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Supporting Parent's at NICU Using Automatic Summary Generator System - NICU Ontology

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Abstract

Parents of infants in NICU are facing challenges in the lack of information or in understanding it, in addition to their negative feeling in this stressful experience. One way to support parents is to develop an automatic system that generates a clear and concise summary about infant progress. In order for this system to function properly there is a need for ontology. This project present a simple ontology contains some main concepts in NICU domain. This ontology was developed through a Protégé version 3.4.2 in seven steps that used to create the RDF and OWL. The ontology mainly includes 10 classes, 17 data properties, 8 object properties, some individuals and cardinality restrictions on relationships between classes, and other descriptions. At the end, the author found the ontology consistent after reasoning then executed four different SPARQL query and its result were correct. This ontology can be developed and used in another application around the NICU domain.

Keywords: *NICU; ontology; clinical text; automatic summary generator; protégé*

1. Introduction

Neonatal intensive care unit (NICU) is specializing in the care of sick or early newborn infants [2]. Inside this unit, all of the critical life support, physiological monitoring and medical attention are provided twenty-four hours a day. The infants that are cared for might have serious and complex medical problems [7]. For parents, the NICU experience is an unanticipated journey filled with stress, emotional turmoil, strains on relationships and sometimes depression [2]. They rarely feel safe from the fear and uncertainty of the problems that can occur while the child is in care; the sequence of events in the NICU journey has many unexpected ups, downs, and turns of event [7]. Usually medical staff provides a large amount of information to the parents. Parents have to come to terms with information that they are not familiar with and have to deal with the emotional impact of the information presented to them [2]. However, the provision of clear and summarized information is important in giving parents a sense of hope and a feeling of involvement in their child's care [7]. Therefore the aim of my research project is to explore current parents experience in the NICU at NGHA, Jeddah [4] and will suggest developing an intervention which is an automatic summary generator that can support parents in this unit.

The system of summary generator is based on the data-to-text architecture. This system will generate textual summaries in number of steps; all of them will access a domain called "ontology". This ontology includes NICU concepts and vocabularies that describe the words that nurses and doctors used to speak about this domain [12]. In addition it includes related properties and relationship between these concepts. Developing of this ontology will help to ensure that the processing steps will communicate properly in the system. It provide a common conceptual vocabulary, thus will help in integrating the different modules.

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Furthermore, combining this vocabulary with other some kind of knowledge will provide support reasoning service [12].

This project will describe an implementation steps of a simple NICU ontology, that including RDF (Resource Description Framework) and OWL. At the end it will present the execution of some SPARQL queries.

2. Related Work

Much of the literature confirms that there is a need for improving interventions, provide consistent information sharing, and high level of support for parents in the environment of NICU; to reduce parental stress, anxiety and negative feelings, improve family-centered care, and to increase parents satisfaction and involvement in the NICU [1], [5-6], [11]. Parents of infants admitted to the NICU will experience stress, depression, anxiety, and feelings of powerlessness, and hopelessness [11]. They used to cope with this stress via preexisting support systems of family and friends [2]. Lam *et al*. findings indicate that parents of infants in the NICU had a lower level of stress if they perceived a high level of support, and there is a need for improving the nursing support strategies in providing parents with clear and updated information [5]. According to Grosik *et al.* once stressors have been identified, then interventions can be developed to improve the family-centered approach to care [2]. It has been shown that there is a need to develop local interventions to decrease stress and enhance parents' abilities and understanding of their infant [6]. In addition, to providing holistic, family-centered, developmentally supportive care and open communication with parents in this stressful experience [11]. Franck *et al*. found that because of an intervention the parental stress during the NICU stay was not reduced, while satisfaction with information and preference for involvement were both increased [1].

