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Analytical Study of Data Mining Applications in Malaria Prediction and Diagnosis

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Abstract— Over the years, healthcare sector has been identified as the most vulnerable sector which is information rich but due to lack of appropriate retrieval methods avail, hidden data pattern cannot be achieved properly. A lot of research persons had already described and identified several research techniques and methods so that information related to various diseases can be viewed, reviewed, predicted and analyzed. In this paper, we have focused to analysis a variety of techniques, approaches and different tools and its impact on the healthcare sector especially for vector borne disease malaria. Malaria fever has been identified as a threat to human existence, killing millions of people annually, and also contributing to economic backwardness due to huge amount of money and time being spent by many countries of the world in managing the menace, mostly Africa and Asia countries. Shortages of medical experts, hospitals, lack of knowledge and necessary equipment have been adjudged some of the prominent factors for the very high number of deaths associated with malaria fever annually. These challenges have made Information Technology (IT) experts to work with medical experts in using modern IT initiatives to address the situation in the form of providing Predictive Models that can carry out diagnosis and in some cases provide therapy. This study looks at some of these Computer Based Systems (Predictive Models) developed to manage malaria with a view to providing meaningful contribution on improving on them. The work looks into present methods and future needs in order to provide computer based viable classifiers in diagnosis and treatment of malaria fever cases. It is hopeful that researchers in the area of providing diagnosis and therapy systems can make use of our valuable improvement suggestions.

Keywords— Malaria Fever, Diagnosis, Therapy, Data Mining, Predictive Models

I. INTRODUCTION

There is a huge amount of data available in the Information Industry. This data is of no use until it is converted into useful information. It is necessary to analyse this huge amount of data and extract useful information from it. Data Mining is defined as extracting information from huge sets of data. In other words, we can say that data mining is the

procedure of mining knowledge from data. Extraction of information is not the only process we need to perform; data mining also involves other processes such as Data Cleaning, Data Integration, Data Transformation, Data Mining, Pattern Evaluation and Data Presentation. Once all these processes are over, we would be able to use this information in many applications such as Fraud Detection, Market Analysis, Production Control, Science Exploration, etc.

The explosive growth of databases makes the scalability of data mining techniques increasingly important. Data mining algorithms have the ability to rapidly mine vast amount of data. Data mining technology provides a user oriented approach to novel and hidden information in the data. Valuable knowledge can be discovered from application of data mining techniques in healthcare system.

Data mining in healthcare medicine deals with learning models to predict patients' disease. Data mining applications can greatly benefit all parties and modules involved in the healthcare industry. For example, data mining can help healthcare insurers detect fraud and abuse, healthcare organizations make customer relationship management decisions, physicians identify effective treatments and best practices, and patients receive better and more affordable healthcare services. The huge amounts of data generated by healthcare transactions are too complex and voluminous to be processed and analysed by traditional methods. Data mining provides the methodology and technology to transform these mass of data into useful information for decision making. Data mining algorithms applied in healthcare industry play a significant role in prediction and diagnosis of the diseases. There are a large number of data mining applications are found in the medical related areas such as Medical device industry, Pharmaceutical Industry and Hospital Management. There is a huge amount of data available in the Information Industry. This data is of no use until it is converted into useful information. It is necessary to analyse this huge amount of data and extract useful information from it. Data Mining is defined as extracting information from huge sets of data. In other words, we can say that data mining is the procedure of mining knowledge from data. Extraction of information is not the only process we need to perform; data mining also involves other processes such as Data Cleaning, Data Integration, Data Transformation, Data Mining, Pattern Evaluation and Data Presentation. Once all these processes are over, we would be able to use this information in many applications such as Fraud Detection, Market Analysis, Production Control, Science Exploration, etc.

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II. APPLICATIONS OF DATA MINING IN HEALTHCARE SECTOR

Today in healthcare sector large amount of data is generated that includes patient personal information, hospital resources, diagnosis of disease, patient history, treatment provided etc. These data collected that present in large amount are key resources that can be processed and analysed for the extraction of knowledge for the purpose of decision-making and cost saving. Data mining applications can be divided into various categories.

1 Treatment Effectiveness:- Data mining applications can be developed for the evaluation of effectiveness of medical treatments. Data mining analysis can be delivered by comparing and contrasting symptoms, causes; course of treatment for a group of patients which were treated for same condition or disease but with different drug regimens to check which treatment or drug is more effective

2 Healthcare management:- To better identify and track persistent disease states and high-risk patients, design proper interventions, and decrease the number of admissions in hospital and claims to support healthcare management data mining applications can be developed.

