HYBRID APPROACH FOR INTELLIGENT DECISION MAKING IN HEALTHCARE

Keywords: IDSS, Hybrid IDSS model, Clinical Decision Support, data mining, Artificial Neural Network, Business Intelligence

Abstract

This Essay demonstrates the comparison between traditional and intelligent system which shows the need of smart decision models. Descriptive and predictive models are combined together to make a hybrid system. A case study of 40 years old Angus shows, how hybrid architecture can be implemented to patient's data by combining the concepts of data mining and artificial neural networks. Also, some latest intelligent systems and applications in different domains have been discussed. All subject objectives mentioned in assignment requirements have been taken into an account.

1. Motivation

The reason to choose this topic is to get proper understanding of the subject and to explorer the intelligent systems and how they can be beneficial compares to different forms of the traditional models. Another reason to choose this topic is because of curiosity on how decisions can be made and how machine learning can be a valid approach in the field of medical.

2. Introduction

Decision Support is a significant task for decision makers in numerous commercial enterprises. Typically, Decision support systems help decision makers to accumulate and decipher data and construct an establishment for decision making. Such frameworks may run from straightforward programming frameworks to complex information based and counterfeit intelligence systems. Decision support systems can be database-oriented, spreadsheet-oriented or text-oriented in nature.

3. Traditional and Intelligent Decision Support Systems

Decision Support Systems (DSS) can be categorized into two types. One is Active DSS which is also known as symbiotic and the other one is self-evolving which is also known as Intelligent Decision Support System (IDSS).The difference between them is that an IDSS instigates particular domain knowledge from raw data by extracting useful designs or patterns from it, thus making the extricated designs reasonable and usable for decision making. According to Foster, unlike traditional Decision Support Systems the IDSS "Supports a wider range of decisions including those with uncertainty"(Foster, McGregor et al. 2005).In addition to that it contributes in estimating the level of confidence in proposed recommendations. And can deal with complex issues, by applying particular area of expertise to evaluate the results of executing its recommendations.

4. Structure of IDSS

Turban, Efraim and others have discussed the Structure of IDSS as shown in Figure 1 with great details in their book "Decision support Systems and Intelligent Systems"(Turban, Aronson et al. 2005).

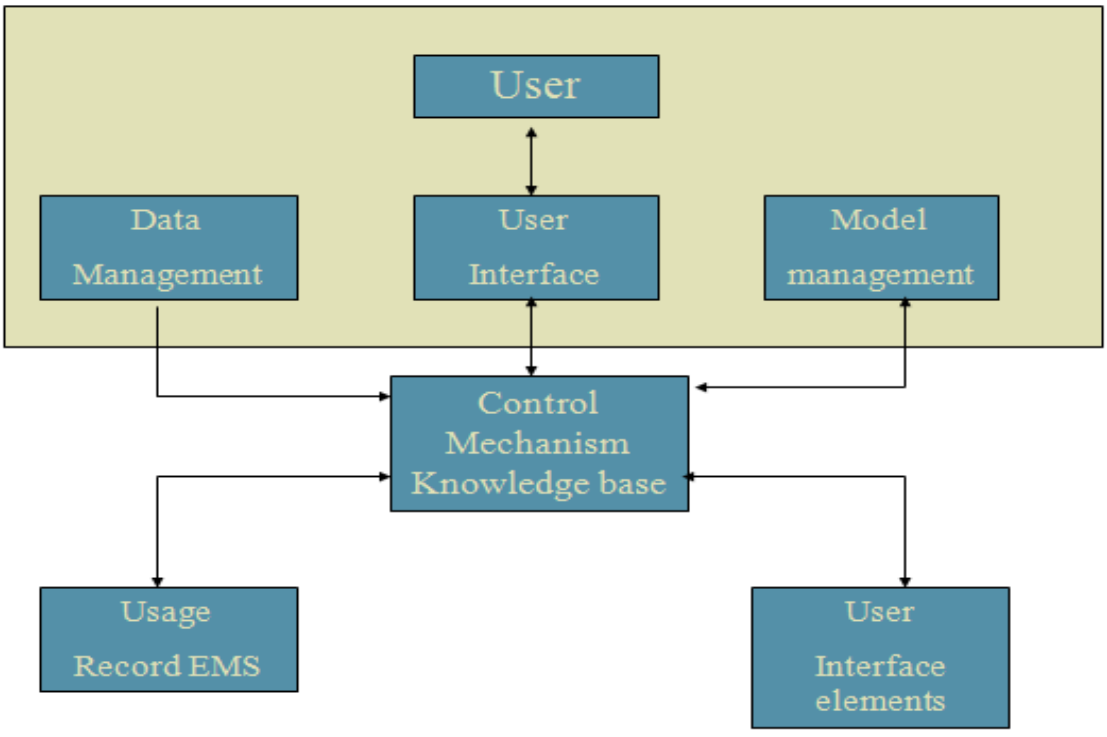

Figure 1- Major components of IDSS(Turban, Aronson et al. 2005)

