EMERGENCY HEALTH CARE ONTOLOGY FOR RISK LEVEL DETECTION

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Abstract *:*

Emergency Medicine is one of the most critical areas in hospital. It is very important to initiate primary treatment to patient who met with any medical emergency. Developing and heavily populated countries, like India, The major issue is lack of medical professional, and it would be very difficult to address this critical issue of primary care to the rural patient. In this scenario, an expert system can be very much useful to facilitate the emergency care providers to take timely decision and to initiate treatment. But again most of the expert systems are based in rule base which depends on the individuals who designed and developed that particular system. In this case, it would be impossible to incorporate all possibilities for integrating the entire knowledge of the experts. Ontology enables explicit and consensual knowledge to be shared and reused between human and software agents. This makes the system interoperable, reusable and scalable. In this paper, we proposed ontology for the emergency risk level detection. This ontology was developed by Protégé editor, an open source editor provided for creating, testing and updating ontology. The developed ontology can be checked for consistency by reasoned and can be validated by running SPARQL query on it.This paper includes the ontology for risk level detection based on the values of patient's vital parameter.

***IndexTerms* - Emergency Health; Ontology; NEWS scoring system,; Protégé; SPARQL.**

I. INTRODUCTION

Emergency medicine is very important in every country because it saves the life of citizens. It primarily includes Rapid assessment, timely treatment and immediate transport of the patient to nearest hospital. Most of the people suffering from acute diseases mostly die because of unavailability of primary care. In addition to this primary care also lacks the trained professional in the rural region in developing countries. This puts limitation to proper health care facilities to all people. Government is constantly trying to address and solve such issues by forming new and advanced health policies, but still the implementation lacks the proper infrastructure and trained professional in such a heavily populated countries. Timely initiation of primary treatment mainly depends on the knowledge of paramedic and other medical staff available in ambulance. In order to assist them it's very much essential to provide them some knowledge based expert system which can help them to at least prioritize the risk level of patient which helps them to initiate treatment and transportation to nearest available health care facility. There are varieties of expert systems available in the market. But there is a requirement of creating generic and scalable expert system with possibilities of interoperability with common taxonomies accepted by the world and understandable by machine [1].

The semantic web was proposed by berners-lee. It offers access to information automatically based on semantics of data which is machine-processable. It also uses heuristics of metadata for automated information access. Using domain theories (ontologies) with this clear illustration of the semantics of data makes a web to offer an entirely innovative way of knowledge. It has the ability to knit together this large network of human knowledge with machine processability [2].

Resource Description Framework (Schema) was proposed by Brickley and Guha, later this proposal becomes W3C recommendation. Primarily, RDF was used to define the statements about resources in form of triples. Triples define the relationship between resource and its property. RDF follows XML based syntax. RDFS is language for defining the ontology and its structure of knowledge as terminological vocabulary, which is used for building the statements [1].

Ontologies formalize the semantics of the domain clearly by describing their elements; and thus, they consist of concepts that describe the internal features of the concepts, and the properties that describe the relationships between these concepts. Ontologies are based on a shared and consensual domain knowledge agreed by a community. Because of these properties, ontologies can support a wide variety of tasks in diverse research areas [8].

OWL (Ontology Web Language) is one of the most standard and widely used ontology languages. It follows XML based syntax and is upgraded from RDF (Resource Description Framework). RDF is a language following XML format for defining information available on the web. OWL has three sub types based on their expressiveness. They are known as: OWL-Lite, OWL DL and OWL Full. OWL-Lite is used for primary classification hierarchy and basic constraints. While OWL DL gives the ability to maximize the expressiveness while retaining computational completeness and decidability. OWL full is meant for users who want maximum expressiveness. OWL contains classes, properties, relations and individuals and it allows a reasoner-based inference.

