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COMMONKADS MODEL FRAMEWORK FOR WEB-BASED EMERGENCY MEDICINE DECISION SUPPORT SYSTEM

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ABSTRACT

Medical decision support system proves one of the most significant usages of Decision Support System (DSS) and ICT (Information and Communication Technology) in the health care domain. Providing medical support and facilities in the rural area is the critical issue in the developing countries, like India. Most of the existing technology focused on providing offline telemedicine approach, which will not be handy for emergency purpose. Other approaches focus on providing offline guidance to the emergency paramedics without actually looking at the patient real time vital parameters. This web-based emergency support system will exhibit reasonable accuracy in predicting patient's risk level and forecasting possible disease with onsite suggestion for treatment. Most of the existing solutions are system specific and their applicability is also limited to the mentioned field. They all are utilizing some specific algorithm design based on some predefined rule base. These methodologies lack the ability to scale up and to support the development of large DSS. The modelling approach for creating Knowledge Base Systems (KBS) is much more popular due to its modular structure and its capability to split the knowledge engineering problem into smaller tasks. Different methodologies are proposed by the different researcher for modeling knowledge-based system. Common KADS is considered to be one of the most popular methods amongst them. This paper incorporates all the different models of Common KADS for emergency medicine DSS. The proposed system includes clinical risk detection, disease prediction and suggesting possible treatment as well.

Keywords: *Emergency Medicine (EM), Clinical Decision Support System (CDSS), CommonKADS, Clinical risk detection, disease prediction, Modified National Early Warning Scoring, (MNEWS), treatment suggestion.*

I. INTRODUCTION

InIndia, asone of the developing countries, with a second largest population on the earth, healthmonitoring in the rural/remote area is one of the most critical issues. Lack of hospitals andprimarycare makes the issue moredifficult to solve. Research shows, earlyprevention and betterdiseasemanagement are effective in reducing hospitalization, emergencyroomuse and rate of mortality fromchronic disease. Specifically, the health promoting influence of primary care is regarded as the basisfor prevention of early illnessleading to healthier outcomes. In addition to this, reforming the health policies will also help to solve this issue. With poor doctor to patient ration in developing countries, it would be very difficult to make healthcare facilities available to all people. Use of Decision Support System (DSS), facilitates this decision-making process with the pre-existing infrastructure and resources [1].

These decision support systems can be broadly classified into two categories: Decision Support System (DSS) and Expert system (ES). DSS is an interactive system that helps decision-makers to utilize data and models to solve unstructured or semi-structured problems. ES is a problem-solving computer program that achieve good performance in a specialized problem domain that is considered difficult and requires specialized knowledge and skill. Both types are intended for decision making process, even though they are slightly different from each other. ES can be further classified in various categories. Amongst which most popular ES are: Rule-based system, Knowledge based system, Case-based system, Agent-based system and ontology-based system. Expert-systems are widely used in healthcare either predicting or diagnosing diseases. They are particularly useful when medical professional is unavailable. Clinical Decision Support System (CDSS) is an electronic system designed to aid directly in clinical decision-making process. So, it makes the system valuable to the clinicians in order to improve the quality of healthcare. CDSS is active knowledge system which uses two or more items of patient data to generate case-specific advice. CDSS has long existed in the medical field since 1950s to improve healthcare quality. CDSS can be consider of two types: knowledge based and non-knowledge-based system [2] [3] [4] [6] [12].

This paper includes commonKADS frame work for web-based emergency medicine DSS. The paper proposes organizational, task, agent, communication, knowledge and design model. The paper concentrates on developing the models for emergency medicine application where this web-based system facilitates EM staff for assessing the patient's condition and to initiate treatment at the earliest. The next session discusses all framework models in details.

II. COMMONKADS MODELLING FRAMEWORK

This commonKADS framework includes six models to construct the knowledge-based system. These models are Organizational, Task, Agent, Communication, Knowledge and Design model. This particular framework is proposed to develop generalized emergency medicine DSS with ability to provide decision on clinical risk to the patient and disease probability with treatment options. The modelling approach to construct Knowledge Base Systems (KBS) becomes well accepted among the Knowledge Engineering (KE) communities due to its modular structure and ability to break down the knowledge engineering problem into smaller tasks [5]. The subsequent section discusses these models in detail.

a) Organizational Model

An organizational model provides an analysis of the socio-organizational environment in which the KBS will have to function. In this context, the model proposed here includes the major contributors helping to develop this emergency medicine DSS. As shown in fig 1, The knowledge engineer gets the knowledge from the knowledge providers which is the main source of information for this particular system. In this case doctors, EM experts and scientists are the knowledge providers. The gathered knowledge is structured and organized in a systematic way by knowledge engineer and with the help of knowledge system developer the computer-based EM-DSS will be designed and implemented. DSS will assist the end-user, in this case they are EM-staff, to take necessary, relevant and quick decision based on the information available with them and ultimately to facilitate the patient [7] [8] [9].