One means of achieving the intervention and support for parents is through developing software that generates summaries of medical data about babies in NICU using natural language processing (NLP). Research by Mahamood and Reiter showed that all parents preferred texts generated with the effective strategies, and the key finding was that the use of these affective strategies might be appropriate [7] whenever an NLP system is communicating emotional sensitive information to a non-expert recipient. Although this research provided a solution using NLP technology, it does not examine whether this software can support parents in Arab countries and gaining their preference through generating daily summary reports. Finally, these studies have not been applied in the Saudi Arabia environment.

The NICU ontology was implemented in two similar systems. The first one is called the BT-Nurse system which automates the generation of a natural language nursing shift summary in a NICU. It based on the data from an electronic medical record (EMR) [3]. The other one called BT-45, which used by doctors and nurses to automate generation of clinical data summaries around 45 minutes , thus help them to make decisions quickly. The ontology was used in both systems to facilitate the communication between processing stages and in modeling uncertainty and incomplete knowledge [2].

3. Methodology

In this section, represent the methodology used to develop the NICU ontology. This ontology was implemented using a Protégé version 3.4.2 through number of steps that used to create the RDF and OWL. This project applies the steps of Noy and McGuinness [10] as following:

3.1. Determine the Domain and Scope

The domain of proposed ontology represents the procedures and intervention for an infant in the NICU at hospital. This ontology will be used to assist in natural language processing and can be used in applications that summarized or retrieve clinical data in this domain. Due to the requirement of this project, the concepts were limited to only describing the information related to the nutrition and treatment for an infant. In addition it includes parents and nurse of a particular infant.

3.2. Consider Reusing Existing Ontologies

A knowledge base of NICU concepts are already exist and can be found on the web such s BioPortal site (http://bioportal.bioontology.org/ontologies). Then the ontology on this knowledge base can be imported and used. In this project, the author started to build a simple ontology from the beginning.

3.3. Enumerate Important Terms in the Ontology

This ontology include the following terms: Neonatal Intensive Care, Preterm_infant, Nurse, Parents and its subtypes that is Father and mother, Treatments, and Nutrition ant its subtypes which is Feed and Fluids.

3.4. Define the Classes and the Class Hierarchy

A top-down development process was used. The developer started with the defining the most general concept which is Neonatal Intensive Care, then specialized this class by some of its subclasses that is Preterm_infant, Nurse , Parents, Treatments, and Nutrition. After that the class of Parent was specialized into Father and Mother Subclasses. In addition, subclasses of the Nutrition that are Feed and Fluids was created. Figure 1.Shows the class hierarchy for this project.

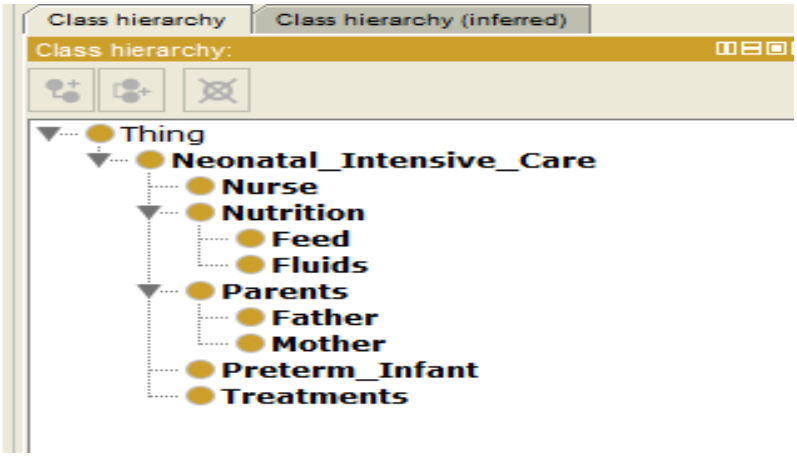


Figure 1. Class Hierarchy for NICU Ontology via Protégé

3.5. Define the Properties of Classes—slots

First, started to define the data properties for each class, the Preterm_Infant class has the following properties: InfantName, MRN, Bed, Weight, AdmittedDate, Consultant, Length, and Gowth. The classes of Parents and Nurse have Name as their property. The properties for

Feed that is a subclass of Nutrition class are Calories, MI, Frequency, Route, Start, Finish, and Comment. The other subclass is Fluids and has IVfluid, Start, Finish, and Comment. Lastly the properties for Treatments class are TreatmentName, Start, Finish, and Comment. Figure 2. Shows the data property hierarchy.

