of the real patient data along through in discuss with the Influenza specialists of Bangladesh. Validate the BRBES by using the practical case studies. This system generated results are effective with more reliable than manual system in terms of accuracy.

Azian Azamimi Abdullah, [14] proposed a Fuzzy expert system for diagnosis of the risk of hypertension patients for patients aged between 20's, 30's and 40's years as well as is divided into male and female gender. Data set are acquired from 10 people which consists of male & female with dissimilar background and input parameters used for this system are age, body mass index, blood pressure and heart rate. In diagnosis process, linguistic variables and their membership functions are based on medical expert's knowledge. This proposed system can provide a cheaper and more accurate result then other techniques for diagnosis of blood pressure i.e. hypertension.

Komal R. Hole, [15] present a rule-based expert system for memory loss disease by the help of rules and facts. For saving the cases Case-based approach is used and compared with previously saved cases. This paper initially discusses diverse approaches in designing of medical expert systems by focus on all the information concerning the memory loss. This system will assist the patients to obtain the advice about the different disorders assault to them due to their nervous system disorders. It is an attempt to center on some of extremely important diseases related to memory. Expert rules developed on symptoms of every type of neurological disease and presented by decision tree also inferred with forward-chaining method. The knowledge base is collected from books and doctors that contain information about memory loss and all its related diseases.

Neshat, M, [16] designed a fuzzy system for learning, analysis and diagnosis of liver disorders. In this work, data have been selected from the trusty database (UCI) that has 345 records and 6 fields as the entry parameters and rate of liver disorder risks is worn as the system resulting. All the standardization methods within medical diagnosis, a correct diagnosis is immobile considered to be an art much of this situation is for, to medical diagnosis needs ability as well as experience in dealing through uncertainty. This system is compared with other traditional diagnostic systems. This fuzzy system can be helpful to a specialist assistant or for training medication students. This system is faster, cheaper, and also more liable and more accurate also a specialist assistant or for training medicine students. The verification on time diagnosis and appointing the rate of liver disorders improvement is 91%.

Noura Ajam [17] attempt has make to use of Artificial Neural network for diagnosis of heart disease. Feed-forward back propagation neural network is utilized as a classifier to differentiate between absence and presence of disease. The result shows that the performance of this network is 88% of cases in testing set.

Maitri Patel, [18] proposed a web based expert system for diagnosis of viral infections. A rule based expert system present consultation along with analysis is more beneficial while used through web based applications. Most important focus is made on practice of technology by the current inventions is made, to benefit the community in overall wellbeing. Prescriptions to these infections canister are deduced through this system, which are accurate as well as many medical practitioners and knowledge has been employ to develop the knowledge base.

E. Bursuk, [19] establish a medical expert system for diagnosis of cardio-logical diseases. This medical system will be practical for both patients and physicians and is developed by using a community domain rule based expert system. In this fact and rules symbolize expert and reference book's knowledge. For program's inference engine a cardio-

logical disease tree is formed and it has "yes" or "no" answers to questions. The database contains the thirteen diseases. The valuation of this program is complete by twenty-five patient information. Proposed system results are compatible with physician's diagnoses.

S Ali, [20] present an automatic delivery system for clinical guidelines (DSCG) to supports clinicians in diagnosing and treating patients tolerate from chest pain in the emergency division. This system obtains patient data, such as illness and assessment results, as well as matches these data with eligibility criteria. Strategies are adaptively chosen from a knowledge base server that has records of clinically defined, graphical strategy. It recommends the majority favorable treatment arrangements and analysis based on the nearly all feasible diagnosis. Clinicians might either use the commendations as a suggestion or trigger an assortment to check the patient's condition during the cure with an intelligent agent.

Md. S. Hossain, [21] developed an expert system for diagnosis of measles under uncertainty. A belief rule-based inference methodology using evidential reasoning approach (RIMER) can be used for developing the system, which is able of handling various types of uncertainties. Measles is usually diagnosed from its signs and symptoms via a physician, which cannot be deliberate with 100% confidence during the diagnosis procedure.

