AutoDoc:
User Manual

github:Dorsa-Arezooji/AutoDoc

Content:

https://github.com/Dorsa-Arezooji/AutoDoc

1.0 Introduction

The purpose of this ontology is to infer what diseases a person might have based on available information about their symptoms, blood tests they have taken, and other personal details (height, weight, age). In a way, this ontology functions as an automated doctor, diagnosing patients based on their symptoms and medical history.

Another point of interest is that the ontology also takes into account whether or not two patients have been in the same environment, or have had close contact or are related to each other. This helps to discover the risks one patient might be at, by considering common factors between them and other patients.

1.1 Motivation

The motivation behind this ontology is to help discover any existing inferences, relations, and connections between different patients that would have been missed otherwise. In a large hospital with many patients, who are each examined by a different doctor, it wouldn't be possible to keep track of the relationships between patients.

For instance, let's assume patient A who was admitted by doctor D in the west wing of the hospital for cadmium poisoning (an environmental disease) works at W. Now, let's assume that another patient, B, who had listed W as their workplace in the personal information form, had been a patient at the hospital. Without the inferences made using the ontology, the medical staff would not know that patient B is also at risk for cadmium poisoning since they have a coworker, A, who was exposed to cadmium in their shared environment W.

1.1.1 Inspiration

The inspiration behind this project came from the current Covid-19 pandemic affecting many people and medical facilities all over the world. Taking advantage of the automated inferences, courtesy of powerful reasoners such as *Pellet*, at-risk patients would be sooner identified and examined.

1.1.2 Applications

As was elaborated earlier, this ontology could be of use to medical facilities such as clinics, hospitals, private practices, etc. Along with the patients' information database, this ontology helps identify eminent diseases in patients. Furthermore, it could be used as an automated diagnostic tool for patients who don't have access to doctors.

Another functionality of this ontology is categorizing patients based on their conditions into: *Sick, At-risk, Contagious* and *critical*. This helps to prioritize medical care to those in critical conditions, to isolate contagious patients, and identify at-risk patients and test them for diseases they might have.

Furthermore, this ontology can be used to identify locations contaminated with heavy metals or other contaminants after diagnosing patients with environmental diseases caused by those contaminants. With the current Covid-19 crisis, the importance of identifying and sanitizing contaminated locations has risen.

2.0 T-Box

The current ontology has a number of classes that relate to each other by the use of DL or SWRL rules defined using object properties and data properties. These classes and relations/constraints associated with them make up the T-Box.

2.1 Classes

There are a total of 22 primitive classes and subclasses in this ontology, each one having a number of concepts associated with them. These classes are described in the following sections.

2.1.1 Primitive Classes

There are 9 primitive classes in this ontology and they were defined as primitive classes since they can not be considered a subcategory of another class.

- **Body_part**: a part/organ of the human body

    It is used to identify where the patient feels pain or has bleeding.

- **Chemical_substance**: a chemical that is the cause of some environmental diseases

    It is used as the primary cause of environmental diseases.

- **Country**: a country

    Some infections are rather specific to some areas or countries and one might contract them when they travel there. *Country* is used to identify these types of diseases.

- **Disease**: a disease

    It was defined as a primitive class with *Hereditary* and *non_Hereditary* as its subclasses. The reason for choosing this structure is the following:

    a) *Disease* is used to identify *Sick* patients regardless of whether they have a *Hereditary* or *non_Hereditary* disease.

    b) *Hereditary* diseases run in families and if a person's close relative is diagnosed with such a disease, they might be at risk for that disease.

    c) non_Hereditary diseases however, do not affect closely related family members.

- **Female**: a female person

    It was defined as a primitive class to facilitate defining *Person* as the disjoint union of *Female* and *Male* since object properties do not differ based on gender. Also, there are some diseases that occur only in females, such as *female_reproductive_organ_cancer*.
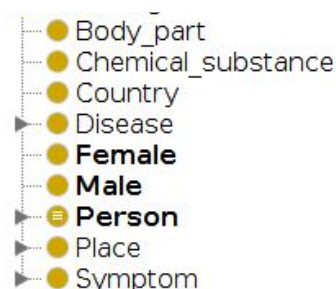
- **Male**: a male person

  The reasoning behind this class is the same as *Female*.

- **Person**: a person

  As was mentioned, object properties are defined for patients regardless of their gender.

- **Place**: a place

  It was defined as a primitive class with *Home* and *Work_place* as its subclasses. The reason for choosing this structure is the following:

  a) People working at a Work_place that is contaminated with some *Chemical_substance*, are identified as *At_risk* for the *Environmental_Disease* associated with that contaminant. It happens often in factories and industrial workplaces, not residential places (Kazantzis 1981).

  b) People sharing a residential space, *Home*, are *At_risk* of contracting bacteria or viruses that have caused one of them to have an *Infectious_Disease.*
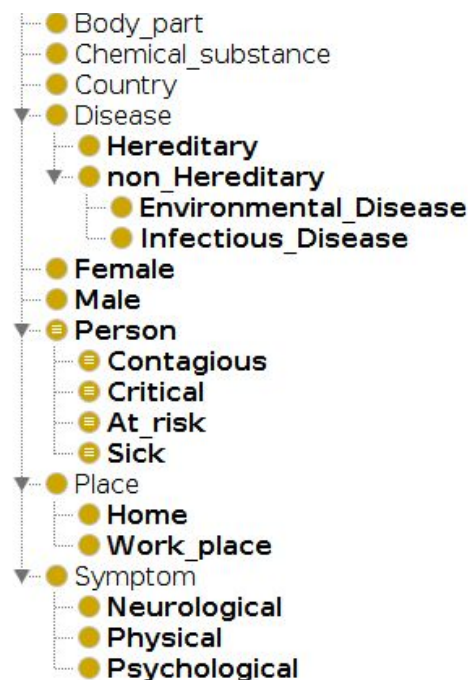
- **Symptom**: a symptom of a disease

  Symptoms are used to identify what diseases a patient has. Symptoms have different origins and causes, thus are categorized into these three categories: *Neurological*, *Physical*, *Psychological*. Some diseases might have one or more than one category of symptoms. Identifying the type of symptoms helps to better diagnose patients.