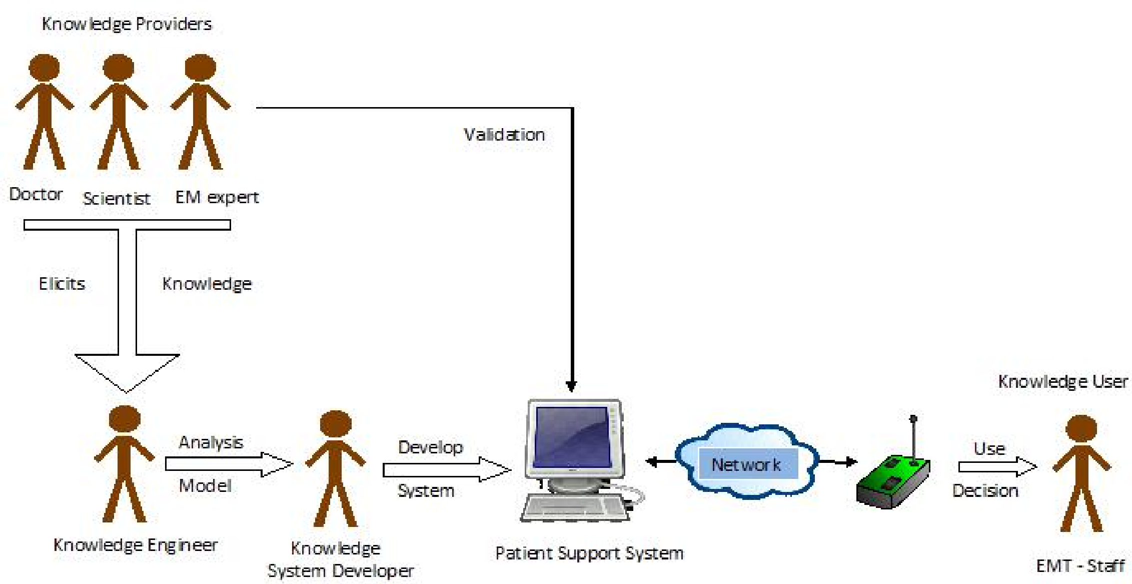

Fig 1 Organizational Model for Patient Support System

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b) Task Model

This model specifies how the function of the system can be achieved by performing number of tasks. An identified task can be decomposed in to sub-tasks. Each separate task is described through an input/output specification, where the output represents the goal that is achieved with the task and the input is the information that is used in achieving the goal.

For the given system as shown in fig 2, three main tasks are identified: i) Clinical risk detection ii) EM score-based disease forecasting iii) Treatment suggestion. Clinical risk detection is based on score calculated from early warning scoring system. EWS is a triage-tool for taking a primary decision, in emergency department or in intensive care unit, based on the values of major vital parameters of patient. This individual score helps to calculate the total aggregate score. Based on the total score the risk level of individual patient can be accessed. This risk detection task also takes the information from the priorities and disease classification defined by emergency medicine guidelines. Second important task is forecasting of probable disease based on the calculated score and decision ontology. This ontology is developed by the knowledge engineer by eliciting knowledge from the domain experts. Third task will be carried out by rule based expert system designed from the data of clinical risk, disease and other historical data of patient [7] [8] [9] [10].

c) Agent Model

Agent model represents all the agents which participates in a problem-solving process. So, this model specifies who does the tasks specified in a task model. It describes the characteristics of agents. Agent in commonKADS has a generic connotation: an agent can be human being, a robot or a software program.