3 Customer relationship management:- To manage interactions between commercial organizations- banks and retailers and their customers, customer relationship management is a core approach. It is also very important in context of healthcare. With the help of call centers, physician's offices, inpatient settings, billing departments, and ambulatory care settings customer interaction may occur.

4 Fraud and abuse:- To identify fraud and abuse data mining applications often set up norms and then recognize unusual patterns of claims by physicians, clinics, laboratory or some others. These data mining applications can also throw a light on unsuitable prescriptions or referrals and false insurance and health claims.

5 Medical Device Industry:- One important point of healthcare system is medical device. This is mostly used for best communication work. Mobile healthcare applications supply a convenient, constant and safe way for monitoring of vital signs of patient. Thus mobile communications and low cost of wireless biosensors have lined the way for development of these applications.

6 Pharmaceutical Industry:- To manage pharmaceutical firms their inventories and for development of new product and services the technology is being used. For a competitive position of firm and organizational decision-making a bottomless understanding of knowledge hidden in the pharmacy data is essential.

7 Hospital Management:- A vast amount of data is collected and generated by organizations which include modern hospitals. Thus data mining is applicable for development of Hospital management system. Hospital management involves: services for hospital management, medical staff and patients.

8 System Biology:- A wide variety of data types with rich relational structure frequently is contained by Biological databases. Thus multi-relational data mining techniques are applied to biological data commonly.

III.DETAIL TOOLS AND TECHNIQUES IMPLEMENTED IN VARIOUS RESEARCH PAPERS

There are different types of tools are used in various research papers. In data mining there are two strategies, which are supervised learning and unsupervised learning. In supervised learning a training set is there with the help of which model parameters are learned. On other hand there is absence of training set in unsupervised learning, no training set is present therefore learning is modelled with unknown target parameter. The models are in descriptive form which describes the interesting and valuable information present in data. Descriptive and predictive are the two categories in which data mining tasks are classified. The goal of descriptive tasks is to review the data and construction of entire model and find

out human interpreted forms and associations. While in predictive task the goal is focused to find out the interesting outcomes. Also it find out there is any relationship present between dependent and independent variables.

Data mining classes are as follows:

Classification –It is the task of generalizing a well-known structure to apply to new data.

Clustering –Cluster analysis or clustering is the task of alliance more similar objects in same group (known as cluster).

Association rule learning – It is an admired and well researched technique for discovering attention-grabbing relations between variables in large databases. It searches for relationships between variables.

Regression – It is the process to find a function which models the data with the least error. It includes various techniques for modelling and analysing several variables.

Anomaly detection – Also known as Outliner detection or Deviation detection. The task involves the discovery of unusual data records, measures or annotations that might be exciting or data errors that require further exploration.

Summarization –Automatic summarization is the process of reducing a text document using a computer program in order to generate a summary that retains the most significant points of the original document. The interest in automatic summarization has increased nowadays due to the increase in information overload and the quality of data has increased.

Time Series Analysis- Time series analyses consist of methods for analysing time series data consecutively to dig out meaningful statistics and other characteristics of the data. Time series analysis can be applied to continuous data, real-valued, discrete numeric data, or discrete symbolic data.

The prediction task- It is a supervised learning task which works on direct data and there is no explicit model for new instance of class value prediction.

Sequence Discovery- Also known as Sequential Pattern mining is a topic of data mining concerned with discovery of statistically significant patterns among data examples where the values are conveyed in a sequence.

Each and every technique has its own importance. All of these tasks can be efficiently used in healthcare field. Many of the researchers are currently working on these techniques for various purposes.

IV. ANALYSIS AND RESULT PART OF COMPARATIVE STUDY

Over the past years and today, there has been a rapid technological improvement in Computer Science which has led to the evolution and developments of data mining technologies in the health sector for the purposes of hidden pattern discovery such as disease prediction, detection, forecasting which has a paramount importance in health decision making. Thus, with the aging population on the rise in developed countries and the increasing cost of healthcare, governments and large health organizations are becoming very interested in the potential of health informatics to save time, money and human lives (Shukla, 2014).