2.1.2 Sub-Classes

There are 13 subclasses defined in the ontology:

- **Hereditary**: a disease that can be passed on from a close family member (genetic)

- **non_Hereditary**: a disease that is not genetic and consists of the following two:

- **Environmental_Disease**: a disease that has an environmental cause (contamination)

- **Infectious_Disease**: a disease that can be transmitted from one person to another who has contact with the first person

- **Contagious**: a person who is diagnosed with an infectious disease

- **Critical**: a patient who is both diagnosed with at least one disease and at risk for at least one other disease

- **At-risk**: a person who is at risk for a disease

- **Sick**: a person who is diagnosed with at least one disease

- Body_part
- Chemical_substance
- Country
- Disease
  - Hereditary
  - non_Hereditary
    - Environmental_Disease
    - Infectious_Disease
- Female
- Male
- Person
  - Contagious
  - Critical
  - At_risk
  - Sick
- Place
  - Home
  - Work_place
- Symptom
  - Neurological
  - Physical
  - Psychological

- **Home**: a place where a person lives in

- **Work_place**: a place where a person works

- **Neurological**: a neurological symptom

- **Physical**: a physical symptom

- **Psychological**: a psychological symptom

2.2 Object Properties

There are a total of 20 object properties defined in this ontology. The SWRL rules or DL used to describe them, and how they help the reasoner infer relations and concepts are explained in detail here. In this section, some basic information about the object properties are listed and explained in short.

- **affects**: used to identify patients affected by the same disease

  Domain: *Person*

  Range: *Disease*

  Inverse of: *is_diagnosed_with*

  This might come in handy when patients with the same disease need to be identified and isolated together. After running the reasoner, all patients with the same disease will be listed under that disease in the individuals' tab.

- **bleeding_in**: used to determine what organ/part of the body a person is bleeding in

  Domain: *Person*

  Range: *Body_part*

  This object property helps diagnose patients since some diseases (such as *Dengue_fever*) cause bleeding in certain organs or parts of the body.
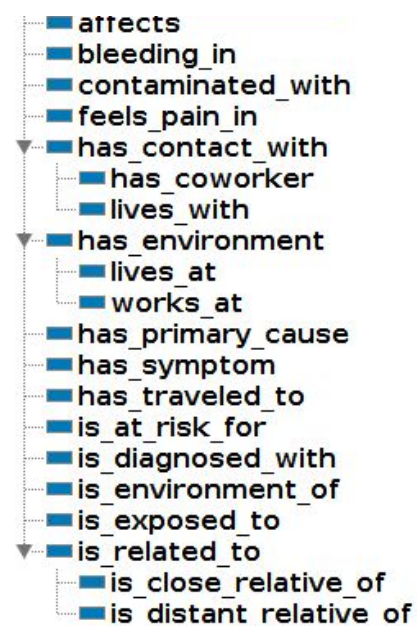
- **contaminated_with**: used to determine what chemical a workplace is contaminated with

  Domain: *Work_place*

  Range: *Chemical_substance*

  Since the primary cause of environmental diseases such as heavy metal poisoning (including *cadmium_poisoning*) is industrial exposure to chemicals, this property is used to identify such *Work_places.*

- **feels_pain_in**: used to determine what organ/part of the body a person feels pain in

```
affects
bleeding_in
contaminated_with
feels_pain_in
has_contact_with
    has_coworker
    lives_with
has_environment
    lives_at
    works_at
has_primary_cause
has_symptom
has_traveled_to
is_at_risk_for
is_diagnosed_with
is_environment_of
is_exposed_to
is_related_to
    is_close_relative_of
    is_distant_relative_of
```

Domain: *Person*

Range: *Body_part*

This object property helps diagnose patients since some diseases cause pain in certain organs or parts of the body.

- **has_contact_with**: used to identify patients at risk for infectious diseases

  Domain: *Person*

  Range: *Person*

  ✓ Symmetric

  Since infections can easily spread from one person to another who have contact with each other, this object property was defined to identify people at risk for infectious diseases. Additionally, this is a symmetric property as if person A has contact with person B, then person B also has contact with person A.

- **has_coworker**: used to identify two people who work at the same place, as coworkers

  Domain: *Person*

  Range: *Person*

  ✓ Symmetric

  This property is defined to facilitate identifying people at risk for environmental diseases since coworkers are exposed to the same contaminant. Based on the same logic as *has_contact_with*, this property is also symmetric.

- **lives_with**: used to identify two people who live in the same home

  Domain: *Person*

  Range: *Person*

  ✓ Symmetric

  This property is defined to facilitate identifying people at risk for infectious diseases since people who live in the same place share the same facilities and have close contact with each other. Based on the same logic as *has_contact_with*, this property is also symmetric.

- **has_environment**: used to identify those at risk of an environmental disease in a contaminated environment

  Domain: *Person*

  Range: *Place*

  This property is defined to facilitate identifying people at risk for environmental diseases since people who work in a contaminated workplace, are at risk for environmental diseases.

Furthermore, on more rare occasions, some residential places (*Home*) might be revealed to be contaminated. In these cases, these

- **lives_at**: used to identify people who live together

  Domain: *Person*

  Range:

  ✓ Functional

  This property is used to find people at risk of infectious diseases. Since a person can only have one home, this property is functional.

- **works_at**: used to identify coworkers

  Domain: *Person*

  Range: *Work_place*

- **has_primary_cause**: used to define the primary cause of environmental diseases

  Domain: *Environmental_Disease*

  Range: *Chemical_substance*

  ✓ Functional

  This property is used to infer which places have been contaminated by which chemical substance. Since an environmental disease can only have one primary cause, this property is defined as functional.

- **has_symptom**: used to diagnose patients with the diseases that cause these symptoms

  Domain: *Person*

  Range: *Symptom*

- **has_traveled_to**: used to identify which countries a person has traveled to

  Domain: *Person*

  Range: *Country*

  Since some diseases are very common in some foreign regions and countries, the property was defined to help facilitate diagnosis of diseases common in such countries.

- **is_at_risk_for**: used to identify the diseases a person might be at risk for

  Domain: *Person*

  Range: *Disease*

  Based on the medical conditions of people one lives with, works with, or is closely related to, they might be at risk for infectious, environmental, or hereditary diseases respectively.

- **is_diagnosed_with**: used to diagnose patients

  Domain: *Person*

  Range: *Disease*

  Using the defined relations between a person with another and the asserted data properties, the reasoner is able to automatically infer what diseases that person has.