There are number of components that are common in other Decision Support System like Data management, model management, and a user interface. Other components are usage record that contains system usage data and User interface elements that are needed for

creating a very user-friendly interface. But the main component is Central control mechanism that manages all the operations of the DSS. This is an astute control that holds a knowledge base.

The control mechanism collects the user's convention data and saves them in the usage record base. Then it analyzes the data and a new version of the DSS is formed. This process is continues and cyclic as long as needed. The control can work independently on each component of the DSS. In other words, it provides an intelligent interfaces, intelligent model management, and intelligent data management. Finally, the system is an online, real-time system.

5. Latest IDSS and Applications

The latest IDSS have been discussed and explained in more details in chapter 2 of the book with title "Biometric and Intelligent Decision Making Support" by Kaklauskas and Arturas(Kaklauskas 2015).In this chapter they showed how different methods can be used to achieve the intelligent decision making. Some of the latest IDSS mentioned in a book are shown in Figure below.

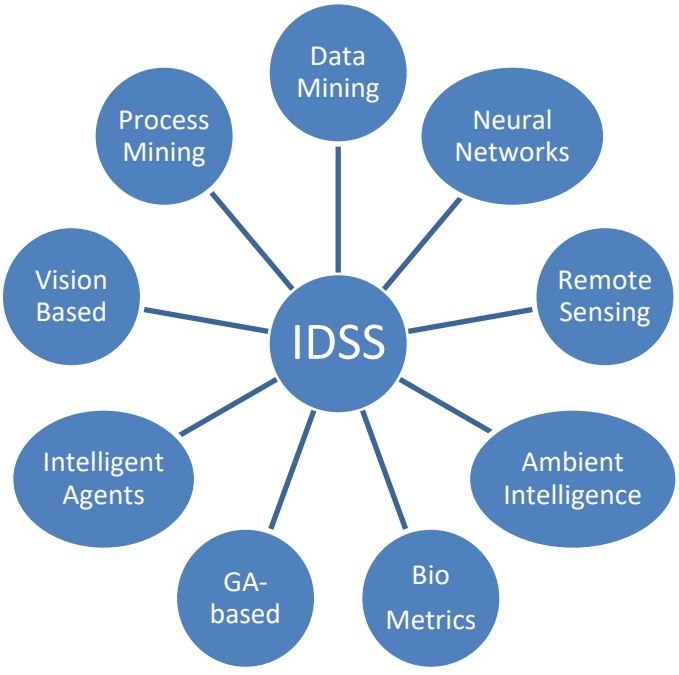

Figure 2- Latest IDSS

Intelligent Decision Support Systems can be applied to different domains and sub domains; some of them are Finance, Data Processing, Marketing, Human Resources, Manufacturing and Healthcare. Some of their sub domains can be seen in Table 1.

Finance	Data Processing	Marketing	Human Resources	Manufacturing	Healthcare
Insurance Evaluation	System Planning	Customer Relationship Management	HR planning	Production Planning	Patient Monitoring
Credit Analysis	Equipment Maintenance	Market Analysis	Performance Evaluation	Quality Management	Medical image Retrieval
Tax Planning	Vendor Evaluation	Product Planning	Scheduling	Product Design	Intelligent diagnostic decision-making

Table 1- Applications of IDSS

6. IDSS Techniques

A variety of techniques have been proposed by Ricci and Rokach in their book "Introduction to recommender systems handbook" that are used to generate recommendations in decision support system(Ricci, Rokach et al. 2011).

- Collaborative: Recommendations are being generated by using information about rating profiles for different users. Collaborative systems locate peer users with a rating history similar to the current user and make recommendations using this neighborhood.
- Content-based: Recommendations are being made from two sources. One is the features associated with products and other is the ratings that a user has given them.
- Demographic: Provides recommendations based on a demographic profile of the user.
- Knowledge-based: Suggests products based on assumptions about a user's needs and preferences.
- Community-based: Recommends items based on the fondness of the users friends. This technique follows the saying, "Tell me who your friends are, and I will tell you who you are".
- Hybrid systems: Recommendations are based on the combination of the above mentioned techniques.