One of the most used standard ontology languages today is OWL (Ontology Web Language). It is written in XML format and is considered a semantic upgrade of RDF (Resource Description Framework). RDF is an XML-based framework for describing information on the web. There are three types of OWL sublanguages differentiated by their expressiveness. These are called OWL-Lite, OWL DL and OWL Full. OWL-Lite supports those users primarily needing a classification hierarchy and simple constraints. OWL DL supports those users who want the maximum expressiveness while retaining computational completeness and decidability. OWL full is meant for users who want maximum expressiveness. OWL contains classes, properties, relations and individuals and it allows a reasoner-based inference [3].

This paper aims to propose ontology architecture for risk level detection in emergency situation. This risk level is recommended based on the score calculated from the vital sign parameters. We have included the components of ontology and their importance in manipulating the ontology. We have also included the step-by-step process of creating ontology and the process of checking its consistency. In order to get the required information from the ontology, it needs to run query through SPARQL. That process in also included in the later section of this paper.

II. Ontology Components

The most popular definition of ontology was proposed by gruber (1993) defined is as "a formal, explicit specification of a shared conceptualisation". In this definition, Gruber sited more emphasis on formalising the specification of concepts and relations; ultimately it allows representation of knowledge and sharing that amongst different agents. Later Studer et al. (1998) analyzed this definition and perceived four main concepts: formal, explicit, shared and conceptualisation. Formal means ontology should be machine readable format; explicit implies that all concepts, properties, relations, functions, constraints and axioms used are defined explicitly; shared indicates that an ontology should capture consensual knowledge accepted by the communities; and conceptualization refers to an abstract model and simplified view of some phenomenon in the world that we want to represent. Guarino (1998) has also given another definition of ontology: "a set of logical axioms designed to account for the intended meaning of a vocabulary". Where, Guarino focused on the role of logic theory as a way of representing an ontology [4] [5] [7].

In ontologies, Formalization of the knowledge is based on five basic components: classes, instances, relations, functions, axioms and instances.

Classes or concepts: It is group of individuals that share common characteristics used in a wide sense. A concept can be anything about which something is said. It can be a description of a task, action, function, strategy, reasoning process, etc. The majority of ontology languages allow the definition of concepts on the basis of these characteristics.

Relations: In Ontologies, The way in which individual are related to each other is described by relations. In other terms, it represents a type of interaction between concepts in the same domain.

Functions: It defines the internal working of a function. They are a particular type of relations, which gives relationship between nth element with n-1 element.

Axioms: Axioms are important component of ontology. It represents assertion formulated in a logical form that comprises the core knowledge that the ontology describes in its domain of application. In other terms, axioms are used to model sentences that are always true. Axiom types can be classified according to their semantic meaning

Instances: Instances are individuals that models concrete objects (people, proteins, machines) and represents the base components of an ontology.

III. Ontology Construction

The first step in the process of developing ontology requires concepts, attributes, relationship and axioms as a part of analysis phase. The second step includes defining conceptual model for a set of tasks identified. In the later phase of development, one has to identify most suitable ontology language to formalize the ontology and to update the ontology as per the concepts in domain in the maintenance phase.The ontology proposed in this study covers the emergency care services where the focus is on primary risk level stratification based on minimal set of data available from the patient. [4] [6] [10] [11] [12].

During the development of the ontology, we interviewed experts and reviewed a number of papers and manuals for the purpose of information extraction. The details of the steps are given below.

Risk level stratification based on early warning scoring system

Early warning scoring systems are developed to facilitate the assessment of patient's condition based on minimal set of medical parameter. There are various systems available proposed by different researcher. NEWS system is one of the most efficient ED-based EWS. Risk level stratification based on the score of individual patient is the key criterion for using this system for mentioned purpose. NEWS needs patients most commonly monitored body vitals and score based on predefined values. Aggregate score indicates the severity of patient's criticality of illness. This table is used for creating emergency health care ontology [13] [15] [16].

