An ontology to improve the first aid service quality

LORENZO DE LAURETIS AND STEFANIA COSTANTINI

What is an ontology?

- An ontology is a very powerful tool to describe the world that surrounds us

- Ontologies provide formal models of domain **knowledge** that can be exploited by intelligent agent

- Web ontologies are built upon the Resource Description Framework (**RDF**), that provides a simple declarative data model of triples (subject, predicate, object)

Ontology reasoning

- Ontologies, given their nature, support reasoning tasks

- A **reasoner** is a program that infers logical consequences from a set of explicitely asserted axioms or facts

- A reasoner provides automated support for reasoning tasks, such as **Queries**

- In our project, we use HermiT[1] as a reasoner

[1] http://www.hermit-reasoner.com/

HermiT reasoner

- It is fast, reliable and open source

- It is fast as other reasoners when classifying relatively easy ontologies

- It is usually much faster when classifying more complex ontologies

- Includes some nonstandard functionalities, such as reasoning with ontologies containing description graphs

- HermiT works very well with large and complex ontologies

The project eHealth

- The project eHealth stems from a collaboration between the Department of Information Engineering, Computer Science and Mathematics (**DISIM**) at Università degli Studi dell'Aquila (UNIVAQ) and the Department of Life, Health and Environmental Sciences (**MESVA**) at UNIVAQ

- This work describe a part of eHealth, that is the **creation** and the **querying** of an ontology based on anonymous data retrieved from first aid phone services, with the scope of **aiding the first aid phone operator in doing his choices**.

Data to be elaborated

- We obtained anonymous first aid phone data from the MESVA department in L'Aquila
- Those complete data are from the years 2017 and 2018
- More than 63000 total records!

Data structure

Column Header	Description
CodiceColore	Is the color code that is assigned to the patient, red is more serious, white is less serious
DataEOraInizioEvento	Is the Datetime of the call
Destinazione	Is the destination inside the hospital
DettaglioPatologia	Is the possible pathology, determined from the phone operator
DettaglioSoccorso	Is the detail of the phone call about the rescue mission
EsitoSoccorso	Is the conclusion of the rescue mission
FasciaOraria	Is the time slot of when the call was received
GravitaPartenza	Is the severity of the departure
GravitaRientro	Is the severity of the return
InfoPatologia	Is additional information about the "DettaglioPatologia"
Localita	Is the location where the event occurred
LuogoEvento	Is the place where the event occurred, for example "home" or "gym"
MezzoAssegnato	Is (one or more) the assigned vehicle(s) to the rescue mission
MotivoDiChiusura	Is the reason for the closure of the mission
Note	Are additional notes on the mission
NScheda	Is the unique number of the mission
NumeroPazienti	Is the number of patients that need help
OspedaleDiArrivo	Is (one or more) hospital(s) of destination
Patologia	Is the pathology determined from the doctor inside the ambulance, when the patient has been visited
Sesso	Is the sex of the patient
TipoEvento	Is the main category of the event
TipoSoccorso	is the main kind of the rescue mission