B. Prasad, [22] presents a knowledge-based system for training student physicians to diagnose bronchial asthma.

Solomon Gebremariam [23] build up a prototype self-learning knowledge-based system that preserve offer advice meant for physicians and patients toward assist the diagnosis plus cure of diabetic patients.

F. Ibrahim, [24] describes a knowledge-based system employing expert system rules to perceive different kinds of eye diseases.

Bekaddour Fatima, [25] summarizes an approach for recognizing breast cancer diagnosis by using adaptive neuro-fuzzy inference system.

IV. OBJECTIVES OF THE RESEARCH

To expedite the diagnostic system and to shed the load from hospitals and medical practitioners, this research aims to develop a knowledge-based system for the provision of medical advice on common diseases by giving the prediction, based on the symptoms and signs of the patient.

The objective of the research is to expedite the medical diagnostics system to provide the services to more people. The aim is divided into following sub-categories:

(a) A Framework is proposed for the expert diagnosis system for non-surgical medical treatment for, Ethiopia.

(b) Identification of the common diseases for Ethiopian community.

(c) Collection of data in the form of symptoms and signs and identification of important features and noise reduction in terms of useless features and redundant data.

(d) Development of association rules, classification of data sets, training of classified data set and testing of test data for evaluation of the accuracy of system.

(e) Building the detection system to predict the diseases on the basis of the model file/inference engine generated after rigorous checking of accuracy.

(f) Development of user interface for non-surgical treatment based expert diagnosis system.

V. PROPOSED FRAMEWORK

The conceptual framework for an expert diagnostic system for common diseases can be understood by non-surgical medical treatment system shown in Figure2, development of detection/inference engine for non-surgical support system shown in Figure 3 and final user interaction with disease prediction system of Figure4. Figure 2 shows the traditional diagnosis process during nonsurgical treatment. Figure 3 shows the Training of the data set and the generation of an inference engine. Figure 4 shows the query process or prediction system.

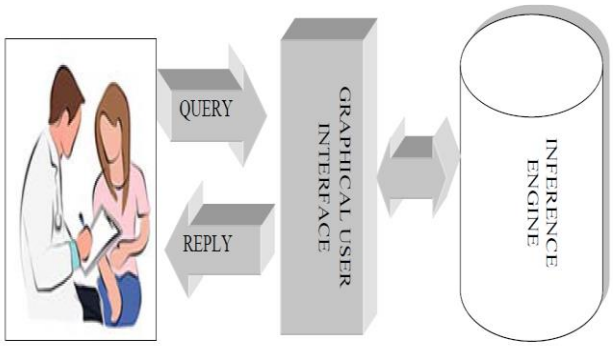

Fig.4: Prediction System Interface

A. *Support Vector Machine*

For training and testing of data set in this research employed support vector machine (SVM) is used as it is the best among the tools available [26], [27], [28], [29], [30], and [31]. SVM is used for solving a variety of learning, classification and prediction problems. SVM is a learning system that uses a hypothetically a space of linear functions. Training is given to the training data set with a learning algorithm from optimization based theory. This learning strategy introduced by Vapnik et al. [32], is a very powerful method that has been applied in a wide variety of applications. The basic SVM deals with a two-class problems in which the data are separated by a hyper plane defined by a number of support vectors. Support vectors are a subset of training data used to define the boundary between the two classes shown in Figure 5. Kernel function plays an important role in SVM, in practice, various kernel functions can be used, such as linear, radial, polynomial or sigmoid as per the complexity of input data set.

B. *Classification Of Data Set And Prediction Analysis*

Expert system alarm analysis provides four possible results for each analyzed data set.