As depicted in fig 2, total four agents are needed to achieve the tasks listed in task model. First task needs two agents and second & third task needs one agent respectively. For a clinical risk detection, score calculated by the emergency medicine based EWS plays a main role. This task is performed by the first agent, where the actual clinical risk detection task is performed. Second agent called EM disease classification will also help to assess the priorities involved in clinical risk. For disease prediction, EM based decision ontology along with disease forecasting agent (third agent) helps to gather disease probability. fourth agent, rule based expert system, helps to identify the possible treatment based on the disease condition and risk levels of individual patient [7] [8] [9].

d) Communication Model

In knowledge-based system, communication model becomes more important than in normal expert system.This model indicates the communication between agents.

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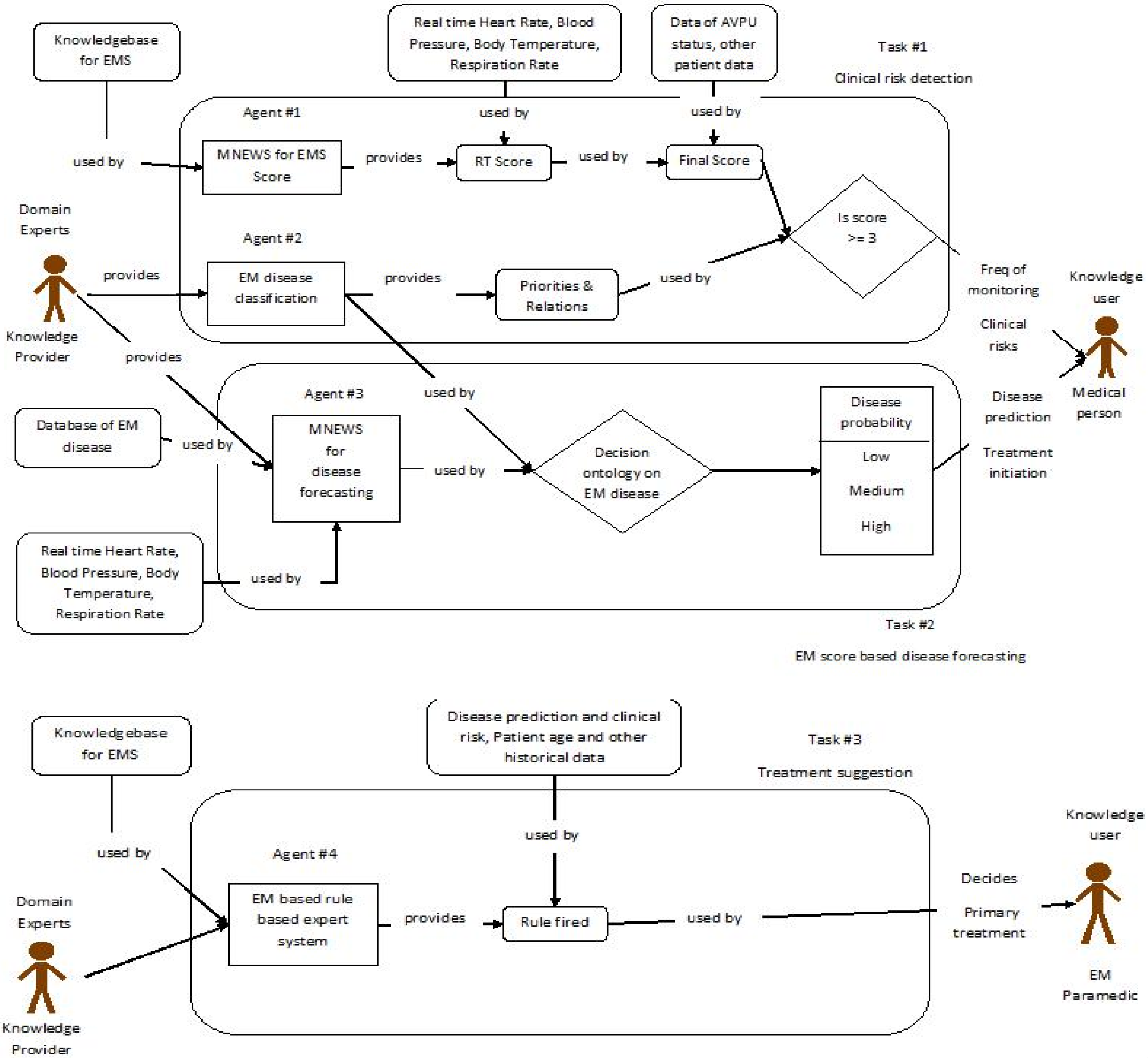

Fig.2: Agent, Task and Communication Model for Patient Support System

Where, AVPU status = Alert/Verbal/Pain/Unresponsive
EM = Emergency Medicine
MNEWS = Modified National Early Warning Scoring System
RT score = Real time score

In fig 2, the third agent requiresdata from the second agent in order to do disease forecasting. In addition to this, agents require database from the external world, that is also indicated in fig. The communication model basically gives the direction of flow of information amongst the agents and with the outside world too.

e) Knowledge Model

This is probably the most important model amongst other models of commonKADS. This model also refers to as expertise model. It contains three knowledge categories: Domain layer, Inference layer and Task layer.