- **is_environment_of**: used to identify people living or working in a place

  Domain: *Place*

  Range: *Person*

  This property helps to get a list of all people living or working in place in case that place has been contaminated. All people in such an environment will be listed under that place in the individuals' tab.

- **is_exposed_to**: used to assess the risk of chemical exposure

  Domain: *Person*

  Range: *Chemical_substance*

  If a person is exposed to a chemical substance that is the primary cause of an environmental disease, then they are at risk for that disease and should be tested.

- **is_related_to**: used to find family members of a patient

  Domain: *Person*

  Range: *Person*

  ✓ Symmetric

  This property can be used to identify family members in cases when it is needed for a family member or relative to be a patient's medical proxy and make decisions on their behalf (e.g. when they are under 18 years of age or in a coma). This is a symmetric property as if person A is related to person B, then person B is also related to person A.

- **Is_close_relative_of**: used to identify close family members

  Domain: *Person*

  Range: *Person*

  ✓ Symmetric

  If a patient's close relative is diagnosed with a hereditary disease, there is a chance that the patient is at risk for that disease. This property helps identify at risk patients and test them for said diseases.

- **is_distant_relative_of**: used to identify distant family members

Domain: *Person*

Range: *Person*

✓ Symmetric

As was stated before, hereditary diseases are only passed on through close family members. So if a distant family member of a patient is diagnosed with a hereditary disease, the patient will not be at risk for that disease.

2.3 Data Properties

There are a total of 14 data properties used in this ontology. These data properties are used to infer relations such as diagnosing a patient with a disease or whether or not a person is at risk for a disease. These inferences are yielded using a collection of SWRL rules defined here. This section includes a general introduction to these data properties.

- **age**: the age of a person

  Domain: *Person*

  Range: *xsd:int*

  Age is an important factor in diagnosing some diseases as they only have prevalence in a certain age group.

- **BMI**: the body mass index

  Domain: *Person*

  Range: *xsd:double*

  Used to assess the risk of some diseases where BMI is an important factor.

- **CA125**: the CA125 levels in the blood

  Domain: *Person*

  Range: *xsd:int*

  Used for diagnosis of female reproductive organ cancer.

- **creatinine**:

  Domain: *Person*

  Range: *xsd:int*

  Used for diagnosis of cadmium poisoning.

- **CRP**: the CRP levels in the blood

  Domain: *Person*

- needs_psychological_consul...
- age
- BMI
- CA125
- creatinine
- CRP
- has_fever
- height
- LDL
- name
- premenopausal
- smoker
- temperature
- weight

Range: *xsd:int*

Used for identifying infections.

- **has_fever**: whether or not the patient has a fever

  Domain: *Person*

  Range: *xsd:boolean*

  Used for identifying infections.

- **height**: the height in meters

  Domain: *Person*

  Range: *xsd:double*

  Used for calculating the BMI.

- **LDL**: the LDL levels in the blood

  Domain: *Person*

  Range: *xsd:int*

  Used for assessing the risks of coronary heart disease (CHD).

- **name**: the name of a patient

  Domain: *Person*

  Range: *xsd:PlainLiteral*

  ✓ Functional

  Has no other used in inferring relations.

- **needs_psychological_consultation**: used to identify

  Domain: *Person*

  Range: *xsd:boolean*

  Used to identify patients who need psychological consult since they are showing psychological symptoms. This property can be used to identify such patients and refer them to a psychologist or psychiatrist.

- **premenopausal**: whether or not a woman is premenopausal

  Domain: *Female*

  Range: *xsd:boolean*

  This property helps identify women who are at risk of CHD.

- **smoker**: whether or not a person regularly smokes

  Domain: *Person*

  Range: *xsd:boolean*

  Since smoking is associated with a range of diseases including CHD, this field was defined to identify patients at risk for these diseases.

- **temperature**: the body temperature of a patient

  Domain: *Person*

  Range: *xsd:float*

  This property was used to determine whether a patient has a fever or not.

- **weight**: the weight of a person

  Domain: *Person*

  Range: *xsd:double*

  This property was used to calculate the BMI of patients.

2.4 Concepts

2.4.1 Description Logic

2.4.1.1 Classes

- **non_Hereditary**:

  Disease and (not (Hereditary))

  Explanation: a disease that is not hereditary is non-hereditary

- **Infectious_Disease**:

  non_Hereditary and (not (Environmental_Disease))

  Explanation: a non-hereditary disease that is not environmental is infectious

- **Person**:

  Disjoint Union Of: *Female*, *Male*

  Explanation: the reason behind this structure is explained here.

- **At_risk**:

  Person and (is_at_risk_for some Disease)

Explanation: a person who is at risk for some disease is an at-risk person (used to identify these patients and test them for diseases they are at risk for)

- **Contagious**:

  Person and (is_diagnosed_with some Infectious_Disease)

  Explanation: a person who is diagnosed with an infectious disease is infectious (used to identify which patients need to be isolated)

- **Critical**:

  Person and (is_at_risk_for min 1 Disease) and (is_diagnosed_with min 1 Disease)

  Explanation: a patient who is already diagnosed with at least one disease and is at risk for at least another disease is classified as critical (used to identify these patients and prioritize their care above other patients)

- **Sick**:

  Person and (is_diagnosed_with min 1 Disease)

  Explanation: a patient who is diagnosed with at least one disease

- **Work_place**:

  Place and (not Home)

  Explanation: a place that is not a home (used for identifying contaminated workplaces)

- **Neurological**:

  Symptom and (not (Physical or Psychological))

  Explanation: a symptom that is neither physical or psychological

  Note: has no specific use in inference - these symptoms could have been listed as individuals of *Symptom,* however, this structure is more technical and meaningful

- **Physical**:

  Symptom and (not (Neurological or Psychological))

  Explanation: a symptom that is neither neurological or psychological

  Note: has no specific use in inference - these symptoms could have been listed as individuals of *Symptom,* however, this structure is more technical and meaningful

- **Psychological**:

  Symptom and (not (Neurological or Physical))

  Explanation: a symptom that is neither neurological or physical (used to identify patients in need of psychological consult)

2.4.1.2 Object Properties

In this section, the object properties defined using chains (SubProperties Of field) are enumerated along with explanations of why they were defined in such a way, and how they can help the reasoner infer relations and concepts.