Creating Emergency Medicine Ontology using Protégé

Ontologies are essential component of the semantic web. It provides a shared a common vocabulary to support the sharing and reuse of knowledge. Protégé is free, open-source ontology editor and a knowledge management system. It provides a graphic user interface to define ontologies. It supports ontology creation, visualization and manipulation in various formats. This segment defines the development of Risk level ontology that is a knowledgebase for the given expert system and is used for querying on user's request [9].

Step1: Creating Class and Subclass

For creating class, OWL classes tab is selected on the main editor page. A new class VitalSign is created by clicking on subclass button. On clicking the subclass button a class explorer opens up with a name and other restrictions like class disjoint with newly created class. Similarly all other classes and subclasses are created in Risk ontology. Fig.1 shows class hierarchy and Fig.2 shows the classes and subclasses included in proposed ontology.

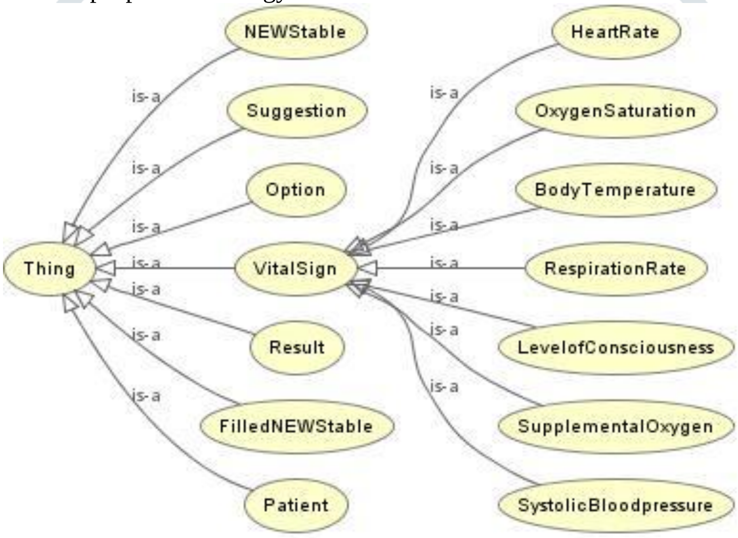

Figure 1: Class hierarchy

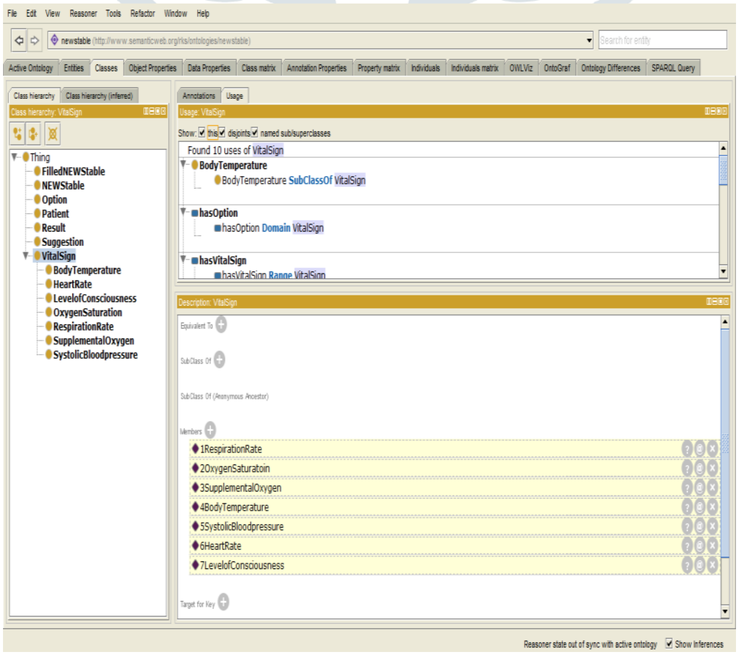

Figure 2: Class in protégé and its usage

Step 2: Creating Object and Data Properties

After creating class hierarchy, various properties and sub properties are added using inbuilt features of protégé to add property and add sub property. Protégé gives facility to add three types of properties: Object property, Data property and Annotation property. Using add property feature, a property editor window can be assessed where we can specify whether the property is inverse, functional, symmetry, transitive or asymmetry. The domain and range of the property should also be defined with this facility. Table 1 shows object properties and Table 2 shows data properties created for this ontology. While Fig.3 and 4 shows the object property and data property window of protégé IDE.