7. Intelligent Decision support in health care

Clinical decision support system (CDSS) plays a considerable role in healthcare. These decisions are normally taken by healthcare service providers and are frequently based on clinical directions and evidence-based conventions derived from medical science. Conversely, intelligent decision support systems (IDSS) conducts the interpretive analysis of patient data with intelligent and learning-based methods that, "permit doctors and nurses to

rapidly gather information and practice it in different ways in order to assist through diagnosis and treatment decision"(Foster, McGregor et al. 2005). IDSS can be applied in healthcare in different areas such as the examination of real-time data from miscellaneous monitoring devices, analyses of patient and family past records for the purpose of diagnosis, and many more.

7.1 How Can Intelligent Decision Support Helps?

Managing knowledge in healthcare organizations to assist clinical decision-making requires actionable intelligence information that can be understandable by different functional work groups within the organization. The representation of the healthcare knowledge in Figure 3 shows how artificial intelligence can be used to analyze healthcare data. And how that data can in turn be used for information and process modelling(Patel, Shortliffe et al. 2009).

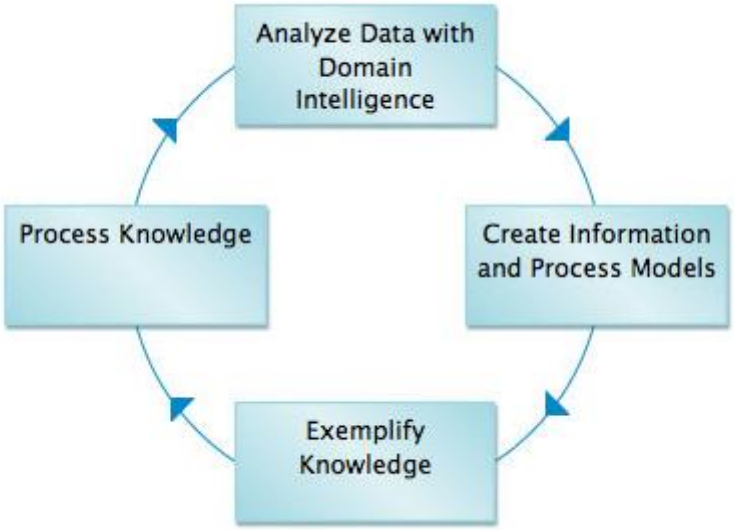

Figure 3- The knowledge cycle(Patel, Shortliffe et al. 2009).

Intelligent decision support systems can help in multiple ways in clinical decision-making at both the individual patient level and the population level. For example:

- Diagnose by regularly interpreting and monitoring patient data. An IDSS can implement rules and patterns for individual patients, based on clinical parameters, and raise warning flags when such rules are violated. These flags can lead to clinical interventions that save lives.
- Help chronic disease management through establishing benchmarks and alerts. For chronically ill patients, a deviation noticed by an IDSS in, say, a blood test reading from a diabetic patient could result in an intervention before the patient gets into difficulty.
- Help public health surveillance by detecting pandemic diseases or in surveillance of chronic diseases. In case of a pandemic, an IDSS can interpret data and predict possible future spread of the disease.
- Additionally, IDSS can perform regular clinical decision support functions like preventing drug-drug interactions. Even if not noticed by the prescribing physician, an

IDSS can spot incompatibilities between prescribed medications and/or dosages for the patient.

7.2 Architecture of a Hybrid IDSS Model

The hybrid IDSS serves as a predictive tool by retrieving past information, that creates the domain knowledge from reviewed information and interprets it into new domain knowledge. The purpose of this is to get intelligent decision making by applying descriptive and predictive models.

The IDSS model described in this essay combines an association rule-generator Algorithm (based on data mining of a knowledge base) with an artificial neural network. It is capable of building field related knowledge from existing database and applying this knowledge to work out the clinical problems. As data mining extracts knowledge related to the specific field from organizational databases, it also augments the process of knowledge acquisition. Neural networks can learn patterns from large levels of data and employ the knowledge to help to solve the problems (Viademonte and Burstein 2006).

The components of the architecture include:

- a decision-oriented data repository(data warehouse)
- case bases
- inductive algorithms for data mining (descriptive method)
- knowledge bases
- an intelligent advisory system (predictive method)

Through training process the system permits raw data to be retrieved from data bases and handled into data models that support's the descriptive methods that are stored in knowledge bases. Accordingly, based on neural network models the predictive methods are generated that produce predictions.