- **contaminated_with**:

  is_environment_of o is_diagnosed_with o has_primary_cause → contaminated_with

  Explanation:

- **is_exposed_to**:

  works_at o contaminated_with → is_exposed_to

  Explanation:

2.4.2 SWRL Rules

- **BMI**:

  Person(?p) ^ weight(?p, ?w) ^ height(?p, ?h) ^ swrlb:pow(?h2, ?h, 2) ^ swrlb:divide(?bmi, ?w, ?h2) -> BMI(?p, ?bmi)

  BMI is calculated using: BMI = weight[kg] / (height[m])^2

- **Lives with**:

  Person(?p1) ^ lives_at(?p1, ?h1) ^ Home(?h1) ^ Home(?h2) ^ Person(?p2) ^ lives_at(?p2, ?h2) ^ differentFrom(?p1, ?p2) ^ sameAs(?h1, ?h2) -> lives_with(?p1, ?p2)

  ✓ Irreflexive

  ✓ (Inherently) Transitive

  If person 1 lives at home 1 and person 2 lives at home 2, and they are two different people (irreflexive), and if home 1 is the same as home 2, they live together. This rule is inherently transitive and there is no need to define this characteristic as a new rule.

- **At risk for CHD (women)**

  Female(?p) ^ BMI(?p, ?bmi) ^ swrlb:greaterThan(?bmi, 30) ^ premenopausal(?p, true) ^ age(?p, ?a) ^ swrlb:greaterThan(?a, 55) ^ smoker(?p, true) ^ LDL(?p, ?ldl) ^ swrlb:greaterThan(?ldl, 160) -> is_at_risk_for(?p, coronary_heart_disease)

  Risk factors of coronary heart disease (CHD) in women are: BMI>30, being premenopausal, being older than 55, smoking, LDL level>160 (Lohe and von der Lohe 2003). If a female person fits this criteria, she is inferred to be at risk for CHD.

- **At risk for CHD (men)**

  Male(?p) ^ BMI(?p, ?bmi) ^ swrlb:greaterThan(?bmi, 30) ^ age(?p, ?a) ^ swrlb:greaterThan(?a, 45) ^ smoker(?p, true) ^ LDL(?p, ?ldl) ^ swrlb:greaterThan(?ldl, 160) -> is_at_risk_for(?p, coronary_heart_disease)

  Risk factors of coronary heart disease (CHD) in men are: BMI>30, being older than 45, smoking, LDL level>160 ("Coronary Heart Disease in Men" 2009). If a male person fits this criteria, he is inferred to be at risk for CHD.

- **At risk for environmental disease**

  Person(?p1) ^ is_diagnosed_with(?p1, ?d) ^ Environmental_Disease(?d) ^ has_environment(?p1, ?e1) ^ Person(?p2) ^ has_environment(?p2, ?e2) ^ sameAs(?e1, ?e2) ^ differentFrom(?p1, ?p2) -> is_at_risk_for(?p2, ?d)

  If two different people, person 1 and person 2 share the same environment (environment1 is the same as environment 2) and one of them is diagnosed with an disease which is an environmental disease, the other person is at risk for that disease.

- **At risk for hereditary disease**

  Person(?p) ^ is_diagnosed_with(?p, ?d) ^ Hereditary(?d) ^ is_close_relative_of(?p, ?r) ^ Person(?r) -> is_at_risk_for(?r, ?d)

  If a person has a genetic (hereditary) disease, and has a close relative, that relative is at risk for that hereditary disease (Wilcox 2001). This rule doesn't apply to non-hereditary diseases as they have no genetic risk factor associated with them. Since the *is_related_to* object property is defined as irreflexive, and *has_close_relative* is a subproperty of that, there is no need for defining this rule as irreflexive as it is automatically inferred.

- **At risk for infectious disease**

  Person(?p1) ^ is_diagnosed_with(?p1, ?d) ^ Infectious_Disease(?d) ^ lives_with(?p1, ?p2) ^ differentFrom(?p1, ?p2) -> is_at_risk_for(?p2, ?d)

  If person 1 has an infection and lives with person 2, and they are different people, person 2 is at risk for that infection.

- **Coworker**

  Person(?p1) ^ Person(?p2) ^ Work_place(?w1) ^ Work_place(?w2) ^ works_at(?p1, ?w1) ^ works_at(?p2, ?w2) ^ differentFrom(?p1, ?p2) ^ sameAs(?w1, ?w2) -> has_coworker(?p1, ?p2)

  ✓ Irreflexive

  ✓ (Inherently) Transitive

  If person 1 works at workplace 1 and person 2 works at workplace 2 and they are different people but workplace 1 is the same as workplace 2, then they are coworkers. This property is inherently transitive and there is no need to introduce a new transitive rule.

- **ddx - Dengue**

Person(?p) ^ has_fever(?p, true) ^ bleeding_in(?p, gums) ^ bleeding_in(?p, nose) ^ has_traveled_to(?p, Malaysia) ^ has_symptom(?p, pain) -> is_diagnosed_with(?p, Dengue_fever)

The symptoms of Dengue fever include: recent travel to tropical countries such as Malaysia, pain, fever, bleeding in nose and eyes (Halstead 2011). A person who fits this criteria is diagnosed with Dengue fever.

- **ddx - Parkinson's disease**

Person(?p) ^ has_symptom(?p, tremor) ^ has_symptom(?p, depression) ^ has_symptom(?p, anosmia) ^ age(?p, ?a) ^ swrlb:greaterThan(?a, 60) -> is_diagnosed_with(?p, Parkinsons_disease)

The symptoms of Parkinson's disease in people older than the age of 60 include: tremor, depression, anosmia (loss of sense of smell) (Carranza et al. 2013). A person who fits this criteria is diagnosed with Parkinson's disease.

- **ddx - cadmium poisoning**

Person(?p) ^ creatinine(?p, ?c) ^ swrlb:greaterThan(?c, 300) ^ feels_pain_in(?p, head) ^ feels_pain_in(?p, chest) ^ has_symptom(?p, cough) ^ has_symptom(?p, dizziness) ^ has_symptom(?p, weakness) -> is_diagnosed_with(?p, cadmium_poisoning)

The symptoms of cadmium poisoning include: urine creatinine level>300, pain in head and chest, coughing, dizziness and weakness (Karlish 1960). A person who fits this criteria is diagnosed with cadmium poisoning.