Global climate change remains one of the biggest environmental threats to human welfare over the coming century. Despite representing only one source of possible increases in morbidity and mortality, changes in the severity and global distribution of vector-borne diseases are thought to represent a significant biologic impact of this change [Intergovernmental Panel on Climate Change (IPCC) 2007; Patz et al. 1996]. Along with schistosomiasis and dengue infection, malaria is considered one of the major vector-borne diseases most sensitive to changing environmental conditions(Martens 1998; Martens et al. 1999; Rogers and Randolph 2000), although a considerable range of infectious diseases, including cholera (Pascual et al. 2002), lymphatic filariasis (Sattenspiel 2000), and tick-borne encephalitis (Randolph and Rogers 2000) may also be affected, with potentially profound

consequences for human health. Accurate prediction of malaria outbreaks may lead to public health interventions that mitigate disease morbidity and mortality. Due to the adverse effect of malaria on people and economy, researchers had undergone series of researches to develop computer based systems that could diagnose or diagnose as well provide therapy for malaria cases. Some of these earlier works are presented below in the table:

Table 1: Some of the available predictive systems on malaria diagnosis and treatment

Paper	Methods	Motivation
[01]	Fuzzy Association Rule	To improve the accuracy in prediction of malaria outbreaks
[02]	Clinical Protocol Based Decision Support	Malaria has become a global scourge killing several millions of people annually.
[03]	Decision Tree	Insufficiency of medical experts which has increased the mortality rate
[04]	Rough Set	Increased deaths due to malaria Most systems on malaria lack therapy
[05]	Fuzzy Logic	Malaria constitute great threat to existence of many communities etc
[06]	Analytical Hierarchy Process (AHP)	Malaria is a major source of morbidity and mortality in most African countries
[07]	Fuzzy Logic	The need to evaluate severity of symptoms and degree of illness
[08]	Rule Based and Bayesian Approach	Timely and accurate diagnosis of different species of malaria to prevent mortality and morbidity.
[09]	Fuzzy Logic	Malaria and Dengue Fever remain the most vital cause of morbidity and mortality in India and Tropical Countries
[10]	Visualization and knowledge representation techniques involving knowledge base, inference engine, rules and decisions	Difficulty in extracting information from the patients databases in Nigeria hospitals
[11]	Rule Based Expert System	The world needed additional 4 million health workers. A child is killed every 30 seconds and annual report of 500 million cases of malaria yearly in Africa .
[12]	Linear Programming	Malaria Caused 1 million deaths from 300-500 million infections every year
[13]	Fuzzy Logic	Malaria and dengue remain to be the most vital causes of morbidity and mortality in India and in many other tropical countries. Imaging based medical tools are not available in remote areas.
[14]	Neural Network and Support Vector Machine	Malaria affect 200 to 300 million people every year causes an estimated 300 million deaths yearly.
[15]	Knowledge Based using Mockler Situation Analysis	A child is killed every 30 seconds, annual report of 500milion cases of malaria yearly. Diagnostic tools are affected by harsh tropical weather and lack of qualified medical lab technicians
[16]	Expert System with three Client Modules	Healthcare System is being transformed by development in e-health.

Anna L. Buczak et al [01] describe an application of a method for creating prediction models utilizing Fuzzy Association Rule Mining to extract relationships between epidemiological, meteorological, climatic, and socio-economic data from Korea. These relationships are in the form of rules, from which the best set of rules is automatically chosen and forms a classifier. Two classifiers have been built and their results fused to become a malaria prediction model. Future malaria cases are predicted as LOW, MEDIUM or HIGH, where these classes are defined as a total of 0–2, 3–16, and above 17 cases, respectively, for a region in South Korea during a two-week period. Based on user recommendations, HIGH is considered an outbreak.

The result is a model that successfully predicts malaria cases 7–8 weeks in advance using performance metrics that do not involve data used in model development and therefore provide for more conservative and less biased estimates of model performance for the user.

Kamukama I [02] developed A Clinical Protocol-Based Decision Support System for Malaria Treatment. The motivations for this research are: The medical field has become overwhelmed by large volume of data to manage, resulting into variations in treatment processes, which sometimes lowers quality of service, malaria has continued to be a global scourge, killing several millions of people annually, the vast majority of deaths occur among young children and pregnant women in Africa, especially in remote rural arrears with poor access to health services, Protocol non-compliance, inadequate knowledge and expertise are all responsible for these millions of death. Research methods: Research and Review of the existing literature on concepts underlying Protocol Based Decision Support System including the critical elements needed in their development and the technology.

Ugwu C [03] explains about the Application of Machine Learning Techniques for malaria diagnosis, motivations for this study are: insufficiency of medical specialist, which has increased the mortality of patients who suffer from malaria and the need to use computer technology to reduce the number of mortality and reduce the waiting time to see the specialist on malaria. Research Methods: The research methodology adopted is the Structured System and Design Methodology (SSADM).Feasibility study of the manual method for performing a medical diagnosis was carried out. The potential of decision tree was used for the design of the system to overcome the weaknesses of the manual method.