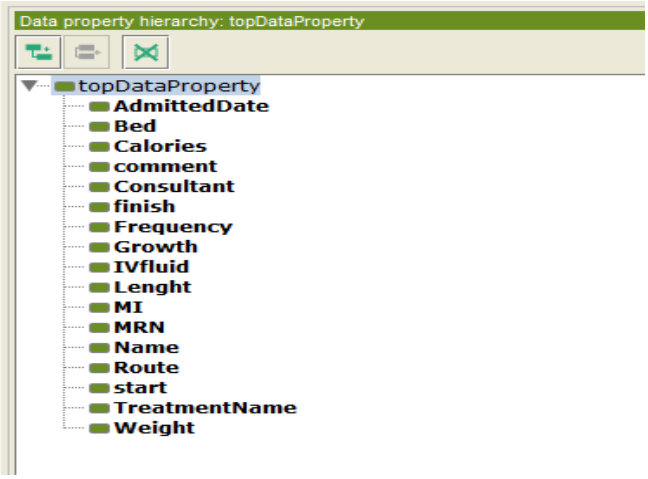


Figure 2. Data Property Hierarchy for NICU Ontology via Protégé

Table 1. Domains and Range for Data Properties

Data Property	Domain	Range
Name	Parents, Nurse	String
InfantName	Preterm_Infant	String
MRN	Preterm_Infant	Integer
Bed	Preterm_Infant	Integer
Weight	Preterm_Infant	Integer
AdmittedDate	Preterm_Infant	dateTime
Consultant	Preterm_Infant	String
Length	Preterm_Infant	Integer
Gowth	Preterm_Infant	Double
Calories	Nutrition	Integer
MI	Feed	Integer
Frequency	Feed	Integer
Route	Feed	String
Start	Nutrition, Treatments	dateTime
Finish	Nutrition, Treatments	dateTime
Comment	Nutrition, Treatments	String
IVfluid	Fluids	String
TreatmentName	Treatments	String

Next, started to define the object properties and they are the relationships between individual members of the class and other items. The CaredBy property created to link between Preterm_Infant and Nurse classes. The FedBy property created to link between Preterm_Infant and Nutrition classes. The HasA property created to link Neonatal_Intensive_Care class to all Classes. The HasInfant property created to link between Preterm_Infant and Parents classes. The HasParent property is an inverse of HasInfant and also link between Parents and Preterm_Infant classes. HasParent has two sub properties,

which is HasFather and HasMother. Last one is TreatedBy property that created to link between Preterm_Infant and Treatments classes. Figure 3.Shows the object property hierarchy.

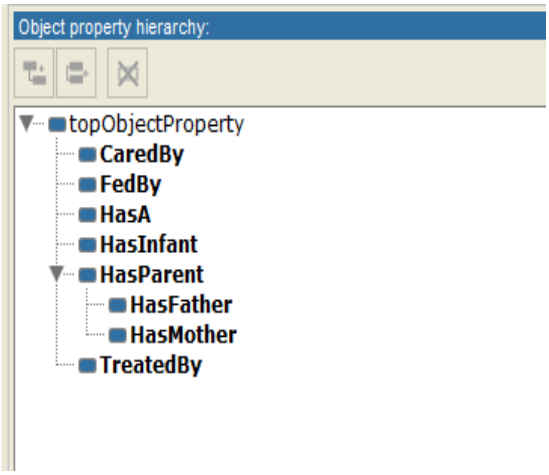


Figure 3. Object Property Hierarchy for NICU Ontology via Protégé

3.6. Define the Facets of the Slots

Fist, the domain and range of the data and object properties has been determined. Table 1 shows the list of data properties with their domains which is related class, and ranges which is data types. Table 2 shows the list of object properties with their domains and ranges classes.