- **ddx - female reproductive organ cancer**

Female(?p) ^ feels_pain_in(?p, abdomin) ^ CA125(?p, ?ca125) ^ swrlb:greaterThan(?ca125, 46) -> is_diagnosed_with(?p, female_reproductive_organ_cancer)

The symptoms of female reproductive organ cancer include: feeling pain in the abdomen, and CA125 level>46 (Institute and National Cancer Institute 2020). A female person who fits this criteria is diagnosed with female reproductive organ cancer.

- **ddx - food poisoning**

Person(?p) ^ feels_pain_in(?p, abdomin) ^ CRP(?p, ?crp) ^ swrlb:greaterThan(?crp, 100) ^ has_symptom(?p, vomiting) -> is_diagnosed_with(?p, food_poisoning)

The symptoms of food poisoning include: feeling pain in the abdomen, vomiting, and CRP level>100 (Merry 1997). A person who fits this criteria is diagnosed with food poisoning.

- **Exposure to chemicals**

Person(?p) ^ is_diagnosed_with(?p, ?d) ^ Environmental_Disease(?d) ^ has_primary_cause(?d, ?c) -> is_exposed_to(?p, ?c)

If a person is diagnosed with an environmental disease and that environmental disease has a primary cause (a chemical substance), then that person has been exposed to that chemical.

- **Fever**

  Person(?p) ^ temperature(?p, ?t) ^ swrlb:greaterThan(?t, 37) -> has_fever(?p, true)

  If a person has a temperature of higher than 37 degrees celsius, then they have a fever.

- **Needs psychological consultation**

  Person(?p) ^ has_symptom(?p, ?s) ^ Psychological(?s) -> needs_psychological_consultation(?p, true)

  A person who is showing psychological symptoms is in need of psychological consult.

- **Related to**

  Person(?P1) ^ is_related_to(?P1, ?P2) ^ Person(?P2) ^ is_related_to(?P2, ?P3) ^ Person(?P3) ^ differentFrom(?P3, ?P2) ^ differentFrom(?P1, ?P3) -> is_related_to(?P1, ?P3)

  ✓ Irreflexive

  ✓ Transitive

  If person 1 is related to person 2 and person 2 is related to person 3 and they are all different people (irreflexive), then person 1 is also related to person 3 (transitive).

3.0 A-Box

3.1 Asserted Axioms

The complete list of all asserted classes, subclasses, domains and ranges, object and data properties, and individual declarations can be found [here](#).

The most important declarations are those related to patients which are the following:

Object Properties:

- works_at
- lives_at
- has_symptom
- feels_pain_in
- has_bleeding_in
- is_close_relative_of
- is_distant_relative_of
- has_traveled_to

Data Properties:

- age
- CA125
- creatinine
- CRP
- height
- LDL
- premenopausal
- smoker
- temperature
- weight

All other object and data properties are inferred based on the above properties. These properties are not asserted for all patients as there was no need to do so. Therefore, a smaller number of declarations were made.

3.2 Inferred Relations

Here are the inferred (and asserted properties) for all patients:

- Patient 1

Types ➕
- 🟡 **Male** ? @ ✕ ⊙
- ⊝ At_risk ? @

Same Individual As ➕

Different Individuals ➕
- ◆ **patient2,** ? @ ✕ ⊙
  patient3,
  patient4,
  patient5,
  patient6,
  patient7,
  patient8,
  patient9

Object property assertions ➕
- ▪ **works_at** ? @ ✕ ⊙
  Pied_Piper
- ▪ **has_contact_with** ? @
  patient4
- ▪ **has_coworker patient4** ? @
- ▪ **has_environment** ? @
  Pied_Piper
- ▪ **is_at_risk_for** ? @
  cadmium_poisoning
- ▪ **is_exposed_to cadmium** ? @

Data property assertions ➕
- ▪ **weight** ? @ ✕ ⊙
  "62.0"^^xsd:dou
- ▪ **name "Richard** ? @ ✕ ⊙
  Hendricks"
- ▪ **height** ? @ ✕ ⊙
  "1.72"^^xsd:dou
- ▪ **BMI** ? @
  "20.9572742022715"^^

Negative object property assertions ➕

Negative data property assertions ➕

- Patient 2

Types ➕
- 🟡 **Female** ? @ ✕ ⊙
- ⊝ Contagious ? @
- ⊝ Critical ? @

Same Individual As ➕

Different Individuals ➕
- ◆ **patient1,** ? @ ✕ ⊙
  patient3,
  patient4,
  patient5,
  patient6,
  patient7,
  patient8,
  patient9

Object property assertions ➕
- ▪ **has_symptom** ? @ ✕ ⊙
  vomiting
- ▪ **feels_pain_in** ? @ ✕ ⊙
  abdomin
- ▪ **is_close_relative** ? @ ✕ ⊙
  patient3
- ▪ **lives_at 221A** ? @ ✕ ⊙
- ▪ **has_contact_with** ? @
  patient9
- ▪ **has_environment** ? @
  221A
- ▪ **is_at_risk_for** ? @
  female_reproductive_or
- ▪ **is_at_risk_for** ? @
  coronary_heart_disease
- ▪ **is_diagnosed_with** ? @
  food_poisoning
- ▪ **is_related_to patient3** ? @
- ▪ **lives_with patient9** ? @

Data property assertions ➕
- ▪ **smoker true** ? @ ✕ ⊙
- ▪ **height** ? @ ✕ ⊙
  "1.53"^^xsd:dc
- ▪ **weight** ? @ ✕ ⊙
  "84.0"^^xsd:dc
- ▪ **CRP** ? @ ✕ ⊙
  "110"^^xsd:int
- ▪ **premenopausal** ? @ ✕ ⊙
  true
- ▪ **age** ? @ ✕ ⊙
  "57"^^xsd:int
- ▪ **LDL** ? @ ✕ ⊙
  "175"^^xsd:int
- ▪ **BMI** ? @
  "35.88363449551455