In Domain layer all domain-specific knowledge is modelled which is needed to solve the task at hand. It includes conceptualization of domain in a domain ontology. Inference layer describes the most basic reasoning steps. Task layer specifies the goals of reasoning process and the strategies to achieve these goals.

In order to construct the Knowledge Model, it requires three stages to be followed: i) Knowledge Identification ii) Knowledge Specification iii) Knowledge Refinement.

This model particularly depends on the knowledge available with the experts. It requires to get as much as information available from the domain expert and convert that knowledge into appropriate form. For that purpose, it proposes a knowledge elicitation form (Table 2) for different diseases of Emergency Medicine department. The knowledge Engineer has to acquire all this information from the expert. Table 3 also lists the most commonly practised treatment in EM department as a part of primary treatment of the patient. While Table 1 helps to stratify the clinical risk detection based on the score calculated by the EWS [7] [8] [9] [11].

Table 1: NEWS table for score calculation and clinical risk determination

NEWS scores	Clinical risk
0	Low
Aggregate 1-4	
RED score (Individual parameter scoring 3)	Medium
Aggregate 5-6	
Aggregate 7 or more	High

Table 2: Knowledge elicitation form for diagnosis of EM disease

Disease Name:	Chronic obstructive pulmonary disease
Physiological Parameter (Abnormal Value):	HR: 97 BPM
	RR: 17 per minute
	BP: 160-120 mmHg
	BT: 35.5°C
	SPO2: 92.4 %
Age dependencies:	Yes
Prior History of patient and its relevance to the disease:	Yes (Social circumstances, quality of life, current treatments, smoking
EM category (Priority)	High

Table 3: Knowledge elicitation form for possible treatment of EM disease

Primary treatment	
List of possible theory	IV lines: Hydrocortisone 200mg IV may be given initially if the oral route is not appropriate
	Medication: Antibiotics (Amoxicillin 500 mg oral tds)
	Defibrillation: Not required

	Airway management: Bronchodilators (Nebulised salbutamol 5mg and ipratropium bromide 500 NIPPV (Positive Ventilation)
	Any other primary care: PEFR and start PEFR chart. FBC, U&Es. Sputum and blood cultures. 12 lead ECG.
Age dependencies:	Yes
Prior History of patient's therapy and its relevance	Reaction or allergy to some specific medicines

f) Design Model

This model maps the conceptual analysis made explicit in the knowledge and communication models to a specific implementation. The model specifies the target software and hardware platform, the various software modules included in the target system, their functional and technical specifications and the mapping between these modules and the conceptual components identified during the analysis phase.

III. DISCUSSION

Web-based EM DSS is primarily designed for the purpose of assisting the emergency medicine staff in order to initiate timely treatment of the patients. The nature of problem which EM staff faces in their day to day work, is vey complex. commonKADS helps to fragment this entire complex system into smaller and modular architecture which ultimately simplifies the development process. The commonKADS methodology implements many of the ideas informing the knowledge modelling paradigm and provides an integrated framework in which to carry out knowledge engineering and management projects. The expertise model of the commonKADS is the most important model. This model is the actual back-bone of the system. Agent model along with communication model helps to form the problem-solving architecture for particular task. Different model developed through this approach would streamlines the process of developing the final design of the system.

IV. CONCLUSION

Development of web-based emergency medicine DSS is advantageous to the EM staff for assessing the patient condition in the primary stage. Existing system relies on only visual observation of the patient condition and assessing them based on the knowledge of EM-staff which ultimately limits the efficacy of the treatment. The modelling approach adopted for designing DSS is always the most suitable approach. This generalizes the development of more and more DSS in the field of Emergency Medicine. This approach will also have the advantage to scale up and helps in the process of developing large DSS.

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