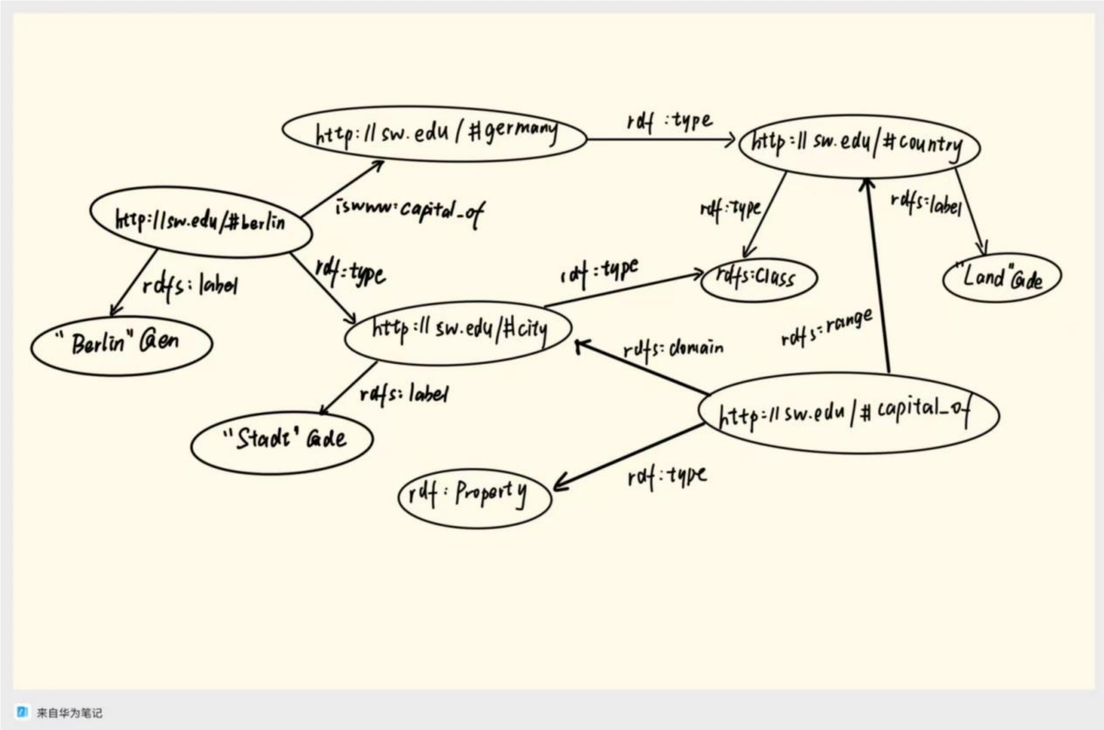
作业 1 知识工程与知识图谱

1. Consider the following RDF document:

```xml
<rdf:RDF
   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
   xmlns:iswww="http://sw.edu/#"
>
    <rdf:Description rdf:about="http://sw.edu/#germany">
       <rdf:type rdf:resource="http://sw.edu/#country" />
    </rdf:Description>
    <rdf:Description rdf:about="http://sw.edu/#capital_of">
       <rdf:type
          rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#Property"/>
       <rdfs:domain rdf:resource="http://sw.edu/#city" />
       <rdfs:range rdf:resource="http://sw.edu/#country" />
    </rdf:Description>
    <rdf:Description rdf:about="http://sw.edu/#country">
       <rdf:type rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class" />
       <rdfs:label xml:lang="de">Land</rdfs:label>
    </rdf:Description>
    <rdf:Description rdf:about="http://sw.edu/#berlin">
       <rdfs:label xml:lang="en">Berlin</rdfs:label>
       <rdf:type rdf:resource="http://sw.edu/#city" />
       <iswww:capital_of rdf:resource="http://sw.edu/#germany" />
    </rdf:Description>
    <rdf:Description rdf:about="http://sw.edu/#city">
       <rdf:type rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class" />
       <rdfs:label xml:lang="de">Stadt</rdfs:label>
    </rdf:Description>
</rdf:RDF>
```

Draw the graph representation of the above document.