- Patient 3

Types ⊕
- Female ? @ ⊗ ○
- Sick ? @

Same Individual As ⊕

Different Individuals ⊕
- patient1, ? @ ⊗ ○
  patient2,
  patient4,
  patient5,
  patient6,
  patient7,
  patient8,
  patient9

Object property assertions ⊕
- feels_pain_in abdomin ? @ ⊗ ○
- is_close_relative_of patient2 ? @
- is_diagnosed_with female_reproductive_org ? @
- is_related_to patient2 ? @

Data property assertions ⊕
- name "April Ludgate" ? @ ⊗ ○
- CA125 "50"^^xsd:int ? @ ⊗ ○

Negative object property assertions ⊕

Negative data property assertions ⊕

- Patient 4

Types ⊕
- Male ? @ ⊗ ○
- Critical ? @

Same Individual As ⊕

Different Individuals ⊕
- patient1, ? @ ⊗ ○
  patient2,
  patient3,
  patient5,
  patient6,
  patient7,
  patient8,
  patient9

Object property assertions ⊕
- has_symptom weakness ? @ ⊗ ○
- works_at Pied_Piper ? @ ⊗ ○
- feels_pain_in head ? @ ⊗ ○
- feels_pain_in chest ? @ ⊗ ○
- has_symptom cough ? @ ⊗ ○
- has_symptom dizziness ? @ ⊗ ○
- has_contact_with patient1 ? @
- has_coworker patient1 ? @
- has_environment Pied_Piper ? @
- is_at_risk_for Parkinsons_disease ? @
- is_close_relative_of patient6 ? @
- is_diagnosed_with cadmium_poisoning ? @
- is_distant_relative_of patient8 ? @
- is_exposed_to cadmium ? @
- is_related_to patient8 ? @
- is_related_to patient6 ? @
- is_related_to patient7 ? @

Data property assertions ⊕
- creatinine "309"^^xsd:int ? @ ⊗ ○

- Patient 5

  Types
  - Male
  - At_risk

  Same Individual As

  Different Individuals
  - patient1,
    patient2,
    patient3,
    patient4,
    patient6,
    patient7,
    patient8,
    patient9

  Object property assertions
  - lives_at 221B
  - has_contact_with patient7
  - has_environment 221B
  - is_at_risk_for Dengue_fever
  - lives_with patient7

  Data property assertions
  - name "Gregory House"

  Negative object property assertions

  Negative data property assertions

- Patient 6

  Types
  - Male
  - Sick

  Same Individual As

  Different Individuals
  - patient1,
    patient2,
    patient3,
    patient4,
    patient5,
    patient7,
    patient8,
    patient9

  Object property assertions
  - has_symptom anosmia
  - is_close_relative_ patient4
  - is_distant_relativ patient7
  - has_symptom tremor
  - has_symptom depression
  - is_diagnosed_with Parkinsons_disease
  - is_related_to patient8
  - is_related_to patient7
  - is_related_to patient4

  Data property assertions
  - age "66"^^xsd:int
  - name "Creed Bratton"
  - needs_psychological_cor true

  Negative object property assertions

  Negative data property assertions

- Patient 7

Types
- Male
- Contagious

Same Individual As

Different Individuals
- patient1, patient2, patient3, patient4, patient5, patient6, patient8, patient9

Object property assertions
- has_symptom pain
- has_traveled_to Malaysia
- lives_at 221B
- bleeding_in gums
- bleeding_in nose
- has_contact_with patient5
- has_environment 221B
- is_diagnosed_with Dengue_fever
- is_distant_relative_of patient6
- is_related_to patient8
- is_related_to patient6
- is_related_to patient4
- lives_with patient5

Data property assertions
- name "James Wilson"
- temperature 39.0f
- has_fever true

Negative object property assertions

Negative data property assertions

- Patient 8

Types
- Male
- At_risk

Same Individual As

Different Individuals
- patient1, patient2, patient3, patient4, patient5, patient6, patient7, patient9

Object property assertions
- is_distant_relativ patient4
- is_at_risk_for coronary_heart_disease
- is_related_to patient6
- is_related_to patient7
- is_related_to patient4

Data property assertions
- weight "105.0"^^xsd:dc
- name "Ron Swanson"
- smoker true
- height "1.82"^^xsd:dou
- age "48"^^xsd:int
- LDL "185"^^xsd:int
- BMI "31.69907016060862"^·

Negative object property assertions

Negative data property assertions

- Patient 9

Types ⊕
  🔴 At_risk   ? @

Same Individual As ⊕

Different Individuals ⊕
  ◆ patient1,   ? @ ✕ ○
     patient2,
     patient3,
     patient4,
     patient5,
     patient6,
     patient7,
     patient8

Object property assertions ⊕
  ▪ **lives_at 221A**   ? @ ✕ ○
  ▪ has_contact_with   ? @
     patient2
  ▪ has_environment 221A   ? @
  ▪ is_at_risk_for   ? @
     food_poisoning
  ▪ lives_with patient2   ? @

Data property assertions ⊕

Negative object property assertions ⊕

Negative data property assertions ⊕

4.0 Issues and Fixes

4.1 Rules

At first, *Male* and *Female* were defined as subclasses of the primitive class *Person*. While using the *differentFrom* option in irreflexive rules, the inferences that should have appeared under related individuals didn't do so. By removing this option the rules were no longer irreflexive. This issue was resolved by introducing *Female* and *Male* as primitive classes and Person as the disjoint union of the two.

4.2 Data Properties

An issue that was dealt with regarding data properties, was that the data property inferences did not appear in the individuals' tab. This problem was rectified by changing the reasoner's configurations:

4.3 Object Properties

When a certain patient was selected in the individuals' tab, upon starting/synchronizing the reasoner, some, but not all of the inferred object properties would appear. And after re-synchronizing the reasoner, a different collection of object property inferences would show up under different individuals.