The case bases can be consists of some specific clinical cases or practice guidelines from which data can be mined. This mined data will be used to generate clinical knowledge for making descriptive clinical features. Afterwards, association rules are applied to generate general knowledge that accumulates in the knowledge base. The dashed lines in Figure 4 represent processes and the hard solid lines with arrowheads indicate data flows between components.

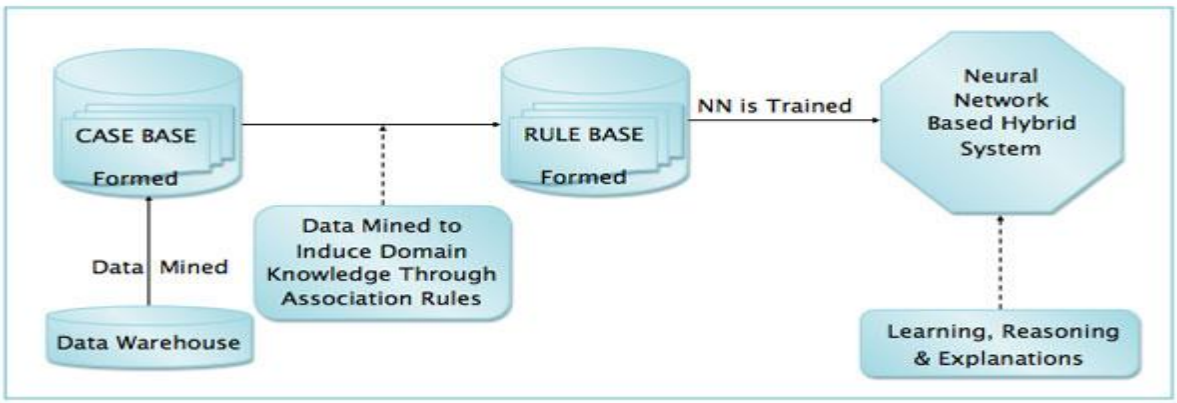

Figure 4- Building blocks of the Hybrid IDSS Model (Viademonte and Burstein 2006).

7.3 Case Study

Basu, Ruki and others have discussed a case of a patient in their paper "Incorporating hybrid CDSS in primary care practice management" that gives the proper understanding of IDSS in health care environment(Basu, Fevrier-Thomas et al. 2011). A diabetic patient named Angus, who is 40 years old with no previous history of cardio-vascular disease. His average measured blood pressure (BP) and heart rate (BPM) are 108/55 mmHg and 60 beats per minute respectively. For the last eight years, he has been examined by a family physician. Angus self-monitors his Blood Glucose Level, BP and BPM and stores the data in an online Patient Health Record (PHR) system. His PHR system is integrated with his family doctor's Electronic Health Record (EHR) system.

On a given day, the family physician finds Angus's BP and heart rate has increased, but he notices minor changes in systolic pressure. Normally in such a situation, he would advise some medicine like Warfarin. But Angus, who is also taking Aspirin, runs the risk of developing uncontrolled bleeding if he takes both medicine at the same time(Basu, Fevrier-Thomas et al. 2011).

At this point, if Doctor's EMR were integrated with an IDSS, a prescription for Warfarin would trigger two alerts and associated recommendations.

The IDSS creates a patient profile over time through the process of machine learning, using previous data collected from the patient, and triggers an alert as soon as one or more values within the profile get out of range. In Angus's case, the system detects that both his BP and heart rate are out of range for his profile, even though the same readings might be within range for other patients, and therefore triggers an alert for immediate intervention. The Table 2 depicts the similar scenario with IDSS intervention for specific patient.

READING NAME	AVERAGE READING	SCENARIOS AND IDSS INTERVENTION
Blood Pressure (BP)	108/55 mmHg Systolic pressure (SBP) = 108 Diastolic pressure (DBP) = 55	If SBP > = 120 and if DPB >= 70 then the system triggers an alert of a higher than normal reading.
		If SBP <= 90 and DBP <= 45 then the system triggers an alert of a lower than normal reading.
Heart Rate (HR)	60 BPM (Beats Per Minute)	If HR >= 80 then the system triggers an alert of a higher than normal heart rate.
		If HR <=50 then the system triggers an alert of a lower than normal heart rate.

Table 2- IDSS intervention in patient specific scenario.(Basu, Fevrier-Thomas et al. 2011)-

The IDSS also detects that the combined prescribed dosage of both aspirin and Warfarin enhances the risk of bleeding and signals an alert of a drug-to-drug reaction, including a recommendation of a corrective dose of 100 mg aspirin per day and also to monitor the international normalized ratio (INR) for Warfarin treatment(Basu, Fevrier-Thomas et al. 2011). An INR is a laboratory test that measures the time for blood to clot and then compares it with an average time. A higher INR indicates a longer time for blood to clot, thereby preventing formation of clots that may cause stroke. INR is a useful test to monitor the impact of anticoagulant medicines such as Warfarin. If INR is too high then uncontrolled bleeding may occur(Sheth, DiCicco et al. 2001).