Web-Based Medical Assistant System for Malaria Diagnosis and Therapy was developed in [04]. The motivations for this work are: most of the existing systems on malaria diagnosis fail to provide therapy while some provide therapy without diagnosis, half of the world's population is at risk of malaria, deaths associated with malaria are at increasing rate and the need of a web-based system that could diagnose malaria and provide therapy. Research Methods: A machine learning technique Rough Set was used on training set to generate a classification model for malaria diagnosis for different malaria cases and therapy was provided accordingly.

A Fuzzy Expert System for the management of malaria was developed by Djam et al in [05]. The motivations for this study are: As a prominent environmental health problem in Africa, malaria constitutes a great threat to the existence of many communities and the complexities in medical practice make traditional quantitative approaches of analysis inappropriate. Research Methods: Fuzzy techniques were incorporated on data collected and fuzzy expert system was developed for the management of malaria.

Uzoka and Barker [06] in Medical Decision Support System using Analytical Hierarchy Process: A case study of malaria diagnosis. The motivation for the research include: Malaria attack is so prevalent, especially in the tropics, malaria is a major source of morbidity and mortality in most African countries, high incidence among children less than 5 years old, roll back malaria has not succeeded in eradicating malaria, research has been intensified in the past decade to facilitate finding more appropriate means of malaria diagnosis, treatment and control. The method used involved interaction with medical doctors on symptoms of malaria, the possible grouping of the symptoms and the pairwise comparison of the symptoms. Design of a computer oriented model using the analytical hierarchy process (AHP) powered inference mechanism. The major components of the model are Knowledge base, Decision Support base (Powered by AHP) and User interface.

Fuzzy-rule based framework for the management of tropical diseases, using malaria as a case study was developed by Obot and Uzoka in [07]. The motivations for this study are: The application of the conventional symbolic rules found in knowledge base technology to the management of a disease suffers from its inability to evaluate the degree of severity of a

symptom and by extension, the degree of the illness. Research Methods: The fuzzy logic for the diagnosis of malaria disease involves fuzzification, inference and defuzzification. There were qualitative and quantitative variables, which were fuzzified, inferred and defuziffied. Fuzzification begins with the transformation of raw data. During the process, linguistic labels are attached to the symptoms and the diagnostic steps are accompanied by associated degrees of intensity rated on a likert scale of 1 – 5. The linguistic labels are later assigned some degrees of membership for mild, moderate, severe and very severe labels and fuzzy rules are then developed. The fuzzy inference employed is root sum square (RSS) and the deffuzification inference is a mapping from a space of fuzzy actions defined over an output universe of disclosure into a space of non-fuzzy actions.

Decision Support Systems to identify different species of malaria parasites was developed by Prabhu et al in [08]. The research was motivated due to the fact that timely and accurate diagnosis of different species of malaria is essential to prevent mortality and morbidity. In the method used, two expert systems were developed to aid in the diagnosis of malaria. A rule based decision support tool (CLIPS) was used to create the medical expert system. A limited Bayesian prototype was also developed in Netica, to compare and assess the usefulness of probabilistic systems. Certain assumptions were made to formalise the knowledge in both the rule based and Bayesian systems.

Olabiyi et al in [09] presented A Decision Support System for Diagnosing Tropical Diseases Using Fuzzy Logic. The motivation for this research include- Tropical diseases are associated with a high level of mortality rate, and also they are very common in tropical countries, the tropical diseases have some similar symptoms which makes it difficult sometimes for doctors to diagnose, patients sometimes have difficulty explaining how they feel to the doctors, some doctors are not familiar with some of the new changes in medicine and human health. Research Method: Data were gathered by interacting with various medical doctors who are experts in diagnosing tropical diseases to gain heuristic knowledge on the diseases. The system was developed to diagnose ten tropical diseases including malaria. Diagnosis was carried out by weighing each symptom with respect to the disease in question using generalized fuzzy soft set (GFSS).

A Knowledge-Based Data Mining System for Diagnosing Malaria Related Cases in Healthcare Management was developed by Olugbenga et al [10]. Research Motivations: In some hospitals in Nigeria, it is difficult to select or extract very important information from the database, the increasing volume of data in modern business and science, most especially the health sector calls for computer based approaches. Methods used-Data collection was obtained by survey from four hospitals in Lagos metropolis of Nigeria. Visualization and knowledge representation techniques were used to present the mined knowledge to the user. The components of the knowledge based data mining system are: knowledge base, inference engine, rules and decisions. The implementation of the system was carried out using C#.NET programming language and Microsoft SQL Server 2005.

