

# ***Different approaches for Health Care Clinical Decision Support Systems- a Survey***

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**Abstract—** Today the use of Artificial Intelligence in medicine

and medical sciences has made it easy for us to analyze and diagnose the medical problems and diseases. This paper focuses on the characteristics of Clinical Decision Support System and the approaches used for their implementation in Health care. It discusses how they are helpful in diagnosis of diseases and pain. The purpose of this case study is to study the aspects of Clinical Decision Support Systems and to figure out the most optimal approach that can be used in Clinical Decision Support Systems to provide the best solutions and diagnosis to medical problems. The case study includes the reading and understanding of the previous research works and to find out better approach. The selection of a particular approach depends upon various parameters of problem domain. Certain approaches are more effective in one domain while other may be even more effective in other domains. The paper concludes that every approach has some good aspects as well as some dark aspects but in a wider aspect, the hybrid approaches appeared to be more efficient and effective.

**Keywords-** *Artificial Intelligence, Clinical Decision Support Systems, Health care, The Hybrid approach*

## I. INTRODUCTION

The branch of computer science which is more actively and efficiently involved in medical sciences is Artificial Intelligence. Various Clinical Decision Support Systems have been constructed by the aid of Artificial intelligence. These systems are now widely used in hospitals and clinics. They are proved to be very useful for patient as well as for medical experts in making the decisions. Different approaches are used for the development of those systems. Any computer program that helps experts in making clinical decision comes under the domain of clinical decision support system. An important characteristic of the Artificial Intelligence is that it can support the creation as well as utilization of the clinical knowledge. Using Artificial Intelligence we can make the systems that will have the capacity to learn and the creation of new clinical knowledge. The main objective of this paper is to present recent trends in Clinical Decision Support Systems and various approaches used in Health Care.

## II. APPROACHES FOR CDSS

The following case study is based on the analysis and comparison of various approaches used in clinical decision

support systems. The data for the case study is obtained from the results and work of various researchers on Decision Support Systems.

### A. Decision Support Systems Using Artificial Intelligence

Artificial Intelligence is an integral part of Decision Support Systems. Decision Support Systems implemented with the aid of Artificial Intelligence have the ability to adopt in new environment and to learn with time [2] [3]. Various methods are used to gather information used for the process of Decision making in Computer Aided Support Systems. These methods include Statistical Method, Neural Network, Knowledge Based Methods, Fuzzy Logic Rule Based, Genetic Algorithms etc. The selection of a particular approach depends upon various parameters such as the problem domain, amount of data available and Researcher choice and purpose. For the diagnosis of pain, medical science need computer aided software that can collect the health related signals from patients and transform them in pain intensity [4].

Pain causes degradation in the life of patients and due to lack of the proper evaluation methods, sometime patient stops asking for further medication as the pain becomes worse [5]. Similarly the critical monitoring of the patient after operation needs accurate measurement of the medicine proportion as over dosage can sometime result into threats of life. The use of a Clinical Decision Support System to measure the intensity and diagnose the pain is much more efficient, effective and economical.

The use of the Clinical Decision Systems in surgery is also very common. Minimal invasive surgery is a preferred method for operations today. The development of a reliable flexible fiber or wave guide will enable surgeon to bring laser beam transendoscopically within body cavities. It combines the endoscopy technique with the advantageous laser interaction with tissue to create a powerful surgical tool for operating procedures. It lower cost fastest healing and minimal post operative pain [6].

### B. Types of Clinical Decision Support Systems

Clinical decision support systems are broadly classified into two main groups. Pictorially it is shown in the Figure 1. They are

- Knowledge based CDSS
- Non-Knowledge based CDSS

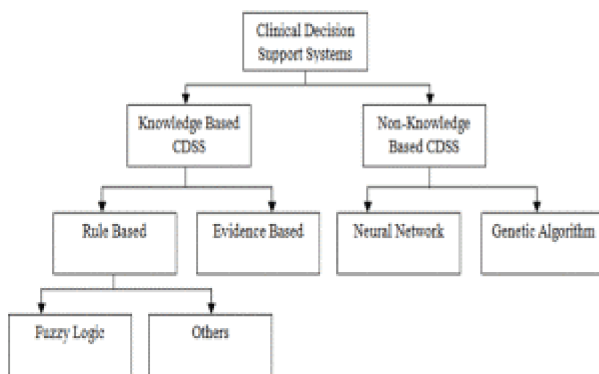


Fig 1. Representing different methodological branches of the Clinical Decision Support Systems.