True Positive (TP) when the attack succeeded and the Detection System (DS) was able to detect
(Success ^Detection).
True Negative (TN) when the attack failed and the DS did not report it:
(¬Success ^ ¬ Detection).
False Positive (FP) when the attack failed and the DS reported on it:
(¬ Success ^ Detection).
False Negative (FN) when the attack succeeded and the DS was not able to detect it:
(Success ^ ¬ Detection).
True Positive and True Negative are the correct classification and they help to improve the accuracy of the system.

C. Accuracy of the System

Recall: Recall is the percentage of total relevant documents in a database retrieved by a search [32]. If the user knew that there were 1000 relevant documents in a database and his search retrieved only 100 of these relevant documents, the recall would be only 10%.
Recall = TP/ (TP+FN). *(Equ.1)*
Precision: The percentage of relevant documents in relation to the number of documents retrieved [32]. If a search retrieves 100 documents and only 20 of these are relevant, then the precision is only 20%.
Precision = TP /(TP+FP). *(Equ.2)*
The accuracy of the IDS system is based on above mentioned parameters.

Accuracy of the System = (TP+TN) / (TP+TN+FP+FN) *(Equ.3)*

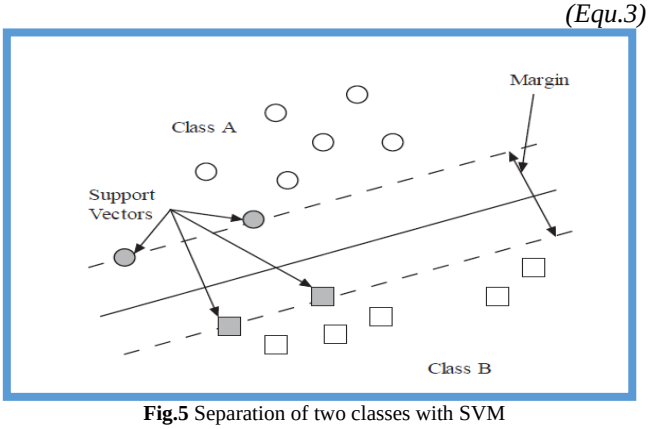

Fig.5 Separation of two classes with SVM

VI. RESEARCH METHODOLOGY

A. Selection of Area/Implementation of the Research

The research is representing the Ethiopia, Africa continent. To succeed the objective of research sampling and implementation area should cover at least 25% of the population of the selected region.

B. Selection of Diseases

The priority of selection of diseases will be done on the basis of following parameters:-

a) Medical practitioner's suggestion.
b) Based on the historical data about the diseases (which disease is more frequent).
c) Based on fatal and killer diseases.

C. Sampling Of Data Collection

Data collection sources will be district hospitals/labs from the various regions. Medical practitioner's interview, questionnaire session, feedback and suggestion will be recorded. Dillman (2007), provides the following formula given in equation-1, for estimating the desired sample sizes to increase the success of research projects and more sampling size increases the more accuracy for the system:

$$N_s = \frac{(N_p)(p)(1-p)}{(N_p-1)(B/C)^2+(p)(1-p)} \quad \textit{Equ-4}$$

where:
Ns = completed sample size needed (notation often used is n)
Np = size of population (notation often used is N)
p = proportion expected to answer a certain way (50% or 0.5 is most conservative)
B = acceptable level of sampling error (0.05 = ±5%; 0.03 = ±3%)
C = Z statistic associate with confidence interval (1.645 = 90% confidence level; 1.960 = 95% confidence level; 2.576 = 99% confidence level)

D. Method Of Data Collection

All the requirement analyst members will pay the visit to the district hospitals and labs for collection of data and gathering of the requirements. Following methodology will be followed for collecting the data:

a) Field visits to the actual sites of implementation (district hospitals and labs)
b) Preparation of Standard Questionnaire Session
c) Arrangement of Interview Session with medical practitioners
d) Arrangement of Group Discussion with medical practitioners
e) Suggestions and feedbacks will be invited from medical practitioners and patients.