Second, the slot cardinality has been determined on the most important classes which is Neonatal_Intensive_Care and Preterm_Infant. Figure 4 shows cardinalities on the Preterm_Infant class. Figure 5 shows cardinalities on the Neonatal_Intensive_Care class.

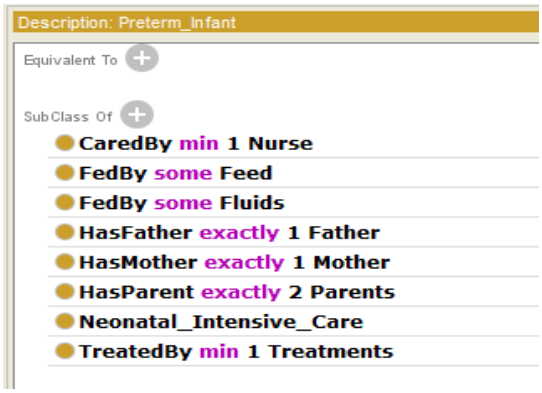


Figure 4. Cardinalities for Preterm_Infant Class

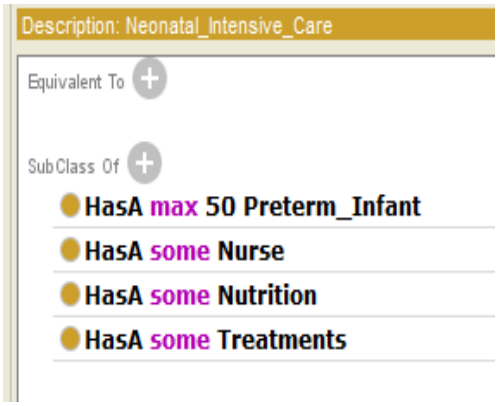


Figure 5. Cardinalities for Neonatal_Intensive_Care Class

3.7. Create Instances (Individuals)

In the last step, some of class instances have been created. And the same types of these individuals were grouped together via "Same Individual As" section. Additionally object properties have been determined for individuals of type Parents and, Preterm_Infant because it was linked to all other classes and some data properties and values has been created as well. Figure 6 shows the list of all individuals and the decryption of one of the individuals (Ahmad).

After the creation of all steps, The FaCT++ Reasoner was applied to test the ontology. Next, some of SPARQL Queries has been implemented as follows. At First, the ontology prefix was found from Active ontology tab and has been added to SPARQL Query section with the default prefixes. This is the Prefix: (PREFIX NICU: <http://www.semanticweb.org/sony/ontologies/2014/4/untitled-ontology-3#>)

Then, we created and executed the following SPARQL Queries (which used to query the RDF and OWL files),

First query to find all treatment names in Treatments class;

```
SELECT ?TreatmentNames WHERE { ?x NICU:TreatmentName ?TreatmentNames }
```

Second query to find All infants who had treated with FolicAcid ;

```
SELECT ?infant  WHERE { OPTIONAL { ?infant NICU:TreatedBy NICU:FolicAcid }}
```

Third query to find the infant that stays on bed number 01;

```
SELECT  ?Infant ?BedNumber
    WHERE {  ?x NICU:InfantName ?Infant .  ?x NICU:Bed ?BedNumber  FILTER (
            ?BedNumber =01) }
```

Last one to retrieve all infants MRNs, their consultants and when they admitted;

```
SELECT ?infants_MRN ?Consultant ?Admitted
    WHERE { ?x NICU:MRN ?infants_MRN  . ?x?Admitted }
```