### 1) Knowledge Based CDSS

The knowledge based clinical decision support system contains rules mostly in the form of IF-Then statements. The data is usually associated with these rules. For example if the pain intensity is up to a certain level then generate warning etc., The knowledge based generally consists of three main parts. Knowledge base, Inference rules and a mechanism to communicate. Knowledge base contains the rules, inference engine combines rules with the patient data and the communication mechanism is used to show the result to the users as well as to provide input to the system. In certain case, such as of chest pain management, the adaptive guidelines from a knowledge base server prove to be much more effective than others [7]. The knowledge within expert system is generally represented as set of rules. Sometimes the knowledge based is used with variance management to execute patient care process and provide high quality health care services dynamically. This knowledge based management system is implemented using the object oriented analysis, UML techniques and handling of variance through the construction of generalized fuzzy ECA (GFECA) rules. [8]

#### a) Fuzzy Logic Rule Based

It is a form of knowledge base and has achieved several important techniques and mechanisms to diagnose the disease and pain in patient. For example RVM Learning Technique is used for pain management in patient who cannot communicate verbally. The pattern recognition technique can assist medical staff in measuring the pain which is an extension of Vector machine algorithm. [9]. The Fuzzy Logic Rule based classifier is very effective in high degree of positive predictive value and diagnostic accuracy. For example in diseases like appendicitis, the results predicted by fuzzy logic rule based classifier have an accuracy rate of 95% on average [10]. For improving the effectiveness of fuzzy set theory, Rough set

theory can be proposed to complement fuzzy set and to deal with vagueness and uncertainty. Its main advantage is that it does not need data such as probability distribution in statistics, basic probability assignment, and grade of membership of value of possibility in fuzzy set theory [11]. Clinical guidelines provide benefits to health outcomes and are economical but they have certain characteristics that are difficult to handle such as vagueness and ambiguity. Fuzzy logic facilitates us for treatment of vagueness in decision support system. Fuzzy logic approach can be a very useful approach for describing vagueness and imprecision in precise mathematical language, explicitly representing clinical vagueness [3].

#### b) Rule- Based Systems & Evidence Based Systems

They tend to capture the knowledge of domain experts into expressions that can be evaluated as rules. When a large number of rules have been compiled into a rule base, the working knowledge will be evaluated against rule base by combining rules until a conclusion is obtained. It is helpful for storing a large amount of data and information. However it is difficult for an expert to transfer their knowledge into distinct rules. For closing the gap between the physicians and CDSSs, evidence based appeared to be a perfect technique. It proves to be a very powerful tool for improving clinical care and also patient outcomes. It has the potential to improve quality and safety as well as reducing the cost [12].

### 2) Non Knowledge Based CDSS

CDSS without a knowledge base are called as non-knowledge based CDSS. These systems instead used a form of artificial intelligence called as machine learning. Non-knowledge based CDSSs are then further divided into two main categories.

#### a) Neural Network

To derive relationship between the symptoms and diagnosis, neural networks use the nodes and weighted connections. This fulfills the need not to write rules for input. However, the system fails to explain the reason for using the data in a particular way. So its reliability and accountability can be a reason. It has been observed that the self organizing process of training the neural network in which it isn't given any priory information about the categories it is required to identify, is capable of extracting relevant information from input data in order to generate clusters correspond to class. Furthermore it requires only a small proportion of available data to train the network [13]. In identifying the pain in infant child, neural networks extract the two features MFCC and LPCC from infant cry and are fed them into recognition module. The accuracy rate of this system under different parameters reported as 57% to 76.2% [14]. The neural networks are also very important especially in complex multi-variable systems to avoid costly medical treatment and for



diagnosis of pain [15].

Its advantage is that it does not need any input from experts. Eliminating the need of expert helps the system to eliminate the need of large databases to store input and output. It can work on incomplete data by guessing the data based on the successive data trend. However it has a disadvantage that it can be sometimes the training process needs too much time. They combine data based on statically recognition patterns with time which is difficult to explain. The use of the weight-elimination cost function is well enough to overcome the network memorization problems [16].