Online System for Diagnosis and Treatment of Malaria was developed in [11]. Motivations for the work: It is estimated that a child is killed every 30 seconds, and there is an annual report of 500 million cases of malaria in Africa. Malaria prompt diagnosis is hindered by the fact that current diagnostic tools are affected by the harsh tropical weather, the lack of qualified medical laboratory technicians to read test results, the lack of regular or no supply of electricity to preserve available diagnostic tools. Additional four million health workers are needed throughout the world. Research Method: Medical experts from Ahmadu Bello University Teaching Hospital, Nigeria were interviewed and data describing the evolution cycle of malaria and the method of treatment were collected. The obtained data were used to build the knowledge based of the rule based system. PhP was used as scripting language;

MySQL was used as the database, while Apache serves as the server that housed the inference engine.

Computer Automation for Malaria Parasite Detection Using Linear Programming by Vipul et al[12]. Motivations: Malaria causes more than 1 million deaths arising from approximately 300-500 million infections every year. Manual microscopy is not a reliable screening method when performed by non-experts. Need of an automated system aims at performing this task without human intervention and to provide an objective, reliable and efficient tool to do so. Methods: Formulation of a linear programming model based on the given data. Solving and displaying the result using graphical method approach for detecting parasite.

Decision Support System for Malaria and Dengue Disease Diagnosis (DSSMD) By Priynka et al [13]. Research Motivations: Malaria and dengue remain to be the most vital cause of morbidity and mortality in India and in many other tropical countries with complete 2 to 3 million new cases arising every year, Malaria is a major health problem in the world, oldest chronic and most widespread fatal disease, unavailability of pathological and imaging based medical diagnosis tool in remote areas. Methods: The system was developed using the MATLAB. The overall classification was done using fuzzy logic toolbox. The system has three modules; GUI interface showing the symptoms, Knowledge Base where fuzzification takes place, and Inference Engine where the fuzzified value is defuzzified in the decision support system model. More than 200 fuzzy rules were generated by the system for diagnosis.

Shruti and Shirgan in [14] developed Automatic Diagnosis of Malaria Parasite Using Neural Network and Support Vector Machine. The research was carried out because malaria affects at least 200 to 300 million people every year and causes an estimated 300 million deaths per annum.

The Integrated Management of Health Care Strategies and Differential Diagnosis by Expert System Technology: A Single- Dimensional Approach [15]. Research Motivations: Malaria and typhoid kill more people than the most dreaded Acquired Immune Deficiency Syndrome (AIDS). Though diagnosing malaria based on signs and symptoms is justifiable, its management by healthcare personnel in the rural areas has become ever more complicated because of its overlapping symptoms and signs with those of other febrile diseases in the region. Methods: The knowledge acquisition and elicitation stages of the system were achieved using questionnaires and interview techniques. The knowledge gathered from these processes were analysed and represented in the form of Mockler Situation Analysis Methodology. Rapid Prototyping, using a simple expert system shell was used to develop the system due to its simplicity and fast learning curve.

A Knowledge Based Expert System for Symptomatic Automated Healthcare was developed in [16]. Research Motivations: Healthcare distribution is being transformed by developments in e-health, the revolution of medical science to computer technology has made life easy and patients or end users are not bound to the doctors or other resources of medical science. Methods- The system is an artificial Expert or Expert System, having three client modules – user interface, inference engine and knowledge base. Patients or users remotely interact with the system and find out the disease by giving some symptoms to the computer. In this way, the system makes feasible diagnosis for patients and also suggests particular treatment regarding the disease. Forty-eight diseases, including malaria, were diagnosed by the system.

V. CONCLUSION

This paper aimed to compare the different data mining application in the healthcare sector for extracting useful information, especially in case of available techniques to diminish the malaria disease. It is evident from the reviewed work that malaria is a deadly disease, killing

millions of people annually with largest proportion in Africa. This study shows the large number of deaths occur annually as a result of many factors which include shortages of medical personnel, laboratory equipment, hospitals and wrong interpretation of laboratory results. It also established the fact that remote areas are majorly affected. The fusion of Medical Science and Computer Science (Information Technology) in managing deadly diseases as a result of the earlier mentioned challenges was also established. This collaboration has led to development of computer based predictive models in medical diagnosis and treatment. These models are either based on available symptoms or images of the malaria parasites. The models are expected to be of immense assistance in both urban and rural areas of the affected regions. However, adequate care must be taken while developing these computer based systems. Accuracy and reliability of such systems must be thoroughly evaluated. It is observed from the reviewed works that most of these Computer Based Systems for malaria diagnosis are based on a single predictive models, most provide diagnosis without therapy and vice versa. In addition, most researchers failed to evaluate the detection rate (accuracy) of the systems. Accessibly and simplicity of these systems must also be put into consideration by future researchers.

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