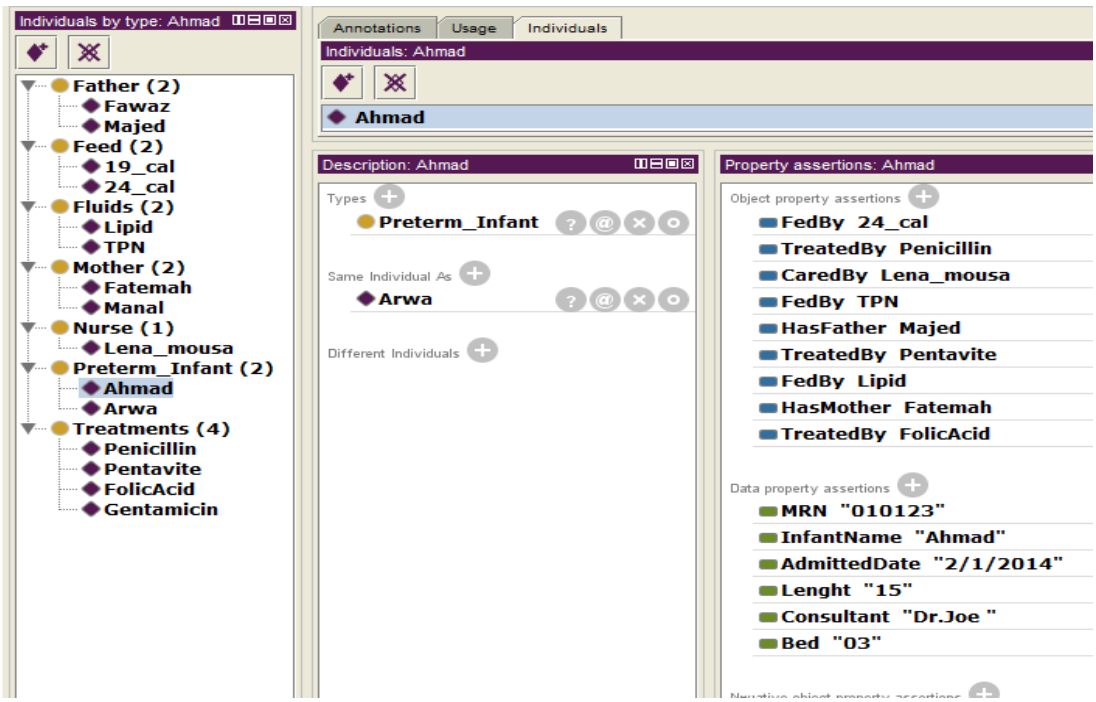


Figure 6. Individuals for NICU Ontology Protégé

4. Result and Discussion

The result of this project is an RFF/OWL file which is the ontology about NICU domain. The resulted ontology includes 10 concepts, 6 main concepts and 4 sub concepts. And mainly 6 object properties and 2 sub properties with their cardinalities. Also contains 17 data properties. Additionally a number of class's instances have been created with the relationships between them. After the Reasoner was applied, we found some inconsistencies in the data types of some data properties values on some instances, and it was corrected.

The result of first SPARQL query returned all Treatment names in Treatments class and it is shown in Figure 7. A second query returned all infants who had treated with "FolicAcid", the result is shown in Figure 8. The result of third one shown in Figure 9 and it returned the infant name that stay on bed number 01. Last query returned a table with infants MRNs, admission date and their consultants as shown in Figure 10.