Ontology skeleton creation

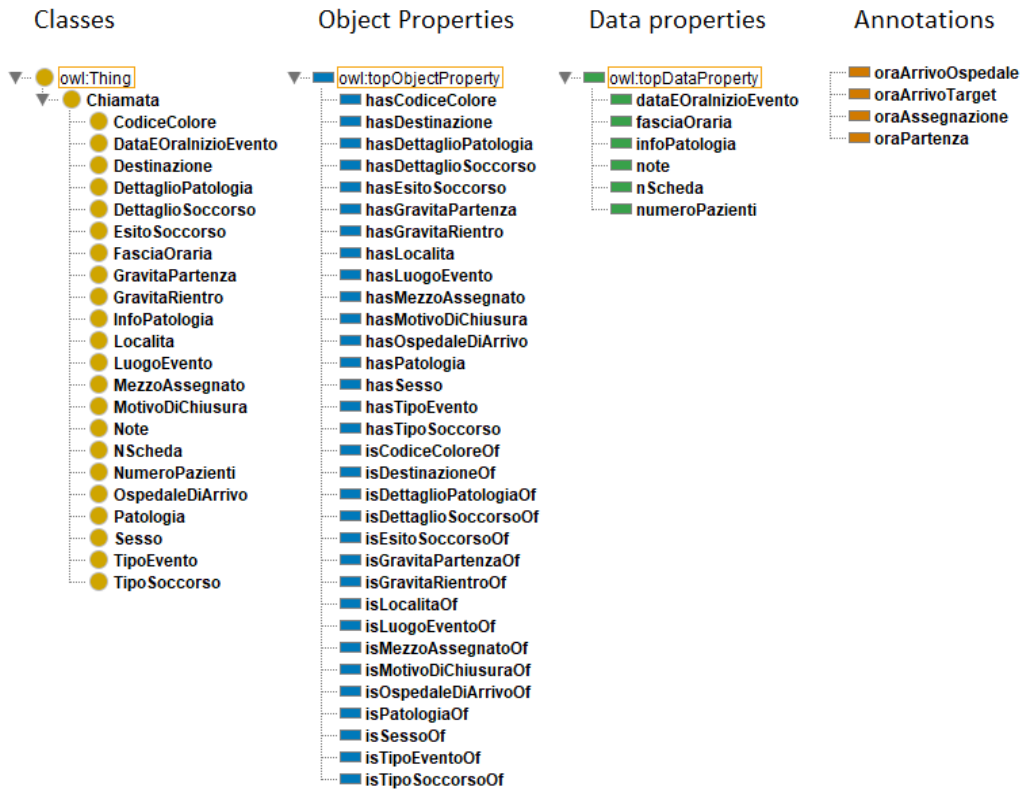
- We create an ontology main class called Chiamata, and 22 subclasses of it, one for each of the columns of the files

- We create the ontology Object properties, used to add some restriction onto classes

- We create the Data properties, used to assign some values to an entity

- We create the Annotations, pieces of extra-logical information describing the ontology or entity

Ontology skeleton



Automatic ontology individuals creation

- Individuals are created automatically into the ontology

- The creation of individuals is made using two Java Programs, because the structure of the two files to import is slightly different

- To import the data inside the ontology we use the OWL API[2]

[2] http://owlcs.github.io/owlapi/

Automatic ontology insertion algorithm

```
Read ontology skeleton "Mesva_vuota.owl"
Read the CSV file "Interventi_201X.CSV"
For each line in the file
        Split the line into columns
        For each column in the line
                If column is empty
                        Skip column
                Replace invalid chars
                Understand the kind of object we are examining
                If object of that kind does not exist
                        Add a prefix
                        Create object of that kind in ontology
                Else
                        Take the object with that name
                Link the object with the main class Chiamata
                If object is a vehicle
                        Add annotations to the relation
Save ontology "Mesva.owl"
```

Resulting ontology

- All elements are prefixed, to aid the human intepretation

- 63361 calls elements inside the ontology!

- Elements correctly linked together

- The CSV files and the Java Program can be downloaded from this URL:

https://github.com/lollix91/mesva-ehealth

- The ontology is downloadable from this URL:

http://www.lorenzodelauretis.it/mesva/Mesva.owl

Ontology reasoning - Inferred object property assertions

- We use the reasoner HermiT on our ontology, to obtain inferred object property assertions
- Once launched the reasoner, the inferred object properties will show up in Protégé
- Inferred object property assertions:

Inferred Fact	Value
Helicopters use	The three available helicopters were used in 570 missions
Highway rescues	There have been 51 rescues on the highway
Deaths	There have been 437 deaths during rescues
Preferred hospital	The hospital where the ambulances dropped more the patients is the hospital of Avezzano, with 12500 visits

- Deducted facts:
  - The helicopters are enough for the rescues, being used only 0,78 times a day for each helicopter
  - The rescue missions on the highway do not need to be potentiated, being 51 a small number with respect to the total number of missions
  - The number of deaths is not so high with respect to the number of incoming calls, being just 0,68% of the total.
  - The hospital of Avezzano is not the biggest in the province of L'Aquila, thus, given the high number of interventions it provides, it may need to be potentiated.