Table 1: Object Property Table

Sr No	Property Name	Domain	Range	Remarks
1	Filledby	Patient	FilledNEWStable	Functional Property, Inverse Property
2	Fillin	FilledNEWStable	Patient	
3	hasChosen		Option	
4	hasCollectedAnswer	FilledNEWStable		
5	hasOption	VitalSign	Option	Inverse Property
6	isOptionof	Option	VitalSign	
7	hasVitalSign	NEWStable	VitalSign	

Table 2: Data Property Table

Sr No	Property Name	Domain	Range
1	has Age	Patient	Integer
2	hasGender	Patient	String
3	hasLocation	Patient	String
4	hasDescription	TotalScore	String
5	hasFilleddate	FilledNEWStable	Timedate
6	hasSuggestion	Suggestion	String
7	hasValue	Option	Integer

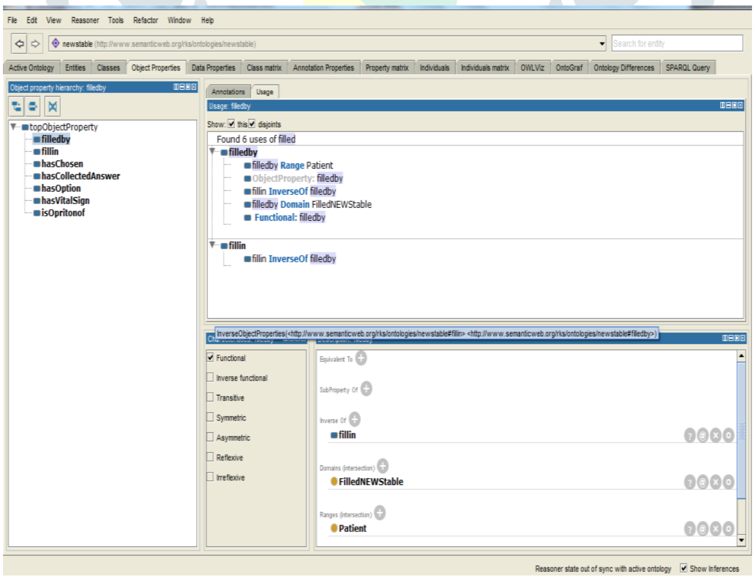

Figure 3: Object property creation in protégé and its usage

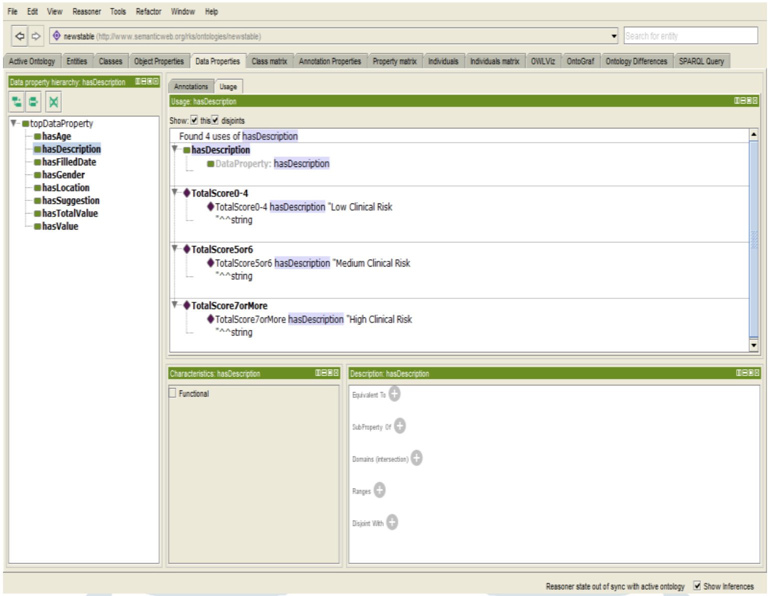

Figure 4: Data property creation in protégé and its usage

Step 3: Creating Individuals

Once all Classes and Properties are created, individuals of classes are created next. Individuals are like instances of classes. Fig 5, shows a view of added individuals of class. Individuals can be added in protégé by using individual tab in editor. Individuals can be added to class by clicking on class and then adding individuals and defining its relevant properties.

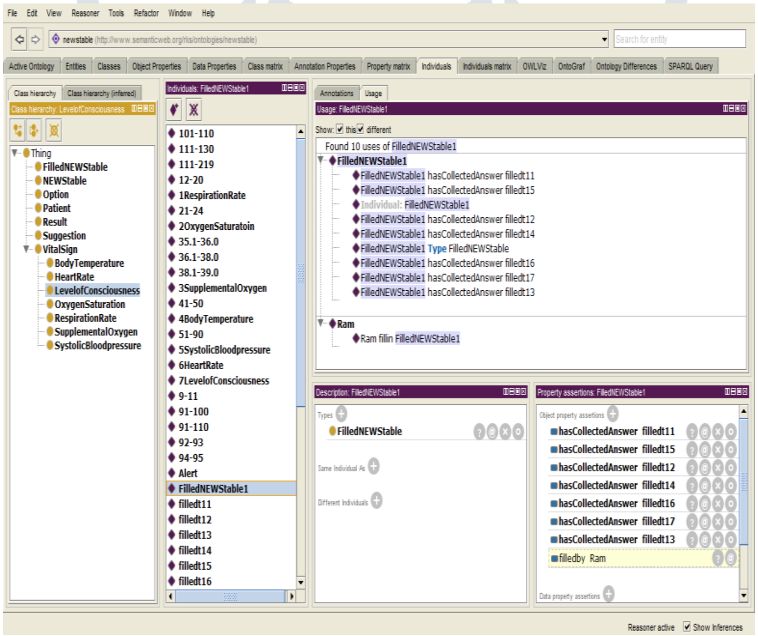

Figure 5: Individual creation in protégé and its usage

Step 4: Consistency Checking

Consistency checking is very important in ontology as it detects the duplication in instances or clustered instances as per their sources in the same ontology. This increases the overall usefulness of the ontology. We checked our ontology thoroughly for any inconsistencies, which may arise during the modelling phase, related to inconsistent data property definition, wrongly associated concepts, relationship and property labelling. After this, reasoning was performed in Protégé by utilizing a Pellet reasoner. People can some other reasoning tools such as Racer, DL and FACT++ to perform intelligent reasoning on OWL ontologies. [13].

IV. Querying ontology using SPARQL

In the use of ontology, SPARQL query has a very important role. Ontologies are designed in a certain way so that they allow finding out certain information by queries applied on the ontology for evaluation and supporting decisions. Using queries we could know how well the ontology is answering the question of the users. Here, we will use SPARQL query language.

RDF (Resource Description Framework), which provides a simple way to represent distributed data, is a standard model for data interchange on the Web. A triple is a simple way to show the relationship between two things. The standard way to access RDF data uses a query language called SPARQL, which is short for SPARQL Protocol And RDF Query Language [3].