This problem was solved by defining the individuals (patients) to be different from each other in the individuals' tab:

5.0 References

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6.0 Appendix

Here is a list of all asserted axioms including class and subclass declarations, object and data properties declarations, individuals and asserted relations between individuals.

patient2 smoker true

is_diagnosed_with Domain Person

Person(?p), weight(?p, ?w), height(?p, ?h), pow(?h2, ?h, 2), divide(?bmi, ?w, ?h2) -> BMI(?p, ?bmi)

ObjectProperty: has_contact_with

Individual: anosmia

Class: Home

is_exposed_to Range Chemical_substance

affects Domain Disease

Critical SubClassOf Person

BMI Domain Person

patient4 has_symptom cough

Class: Work_place

Individual: memory_loss

premenopausal Domain Person

has_fever Domain Person

patient2 weight "84.0"^^xsd:double

patient7 has_traveled_to Malaysia

weight Range: xsd:double

Class: Female

patient2 Type Female

ObjectProperty: is_distant_relative_of

DataProperty: age

has_coworker Range Person

patient5 Type Male

has_primary_cause Range Chemical_substance

is_environment_of Domain Place

is_distant_relative_of Range Person

has_environment InverseOf is_environment_of

 Symmetric: lives_with

has_fever Range: xsd:boolean

DataProperty: weight

patient7 temperature 39.0f

Individual: cadmium

has_primary_cause Domain Environmental_Disease

patient2 premenopausal true

Male(?p), BMI(?p, ?bmi), greaterThan(?bmi, 30), age(?p, ?a), greaterThan(?a, 45), smoker(?p, true), LDL(?p, ?ldl), greaterThan(?ldl, 160) -> is_at_risk_for(?p, coronary_heart_disease)

Individual: Malaysia

Individual: coronary_heart_disease

Individual: patient9

 DifferentIndividuals: patient1, patient2, patient3, patient4, patient5, patient6, patient7, patient8, patient9

lives_at Domain Person

Critical EquivalentTo Person and (is_at_risk_for min 1 Disease) and (is_diagnosed_with min 1 Disease)

Psychological SubClassOf Symptom and (not (Neurological or Physical))

DataProperty: LDL

patient2 feels_pain_in abdomin

age Range: xsd:int

non_Hereditary SubClassOf Disease and (not (Hereditary))

Infectious_Disease SubClassOf non_Hereditary and (not (Environmental_Disease))

is_close_relative_of Domain Person

Individual: pain

patient4 feels_pain_in head

Class: Person

ObjectProperty: is_at_risk_for

Individual: Pied_Piper

Individual: cough

ObjectProperty: bleeding_in

ObjectProperty: has_symptom

patient3 Type Female

Person(?p), feels_pain_in(?p, abdomin), CRP(?p, ?crp), greaterThan(?crp, 100), has_symptom(?p, vomiting) -> is_diagnosed_with(?p, food_poisoning)

patient4 Type Male

patient2 is_close_relative_of patient3

is_at_risk_for Domain Person

Class: Hereditary

Individual: gums

Class: Male

patient4 has_symptom weakness

patient4 name "Bertram Gilfoyle"

Individual: patient7

Individual: abdomin

is_exposed_to Domain Person

Work_place SubClassOf Place

has_symptom Domain Person

works_at Domain Person

patient4 feels_pain_in chest

ObjectProperty: is_related_to

patient1 height "1.72"^^xsd:double

name Domain Person

smoker Range: xsd:boolean

LDL Domain Person

ObjectProperty: has_primary_cause

At_risk SubClassOf Person

Work_place EquivalentTo Place and (not (Home))

has_environment Domain Person

works_at SubPropertyOf: has_environment

feels_pain_in Domain Person

DataProperty: name

bleeding_in Domain Person

contaminated_with Range Chemical_substance

Individual: patient8

Neurological SubClassOf Symptom and (not (Physical or Psychological))

Physical SubClassOf Symptom and (not (Neurological or Psychological))

Person(?p), has_symptom(?p, tremor), has_symptom(?p, depression), has_symptom(?p, anosmia), age(?p, ?a), greaterThan(?a, 60) -> is_diagnosed_with(?p, Parkinsons_disease)

patient4 has_symptom dizziness

ObjectProperty: is_environment_of

cadmium_poisoning Type Environmental_Disease

patient1 works_at Pied_Piper

Female(?p), BMI(?p, ?bmi), greaterThan(?bmi, 30), premenopausal(?p, true), age(?p, ?a), greaterThan(?a, 55), smoker(?p, true), LDL(?p, ?ldl), greaterThan(?ldl, 160) -> is_at_risk_for(?p, coronary_heart_disease)

Class: non_Hereditary

 Symmetric: is_close_relative_of

patient3 feels_pain_in abdomin

is_related_to Domain Person

Individual: patient5

 Functional: name

DataProperty: temperature

Person(?p), is_diagnosed_with(?p, ?d), Hereditary(?d), is_close_relative_of(?p, ?r), Person(?r) -> is_at_risk_for(?r, ?d)

Contagious SubClassOf Person

lives_with Domain Person

patient6 is_close_relative_of patient4

patient7 has_symptom pain

Class: At_risk

patient3 name "April Ludgate"

has_environment Range Place

Individual: dizziness

ObjectProperty: contaminated_with

is_environment_of Range Person

ObjectProperty: lives_with

 Symmetric: has_coworker

Individual: patient6

patient6 name "Creed Bratton"

DataProperty: smoker

Class: Infectious_Disease

Person(?p1), is_diagnosed_with(?p1, ?d), Environmental_Disease(?d), has_environment(?p1, ?e1), Person(?p2), has_environment(?p2, ?e2), SameAs (?e1, ?e2), DifferentFrom (?p1, ?p2) -> is_at_risk_for(?p2, ?d)

Class: Environmental_Disease

height Domain Person

lives_with SubPropertyOf: has_contact_with

is_distant_relative_of SubPropertyOf: is_related_to

Individual: food_poisoning

needs_psychological_consultation Domain Person

AnnotationProperty: isRuleEnabled

age Domain Person

Individual: vomiting

depression Type Psychological

is_at_risk_for Range Disease

Individual: Dengue_fever

Individual: weakness

food_poisoning Type Infectious_Disease

Person(?p1), is_diagnosed_with(?p1, ?d), Infectious_Disease(?d), lives_with(?p1, ?p2), DifferentFrom (?p1, ?p2) -> is_at_risk_for(?p2, ?d)

works_at Range Work_place

Individual: patient3

patient2 CRP "110"^^xsd:int

Individual: tremor

DataProperty: needs_psychological_consultation

weakness Type Physical

patient2 name "Pam Beesly"

is_related_to Range Person

has_contact_with Domain Person

Person(?p), temperature(?p, ?t), greaterThan(?t, 37) -> has_fever(?p, true)

patient8 is_distant_relative_of patient4

has_coworker Domain Person

cadmium_poisoning has_primary_cause cadmium

dizziness Type Physical

Individual: patient4

patient1 name "Richard Hendricks"