#### b) Genetic Algorithms

They are based on evolutionary process. Selection algorithm evaluates components of solutions to a problem. Solution that comes on top are recombined and the process runs again until a proper solution is observed. The generic system goes through an iterative procedure to produce the purpose the best solution of a problem. It has been observed that none of the case, studied in this paper used genetic algorithm which means researcher miss the opportunity to take the advantage of genetic algorithm. It also explains that there is a scope to implement clinical decision support system using genetic algorithms. This can be topic of future work.

#### C. Modern Trends of Implementing Clinical Decision Support Systems

Clinical decision support systems in modern trends are broadly classified into two main groups. They do not lie under the clinical decision support system tree of Figure 1. However they can be considered as its subsection. Pictorially it is shown in the Figure 2. They are

- Statistical Method
- Hybrid Systems

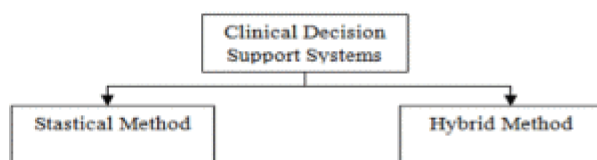


Fig 2 Representing two modern trends of implementing the clinical decision support systems..

#### 1) Statistical Method

It is one of most simple and useful method used for data collection. It can be in the form of a survey, experiment result or questionnaire. Development of clinical decision support systems using statistical method as an integral part is very common [4]. For example to focus the economics of post operative pain with focus on opioid and the local regional anesthetic, a bibliographic database survey can be a good option [4]. Data can be collected as a questionnaire mentioning the status of patient how he looks like, its way of

talking, what he feels and many more. It can be a better way of qualitative assessment of postoperative pain [17].

#### 2) Hybrid Systems

A combination of two or more approaches within a design of single system results into a hybrid system. Hybrid systems extract the best from all approaches and provide an optimal solution for clinical decision support systems [18]. For example to identify the clinically relevant aspects of MEDLINE automatically, the combination of knowledge-based and statically techniques can be good approach. The extracted elements then served as an input to the algorithm to score a relevance of citations with respect to structured representation of information needed, based on the principles of evidence based medicine. The principles of evidence based medicine can be captured computationally and implemented in a system. It has the potential of improving the quality of health care. Meta reasoning method such as hybrid systems consists of different reasoning approaches. It can consist of a rule based, case based and model based reasoning. That finally results into an overall improvement of the system performance.

### III. RELATED WORK

Since computer was invented, it has been used for assisting medical professionals. The first research article dealing with medicine and computers appeared in late 1950s (Ledley & Lusted, 1959). Later an experimental prototype appeared in the early 60s (Warner et al., 1964). At that time limited capabilities of computer did not allow it to be a part of medical domain. In 1970s the three advisory systems: de Dombal's system for diagnosis of abdominal pain (de Dombal et al., 1972), Shortliffe's MYCIN system for antibiotics selection (Shortliffe, 1976), and HELP system for medical alerts delivery (Kuperman et al., 1991; Warner, 1979). 1990s witnessed a large scale shift from administrative systems to clinical decision support systems [1].

A randomized and non randomized controlled trial exercise is used to evaluate the effect of CDSS compared to without a CDSS on practitioner performance. The data from hundred subjects has independently abstracted by the reviewers. It was observed that in most of the cases Clinical Decision Support Systems improve the practitioner performance [28]. On comparing the diagnostic accuracy of computer program with emergency room physician, by using 132 subjects, the result appears to be very much promising and encouraging [29]. Evaluation of the Decision Support System to tackle the sensitivity of the medical equipments is an area of concern for most health physicians. The use of a hybrid Bayesian method and a statistical approach can be a better approach to evaluate system performance [31]. From TABLE I we can summarize the results of our case based study.