Ontology reasoning - ARQ query for cardiocirculatory disease

- ARQ is a query engine, used to query ontologies

- In our ontology we have 5340 records that have the **possible pathology** (the pathology assigned from phone operator) as Cardiocirculatory

- Phone diagnosis may be imprecise

- We use an ARQ query that counts the data that has the **possible pathology** set as cardiocirculatory and the **real pathology**, described from the doctor in the ambulance, set as cardiac

```
PREFIX mesva:  <http://www.disim.univaq.it/Mesva#>
SELECT ?chia (count(distinct ?chia) as ?count)
WHERE {
        ?chia mesva:hasDettaglioPatologia ?dettp .
        ?chia mesva:hasPatologia mesva:PATO_C2_Cardiaca .
FILTER (
?dettp = mesva:DETT_P_Altracardio-circolatoria ||
?dettp = mesva:DETT_P_Arresto_cardio-circolatorio ||
?dettp = mesva:DETT_P_Cardiopalmo-Aritmia ||
?dettp = mesva:DETT_P_Scompenso_cardio-circolatorio )
}
```

- The query returned 2430 records, that are, more or less, the 45% of the 5340 potential diseases

- it means that the **55%** of the potential cardiocirculatory diseases **are not really cardiocirculatory diseases**.

Ontology reasoning - ARQ query for traumatic disease

- In our ontology we have 8248 records that have a **possible** traumatic disease

- We use an ARQ query that counts the number of records that has the **possible pathology** set as traumatic and the pathology **assured from the doctor** as traumatic.

- We obtained 7736 records of real traumatic disease, diagnosed from the doctor on the ambulance.

- It means that 94%, more or less, are real traumatic diseases, and, the other 6%, are not traumatic diseases.

```
PREFIX mesva:  <http://www.disim.univaq.it/Mesva#>
SELECT ?chia (count(distinct ?chia) as ?count)

WHERE {
        ?chia mesva:hasDettaglioPatologia ?dettp .
        ?chia mesva:hasPatologia mesva:PATO_C1_Traumatica .
FILTER (
?dettp = mesva:DETT_P_Altra_traumatica ||
?dettp = mesva:DETT_P_Traumatica_Addome ||
?dettp = mesva:DETT_P_Traumatica_Amputazione ||
?dettp = mesva:DETT_P_Traumatica_Arti ||
?dettp = mesva:DETT_P_Traumatica_Contusione ||
?dettp = mesva:DETT_P_Traumatica_Cranio ||
?dettp = mesva:DETT_P_Traumatica_Emorragia ||
?dettp = mesva:DETT_P_Traumatica_Ferita ||
?dettp = mesva:DETT_P_Traumatica_Frattura ||
?dettp = mesva:DETT_P_Traumatica_Lesione_agli_occhi ||
?dettp = mesva:DETT_P_Traumatica_Lesionedafreddo ||
?dettp = mesva:DETT_P_Traumatica_Rachide ||
?dettp = mesva:DETT_P_Traumatica_Torace ||
?dettp = mesva:DETT_P_Traumatica_Ustione ||
?dettp = mesva:DETT_P_Politraumatismo )
}
```

Discussion

The inferred object property assertion we have shown, consist of interesting inferred object properties found inside the ontology. Those data are useful for statistical reasons

- The ARQ query for cardiocirculatory disease proves that **only 45%** of the **potential** cardiocirculatory diseases are **really** cardiocirculatory diseases, an improvable result

- The system used to diagnose cardiocirculatory diseases **should be more accurate**, and the phone operator may need to do a few more questions to the caller to really understand the real disease.

- The ARQ query for traumatic disease proves that **94%** of the **potential** traumatic diseases are **really** traumatic diseases.

- The procedure to identify traumatic diseases works fine

Conclusion and future ideas

- Thanks to the inferred object properties, we can deduce very important facts about the first aid services, that can potentially help in saving lives, improving the service itself

- The ontology can be useful in a lot of fields, and, in our case, it can mainly help us understanding when phone diagnoses are not precise: if the diagnosis is not correct, the rescue vehicle sent out for the mission can be wrong, and potentially lead to a death

- The ontology can help the operator in the choice of the correct rescue vehicle to be sent out for the mission

- In the near future, integrating the ontology with a map service, and with the use of appropriates queries, the operator can also know for which mission the helicopter should be used

- In the far future, we will use this ontology to train a neural net with deep learning, that will help us in making more accurate previsions of the diseases, based on various parameters, **improving the first aid service**

Thanks for your attention ☺