Many parents are faced a lot of negative feelings and bad experience in NICU environment. They may not get enough information about their infant or not understand it. The literature shows there is a need for intervention to give parents more support. One way is to develop an Automatic Summary

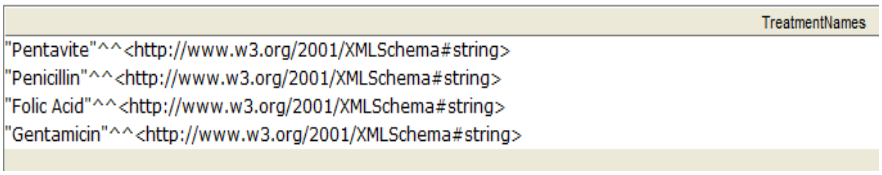
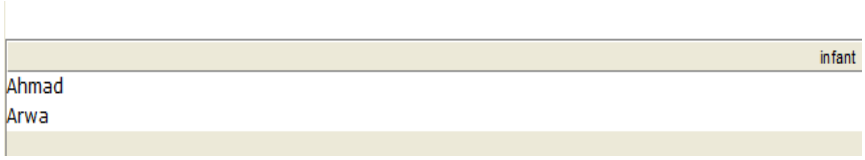
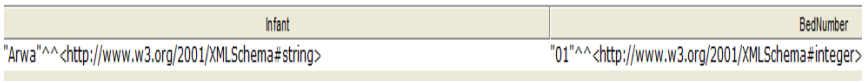


Figure 7. The Result of First SPARQL Query



infant
Ahmad
Arwa

Figure 8. The Result of Second SPARQL Query



Infant	BedNumber
"Arwa"^^<http://www.w3.org/2001/XMLSchema#string>	"01"^^<http://www.w3.org/2001/XMLSchema#integer>

Figure 9. The Result of Third SPARQL Query

infants_MRN	Consultant	Admitted
"010145"^^<http://www.w3.org/2001/XMLSche	"Dr.Mary"^^<http://www.w3.org/2001/XMLSche	"20/2/2014"^^<http://www.w3.org/2001/XMLSc
"010123"^^<http://www.w3.org/2001/XMLSche	"Dr.Joe "^^<http://www.w3.org/2001/XMLSchen	"2/1/2014"^^<http://www.w3.org/2001/XMLSch

Figure 10. The Result of Fourth SPARQL Query

Generator System. This system needs an ontology to work appropriately that contains concepts describing the NICU domain. This project demonstrated the development steps of this ontology using protégé version 3.4.2. After defining the scope of the ontology the developer defined the most important classes and built the class hierarchy. After that, the data properties for each class were defined. All subclasses of a class inherit the property of that class such as the start, finish and comment properties of Nutrition class is inherit to its subclasses (Feed, and Fluids). Also object properties have been defined that represent the relations between classes and their individuals. There was six main relation and two sub relation that under "HasParent".

Next, the domain and range of each property was determined. The range of a data properly is represent a type of data wither it is a string, integer, double, *etc*. The domain is a class that properties owned. About the object property properties they represent the classes that participate on the relationship. Each object property has a cardinality that restrict relationships with other classes such as min, max, some, *etc*. Next, some instances were created for each type of a class. Since the Preterm_Infant is considered as a center that linked to all classes, the decryption of its instances was created that include values for some data properties, and object properties assertions that linked the instances with other class instances.

After checking the consistency and applicability of the ontology created through the reasoning, the developer executed some SPAEQL queries. Some of them retrieved instances and some used to get some values of a particular instance. The first one used to list all treatment names available. Second one is used to get all pretem_infant instances that had treated by "FolicAcid", Optional was used because may be there is no infant had this kind of treatment. Third one used to retrieve the infant that stay on bed number 01, FILTER was used to restrict the result. Last one to retrieve a group pattern includes Infants' MRN, their consultant, and Admission date. The output result was as expected and no conflict occurs, thus ensured that the ontology is correct.

5. Conclusion

This paper present a simple NICU ontology development steps, includes RDF and OWL. Also some SPARQL Query was executed. In future work this ontology might be benefit to be used in another application for various tasks and purposes. Such as, applications for medical terminologies in NICU domain, and in systems that used for automatic verification of the messages accuracy which exchanged between other healthcare applications. It is not limited to natural language processing system that includes automated decision support systems.

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