E. Description Of Variables

Standard forms will be generated for the symptoms and signs of diseases. Symptoms indicates the physical appearance of the patient and signs indicates the internal feelings (like headache, stomach pain, chest pain etc.) of patient.

F. Assumptions And Dependencies

a. Assumptions

i. Our assumption is operator is having basic knowledge of computer skills. He needs to fill the questionnaire form on the system by asking the patient in Boolean format (yes/no).
ii. The form will be available in international language. (Though it can be translated to local languages.)
iii. Software will be available online, so need of internet connection. (Though offline filling of forms and prediction of diseases is possible)

b. Limitations

i. The system cannot screen the patient automatically.

ii. The system should not be used to prescribe the medication without consulting the medical practitioners.

G. *Plan Of Data Analysis And Implementation / Technical Aspects Of Research*

a) Disease analysis and identification

This section is visualized for identification of common diseases in the Ethiopia. For disease selection for the initial phase advice and suggestion will be taken from the medical practitioners of zone one and regional health departments.

b) Collecting the raw data from labs and hospitals

This Section is inclined for collecting the raw data and the given tasks are explained below. After identification of the diseases the next objective is to collect the data from hospitals and labs. Expert advice on the diseases from the expert medical practitioners will be taken. Common physical and visible symptoms and pathological data record will be collected.

c) Training & Testing of data sets

After collecting the raw data, noise (Redundant, duplicate, pruning of unnecessary data) on the data sets will be removed. ***Important Features*** will be identified. Association rules will be generated. Data will transfer to a common format. Then classification rule will be applied. The Support Vector Machine (SVM) will be used as a classifier and data will be train for prediction. Testing will be done to check the accuracy of the detection system.

d) Deploying the model file

After verification and validation of the model file by the experts, model file will deploy to the inference engine for further prediction of diseases.

e) *Providing the Graphical User Interface (GUI) to the prediction system*

The GUI will be provided to predict the diseases. The GUI will have the form of symptoms and signs. When user will fill the form, the system will check the model file and it will provide the prediction about the disease with degree of precision.

VII. CONCLUSION

Ethiopia is a land of cultural diversity and also the place for the different ethnic groups and nomadic tribes. Medical facility is very poor and difficult to reach to the people. Due to difficult approach and survivability skilled human resources are neglecting to serve the region. Medical diagnosis system in Ethiopia is based on manual monitoring system. Due to lack of expert medical practitioners, it increases diagnosis time, cost of diagnosis and high probability that patients are abused medically. This research is proposing a framework to help those medical practitioners who are serving the community in hard situation by proposing a knowledge based expert disease detection system to expedite the diagnostic system and to shed the load from hospitals and medical practitioners.