SPARQL has two important keywords: SELECT and WHERE. A SPARQL SELECT query contains two parts: a set of question words and a question pattern. The keyword WHERE indicates the selection pattern, which is written in braces. The question words with "?" in front are displayed after keyword SELECT and in the braces followed keyword WHERE, some information and relationships related to the question words needed to query.
Here, we have listed few important queries and their results from the developed ontology.

Query -1 To know who filled data
SELECT ?PatientName ?FilledNEWStable
WHERE{ ?PatientName A:fillin ?FilledNEWStable. }

Result: Ram

Query -2 To know selected option by the patient
SELECT ?PatientName ?FilledNEWStable ?Option
WHERE{ ?PatientName A:fillin ?FilledNEWStable. ?FilledNEWStable A:hasCollectedAnswer ?Option.}
Result:

Patient Name	FilledNEWStable	Option
Ram	FilledNEWStable1	Filledt11
Ram	FilledNEWStable1	Filledt12
Ram	FilledNEWStable1	Filledt13
Ram	FilledNEWStable1	Filledt14
Ram	FilledNEWStable1	Filledt15
Ram	FilledNEWStable1	Filledt16
Ram	FilledNEWStable1	Filledt17

Query-3 To know patient name vital sign range and its individual score
Result:

Patient Name	VitalSign	Value	Score
Ram	1RespirationRate	12-20	0
Ram	2OxygenSaturation	94-95	1
Ram	3SupplementOxygen	No	0
Ram	4BodyTemperature	38.1-39.0	1
Ram	5SystolicBloodpressure	91-100	2
Ram	6Heartrate	More_than_131	3
Ram	7LevelofConsciousness	V,P,U	3

Query-4 To know the total aggregate score of patient
SELECT (SUM(?Score) AS ?TotalScore)
WHERE
{ A:FilledNEWStable1 A:hasCollectedAnswer ?Option. ?Option A:hasChosen ?Value. ?Value A:hasValue ?Score.}
Result: 10

Query-5 To know name of patient total score and clinical risk
SELECT ?PatientName ?FilledNEWStable ?TotalScore ?Description
WHERE{ {SELECT ?PatientName ?FilledNEWStable (SUM(?Score) AS ?TotalScore)
WHERE { ?PatientName A:fillin ?FilledNEWStable. ?FilledNEWStable A:hasCollectedAnswer ?Option. ?Option A:hasChosen ?Value. ?Value A:hasValue ?Score.} GROUP BY ?PatientName ?FilledNEWStable }
{SELECT ?Score1 ?Description
WHERE {?TotalScore A:hasTotalValue ?Score1. ?TotalScore A:hasDescription ?Description}}
FILTER (?Score1 = ?TotalScore)}

Result:

PatientName	FilledNEWStable	TotalScore	Description
Ram	FilledNEWStable1	10	High Clinical Risk

Discussion & Conclusion:

In this paper, we introduce our preliminary effort to create an ontology for risk stratification in emergency primary care. It uses the most basic and readily available and most frequently measured body vital parameters from the patient. It calculates the score based on the value of vital sign parameter and gives risk level of the patient. This ontology can be useful to the paramedic for initial assessment of the patient and to initiate the treatment accordingly. As this decision making system is created with architecture of ontology, it helps the end users to get the updated and most appropriate knowledge.

The primary purpose of this ontology is to serve as an initial assessment tool for identifying the patient's criticality. The scoring system adopted for this system is adopted by eastern countries. By incorporating this system with this ontology architecture this system can easily be upgraded or modified as per the criterion and condition of the different regions. This system helps to give a common architecture to add as many parameters as the experts want and as to modify the range as per their expertise.

Currently this system accepts the inputs from users and need to enter manually, but this system can be upgraded to interface with vital parameter sensors such that it gets updated and reflected on screen automatically. This helps the paramedic for the rapid assessment of the patient's condition so that accordingly, paramedic can assess the efficacy of the treatment or accordingly modify the treatment. We also plan to incorporate disease ontology with this so as to come out with probable diagnosis and treatment suggestion too.

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