Note that if Doctor were using an EMR with an installed DSS, a drug-drug interaction alert would have triggered but not a heart rate or blood pressure alert, which is based on patient profiling and pattern recognition.

INTERACTION	POTENTIAL EFFECT	TRIGGER ALERT	RECOMMENDATIONS
Acetylsalicylic acid (Aspirin) plus Warfarin	Increased bleeding, increased INR	Yes	Limit aspirin dosage to 100 mg per day and monitor INR.

Table 3- Potentially clinically significant drug-drug interactions(Basu, Fevrier-Thomas et al. 2011)

8. Research Challenges

The culture of medicine has always emphasized individual physician autonomy. System changes are not always well-received if physicians are concerned about maintaining that autonomy. In addition to worries about autonomy, physicians have been concerned about over reliance on an outside device.

Ethical concerns should also be taken into an account. The use of these systems is not currently part of the standard of care and, although it can frequently provide useful advice, the advice is not foolproof. It should be recognized that these concerns are not new, nor are they confined to IDSS.

9. Discussion and Suggestions

The purpose of this essay was to get in-depth and the proper understanding of the subject “Intelligent Decision Support Systems” and how its different applications can be applied to various domains. We also saw how the model based on knowledge and Artificial neural networks can be used without user intervention. Whilst writing this essay, we taken into an

account all the objectives mentioned in the assignment description and similarly on course outline. Point wise we have achieved the following objectives

- Identification of key elements of Decision Support system conferred in section 4
- Identification of main decision model or method discussed in section 7 and 7.2
- Implementation of decision making model in related fields talked about in section 7
- Current research issues discussed in section 7 and 8 respectively
- Applications in business intelligence talked about in section 2 and 5
- In depth understanding of material covered in section 7.1, 7.2 and 7.3

The hybrid model discussed here is the combination of descriptive and predictive model. This makes it fast, cost effective and easy to use. Our assumption is, this model can be faster and more reliable if different sets of model techniques are considered. Like demographic based technique with predictive model can be used to identify the people who have more chance to develop certain disease.

While writing this essay we found that two different practices are generally exercised in the field of healthcare. One can be the manual way of prescribing the medicines and the other can be by the use of Clinical Decision Support Systems. In Clinical Decision Support Systems, System provides the recommendations based on the methodology used in its implementation.

According to research done by Abbasi shows that "Clinical Decision Support Systems have several edges over manual systems as they are efficient, effective and low cost"(Abbasi and Kashiyarndi 2006). Another interesting thing they mentioned in their research is that many researchers are using some infrequent methodologies. It shows that there are still opportunities and place for enhancement in the implementation methodologies of Clinical Decision Support Systems.

As the patients are the main stake holders and would be directly affected by the wrong decisions or recommendations by this system. So, we suggest that, due to the sensitivity of the environment, the system should be properly evaluated and tested before its actual deployment.

And future applications may also include application in pharmacy systems to help individuals with adherence to a medication regimen by creating a patient-specific profile and triggering alerts if it deviates from that threshold.

10. Future Work

Over time, monitored data can generate significant sets of information that can be used, in combination with medical care guidelines, for the care of patients. The data can be mined to derive and update intelligent decision rules that are persistent to specific patients and that can adapt over time to patient status.

The structural, and workflow issues that lead to less than optimal design or implementation and, therefore, limited use and effectiveness can be addressed in future work. While

constructing intelligent models the insights gained from research and development efforts will increase, rather than decrease, clinician efficiency.

11. Conclusion

The IDSS model described in this essay is equipped with learning, generalization and self-arranging in order to perceive complex patterns and help with decision support (Viademonte and Burstein 2006). The contextual analysis of case study of, the 40-year-old diabetic patient, demonstrates that when self-monitoring and test information of each patient visit are accessible to a doctor(by utilizing an EMR with IDSS support) than the doctor would have the capacity to settle on better choices. In the future, uploading of self-administered data from patient records to family doctor's electronic medicinal records may turn into the standard for chronically sick patients, and the intelligent (hybrid) decision support system talked about here would be able to play a critical part in giving enhanced patient care.

For future research, incorporating communications between distinctive segments will be executed through a manager component for coordinating neural system capacities and data mining.

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