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TABLE I
SURVEY ON AVAILABLE PREDICTION SYSTEM

Reference	Disease Diagnosed	Inputs to System	Remarks
Hossain, M.S, Khalid, M.S, Akter, S, Dey, S [13]	Influenza Disease	Real patients data are collected by consulting the Influenza specialists of Bangladesh, Disease Symptoms	This system is developed by using rule-based inference method of evidential reasoning and handle different types of uncertainties. Validate the system by using the practical case studies and shows that system results are effective than manual system.
Azian Azamimi Abdullah, Zulkarnay Zakaria, Nur Farahiyah Mohammad [14]	Hypertension Disease	Age, Gender, Blood pressure, Body mass index and heart rate	This system is used to diagnosis of hypertension for patient's divided between aged and gender. Experimental results shown that this system is more accurate than other traditional methods
Komal R. Hole, Vijay S. Gulhane [15]	Memory Loss Disease	Disease Symptoms	The developed system based on rules and helps patients to obtain the advice about the different disorders. The knowledge base collects information from books and doctors about neurology and its disorders.
Neshat, M, Yaghobi, M, Naghibi, M.B, Esmaelzadeh, A [16]	Liver Disorders	Data gathered from trusty database, 6 entrance parameters of liver disorders	This fuzzy system can be helpful to a specialist assistant or for training medication students for diagnosis of liver disorders. The system verification on time diagnosis and appointing the rate of liver disorders is 91%.
Noura Ajam [17]	Heart Disease	Disease Symptoms	88% accuracy is achieved in diagnosis of heart disease by using feed forward back propagation neural network.
Maitri Patel, Atul Patel, Paresh Virparia [18]	Viral Infection	Disease Symptoms	This system has most important focus is made on practice of technology by the current inventions is made, to benefit the community in overall wellbeing.
E. Bursuk, M. Ozkan, B. Llerigelen [19]	Cardiological Diseases	Disease Symptoms	This proposed medical expert system is practical for both patients and physicians for providing decision of disease.
S Ali, P Chia, K Ong [20]	Chest Pain	Data obtained from Laboratory examinations, Ultrasound, Chest X-Ray images, Narrative texts describing the patient's condition	This expert system distributes appropriate clinical strategy and is finalized for pilot trial on the accidents and emergency department of the national university hospital.
Md. S. Hossain, K. Andersson, S. Naznin [21]	Measles Disease	Disease Symptoms	This rule based expert system detects the measles under uncertainty using evidential reasoning approach. An experimental result shows that proposed system is more reliable and accurate.
B. Prasad, H. Wood, J. Greer, G. McCalla [22]	Bronchial Asthma Disease	Disease Symptoms	This expert system helps student learns how to diagnose bronchial asthma through practice on carefully selected cases and has been tested through actual physicians, and is currently organism field tested with physicians and residents in interior medicine.
Solomon Gebremariam [23]	Diabetes Disease	Disease Symptoms, Lab test results, Age, obesity, family history, Ketone	This system presents advice toward physicians and patients to help the diagnosis and treatment of diabetes. The Performance of the system is 84.2%.
F. Ibrahim, J.B. Ali, A.F. Jaais, M.N. Taib [24]	Eye Disease	Disease Symptoms	This expert system gives advice about types of eye disease found in Malaysia.
Bekaddour Fatima, Chikh Mohammed Amine [25]	Breast Cancer Disease	Disease Symptoms	This system assisted diagnosis can be helpful for doctors in detection and diagnosing of potential abnormalities. The performance of model is 98.25%.