#### IV. DISCUSSION

The results of our case based reasoning showed that two different practices are generally exercised in hospitals. One can be the manual way of prescribing the medicines by health professionals after analyzing the patient history and reports [1]-[33]. On studying both practices on a relatively smaller scale, it is observed that the Clinical Decision Support Systems have several edges over manual systems. They are efficient, effective and low cost. The case study provides an overview of the current practices regarding post operative pain and physiotherapy management of patients. The findings identify discrepancies in services provided to patients and highlight current research not always reflected in treatment provided [23]. It highlights that the difference between the correct diagnosis by program and by physicians is 72% to 79%. In some cases such as diagnosis of CAD, the computer aided program being relatively simple and reliable makes it easy for physicians to estimate probability of CAD, whether additional non invasive diagnostic studies should be employed to improve probability of disease and to appropriate select patients to coronary angiography [25].

On comparing the clinical decision support systems with non clinical decision support systems it is observed that there is no way by which non clinical decision support systems can compete [28]. It is a knowledge based system having domain knowledge represented by rule based; object oriented scheme and an inference engine including mechanism for generating decision support. Similarly PROSPECT [23] is an evidence based procedure-specific postoperative pain management website for clinical decision making. Hybrid Decision Support Systems can be both CBR and RBR [31].

#### V. CONCLUSION

Different approaches for implementing the clinical decision support systems have been studied in this case study. By comparing these approaches, it is observed that some techniques are domain based. They are effective only within a specific diseases area. Whereas some are on average useful in all domains. The selection of a particular approach also depends upon some external parameters such as the cost of system, efficiency required, and amount of data available and the sensitivity of the system. From the study it can be concluded that a hybrid CDSS with two or more approach can be a better approach. In future, the knowledge from this paper can be reused as a thesis work or as a research topic itself.

TABLE I. CASE STUDY OF CLINICAL DECISION SUPPORT SYSTEM FINDINGS

Article	Purpose	Work Method	Application Domain
[13]	Pain Detection,	Artificial	Discogenic Pain

	Diagnosis	Intelligence	
[19]	Surgical Healing Process	Artificial Intelligence	Anatomy
[20]	Safety Interlocks to avoid severe complications	Artificial Intelligence	Respiratory Mechanism
[6]	Post Operative Pain Diagnosis, Cost Reduction	Artificial Intelligence	Surgeries & Operations
[21]	Post Operative Pain Diagnosis, Cost Reduction	Opioid Sparing	Medicine
[22]	Post Operative Pain Diagnosis, Stable pain score	Ketamine plus 2/3 Morphine	Medicine
[23]	Stable Pain Score, Reduced Opioid Requirements	Medicine	Children Surgeries
[24]	Healing Wound Inflation	Medicine	Health Care (PostOperative pain)
[14]	Pain Recognition	AI(Neural Network)	Infant Child Diseases
[11]	Vagueness & Uncertainty	Rough set Theory	Artificial Intelligence
[25]	Cost Reduction	AI(Knowledge Based)	Multidisciplinary Web Based
[8]	Object oriented Analysis, Design Techniques	AI(Knowledge Based)	Health care Services
[26]	Pain Diagnosis	AI(Web Based CDSS)	Healthcare(Lower Back)
[18]	Effective Clinical Decision Support System	AI(Knowledge Based Hybrid)	Medical Health care Services
[15]	Urinary Tract Disease Prediction, Classification & diagnosis	AI(Neural Network)	Urology Diseases
[27]	Pain diagnosis decision making	Artificial Intelligence	Ontology
[28]	Improving Clinical Decision Support System	AI(Hybrid)	Gastroenterology
[29]	Clinical Decision Support Systems Performance Improvement	Artificial Intelligence	Decision Support Systems
[16]	Weight Elimination, Cost Reduction, Network Training	AI(Neural Network)	Intensive Care Unit
[26]	Effectively Decision Making	Artificial Intelligence	Oncology
[27]	Evaluation of Decision Support Systems	Artificial Intelligence	VentEx Decision Support System
[30]	Integration of Rule Based, Case Based & Model Based Programming	Artificial Intelligence	Meta Level Reasoning, Clusters
[31]	Pain Diagnosis	Artificial	Chest Disease



		Intelligence	
[32]	Pain Management	Behavioral Pattern	Artificial Intelligence
[1]	Post Operative Pain Management	Artificial Intelligence	Lumbar Disc Prolapse, Physiotherapy
[33]	Drug Prescription & Imputing the missing Data	Machine Learning & AI(Knowledge Based)	Medicine

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