Class: Sick

Individual: 221B

patient2 lives_at 221A

Individual: chest

ObjectProperty: is_close_relative_of

Class: Critical

Class: Body_part

patient7 lives_at 221B

At_risk EquivalentTo Person and (is_at_risk_for some Disease)

ObjectProperty: lives_at

patient1 Type Male

patient6 age "66"^^xsd:int

DataProperty: height

LDL Range: xsd:int

pain Type Physical

patient7 name "James Wilson"

temperature Domain Person

Individual: head

Person(?p), has_symptom(?p, ?s), Psychological(?s) -> needs_psychological_consultation(?p, true)

needs_psychological_consultation Range: xsd:boolean

vomiting Type Physical

patient6 has_symptom depression

has_symptom Range Symptom

DataProperty: CA125

Person(?p), creatinine(?p, ?c), greaterThan(?c, 300), feels_pain_in(?p, head), feels_pain_in(?p, chest), has_symptom(?p, cough), has_symptom(?p, dizziness), has_symptom(?p, weakness) -> is_diagnosed_with(?p, cadmium_poisoning)

Individual: patient1

Hereditary SubClassOf Disease

height Range: xsd:double

Person(?P1), is_related_to(?P1, ?P2), Person(?P2), is_related_to(?P2, ?P3), Person(?P3), DifferentFrom (?P3, ?P2), DifferentFrom (?P1, ?P3) -> is_related_to(?P1, ?P3)

patient8 age "48"^^xsd:int

Individual: depression

creatinine Range: xsd:int

Class: Physical

affects InverseOf is_diagnosed_with

patient2 has_symptom vomiting

memory_loss Type Neurological

Class: Country

temperature Range: xsd:float

patient8 height "1.82"^^xsd:double

Individual: Parkinsons_disease

ObjectProperty: is_diagnosed_with

Contagious EquivalentTo Person and (is_diagnosed_with some Infectious_Disease)

ObjectProperty: affects

patient7 bleeding_in nose

is_close_relative_of Range Person

Individual: patient2

Class: Neurological

BMI Range: xsd:double

Class: Psychological

is_distant_relative_of Domain Person

patient9 lives_at 221A

lives_at Range Home

patient6 is_distant_relative_of patient7

DataProperty: creatinine

 DifferentIndividuals: Dengue_fever, Parkinsons_disease, cadmium_poisoning, coronary_heart_disease, female_reproductive_organ_cancer, food_poisoning

patient8 Type Male

ObjectProperty: has_coworker

CRP Domain Person

lives_with Range Person

 Symmetric: is_distant_relative_of

has_traveled_to Domain Person

 Functional: lives_at

Sick SubClassOf Person

lives_at SubPropertyOf: has_environment

Person(?p1), lives_at(?p1, ?h1), Home(?h1), Home(?h2), Person(?p2), lives_at(?p2, ?h2), DifferentFrom (?p1, ?p2), SameAs (?h1, ?h2) -> lives_with(?p1, ?p2)

bleeding_in Range Body_part

Female(?p), feels_pain_in(?p, abdomin), CA125(?p, ?ca125), greaterThan(?ca125, 46) -> is_diagnosed_with(?p, female_reproductive_organ_cancer)

patient4 works_at Pied_Piper

premenopausal Range: xsd:boolean

Person(?p), is_diagnosed_with(?p, ?d), Environmental_Disease(?d), has_primary_cause(?d, ?c) -> is_exposed_to(?p, ?c)

patient5 name "Gregory House"

Dengue_fever Type Infectious_Disease

patient7 bleeding_in gums

patient3 CA125 "50"^^xsd:int

has_traveled_to Range Country

Person(?p), has_fever(?p, true), bleeding_in(?p, gums), bleeding_in(?p, nose), has_traveled_to(?p, Malaysia), has_symptom(?p, pain) -> is_diagnosed_with(?p, Dengue_fever)

patient6 has_symptom anosmia

 Symmetric: has_contact_with

affects Range Person

female_reproductive_organ_cancer Type Hereditary

DataProperty: BMI

DataProperty: CRP

is_diagnosed_with Range Disease

Individual: female_reproductive_organ_cancer

ObjectProperty: has_traveled_to

Individual: cadmium_poisoning

ObjectProperty: has_environment

patient7 Type Male

patient4 creatinine "309"^^xsd:int

Class: Place

CA125 Domain Person

Individual: 221A

ObjectProperty: works_at

ObjectProperty: feels_pain_in

weight Domain Person

patient8 smoker true

Environmental_Disease SubClassOf non_Hereditary

Home SubClassOf Place

CA125 Range: xsd:int

patient1 weight "62.0"^^xsd:double

Person(?p1), Person(?p2), Work_place(?w1), Work_place(?w2), works_at(?p1, ?w1), works_at(?p2, ?w2), DifferentFrom (?p1, ?p2), SameAs (?w1, ?w2) -> has_coworker(?p1, ?p2)

patient8 name "Ron Swanson"

coronary_heart_disease Type Disease

ObjectProperty: is_exposed_to

DataProperty: has_fever

patient2 LDL "175"^^xsd:int

feels_pain_in Range Body_part

patient8 LDL "185"^^xsd:int

 Functional: has_primary_cause

tremor Type Physical

is_close_relative_of SubPropertyOf: is_related_to

name Range: rdf:PlainLiteral

anosmia Type Neurological

 Symmetric: is_related_to

Class: Contagious

Class: Chemical_substance

patient5 lives_at 221B

patient2 age "57"^^xsd:int

has_contact_with Range Person

Class: Symptom

patient8 weight "105.0"^^xsd:double

CRP Range: xsd:int

patient2 height "1.53"^^xsd:double

contaminated_with Domain Place

cough Type Physical

has_coworker SubPropertyOf: has_contact_with

Class: Disease

Parkinsons_disease Type Hereditary

Sick EquivalentTo Person and (is_diagnosed_with min 1 Disease)

Individual: nose

patient6 has_symptom tremor

smoker Domain Person

DataProperty: premenopausal

patient6 Type Male

creatinine Domain Person