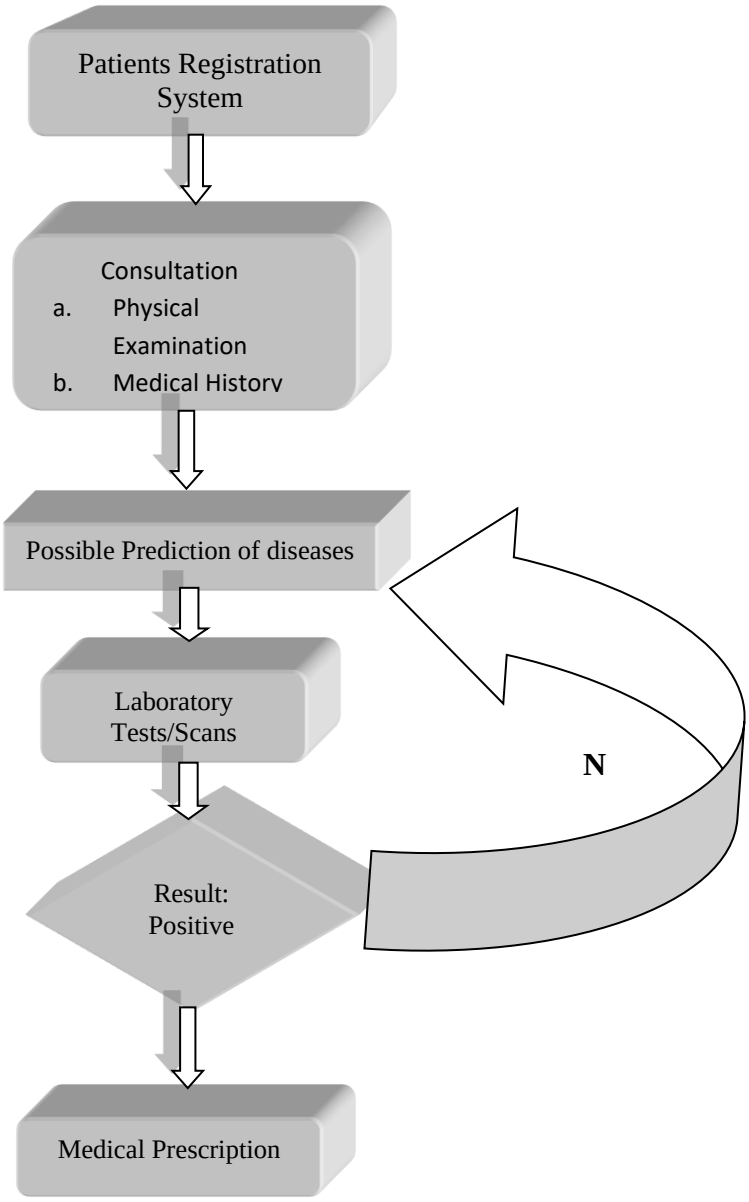

Fig.2: Non-Surgical Medical Treatment System

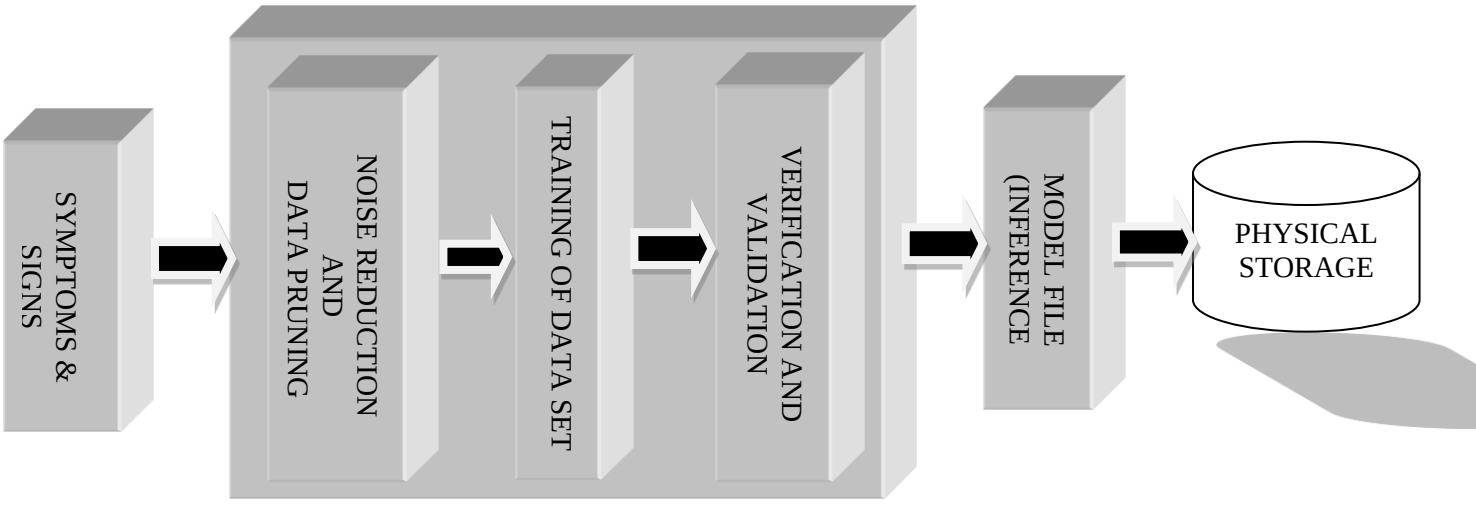

Fig.3 Development of Inference Engine