2. Translate the culinary-allergic example ontology as follows into RDF/XML syntax.

```
ex:vegetableThaiCurry  ex:thaiDishBasedOn    ex:coconutMilk .
ex:sebastian           rdf:type              ex:AllergicToNuts .
ex:sebastian           ex:eats               ex:vegetableThaiCurry .

ex:AllergicToNuts      rdfs:subClassOf       ex:Pitiable .
ex:thaiDishBasedOn     rdfs:domain           ex:Thai .
ex:thaiDishBasedOn     rdfs:range            ex:Nutty .
ex:thaiDishBasedOn     rdfs:subPropertyOf    ex:hasIngredient .
ex:hasIngredient       rdf:type    rdfs:ContainerMembershipProperty.
```

```
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:ex="http://example.org/ns#"
>
```

```
  <rdf:Description rdf:about="ex:vegetableThaiCurry">
    <ex:thaiDishBasedOn rdf:resource="ex:coconutMilk"/>
 </rdf:Description>

  <rdf:Description rdf:about="ex:sebastian">
    <rdf:type rdf:resource="ex:AllergicToNuts"/>
    <ex:eats rdf:resource="ex:vegetableThaiCurry"/>
 </rdf:Description>

 <rdf:Description rdf:about="ex:AllergicToNuts">
    <rdfs:subClassOf rdf:resource="ex:Pitiable"/>
 </rdf:Description>

  <rdf:Description rdf:about="ex:thaiDishBasedOn">
    <rdfs:domain rdf:resource="ex:Thai"/>
    <rdfs:range rdf:resource="ex:Nutty"/>
    <rdfs:subPropertyOf rdf:resource="ex:hasIngredient"/>
 </rdf:Description>

 <rdf:Description rdf:about="ex:hasIngredient">
    <rdf:type
rdf:resource="http://www.w3.org/2000/01/rdf-schema#ContainerMembershipPr
```

operty"/>

</rdf:Description>

</rdf:RDF>

3. Decide whether the following propositions can be satisfactorily modeled in RDFS and, if so, give the corresponding RDF(S) specification:

- Every pizza is a meal.
- Pizzas always have at least two toppings.
- Every pizza from the class PizzaMargarita has a Tomato topping.
- Everything having a topping is a pizza.
- No pizza from the class PizzaMargarita has a topping from the class Meat.
- “Having a topping” is a containedness relation.

1、可以。 :Pizza rdfs:subClassOf :Meal.
2、不可以。 RDFS 不支持基数约束
3、不可以。 RDFS 无法强制要求每个实例必须拥有该属性，仅能声明关联关系。
4、可以。 :hasTopping rdfs:domain :Pizza.
5、不可以。 RDFS 无法表达否定约束
6、可以。 :hasTopping a rdf:Property.

4. As an example of an interpretation, this time with an infinite domain, consider the following vocabulary:

- $\mathsf{N}_I = \{\mathtt{zero}\}$.
- $\mathsf{N}_C = \{\mathtt{Prime}, \mathtt{Positive}\}$.
- $\mathsf{N}_R = \{\mathtt{hasSuccessor}, \mathtt{lessThan}, \mathtt{multipleOf}\}$.

Now, we define $\mathcal{I}$ as follows: let $\Delta^{\mathcal{I}} = \mathbb{N} = \{0, 1, 2, \ldots\}$, i.e., the set of all natural numbers including zero. Furthermore, we let $\mathtt{zero}^{\mathcal{I}} = 0$, as well as $\mathtt{Prime}^{\mathcal{I}} = \{n \mid n \text{ is a prime number}\}$ and $\mathtt{Positive}^{\mathcal{I}} = \{n \mid n > 0\}$. For the roles, we define

- $\mathtt{hasSuccessor}^{\mathcal{I}} = \{\langle n, n+1 \rangle \mid n \in \mathbb{N}\}$
- $\mathtt{lessThan}^{\mathcal{I}} = \{\langle n, n' \rangle \mid n < n',\ n, n' \in \mathbb{N}\}$
- $\mathtt{multipleOf}^{\mathcal{I}} = \{\langle n, n' \rangle \mid \exists k. n = k \cdot n',\ n, n', k \in \mathbb{N}\}$

Describe (both verbally and formally) the extension of the following concepts with respect to the interpretation $\mathcal{I}$ defined above

(a) $\forall \mathtt{hasSuccessor}^{-}.\mathtt{Positive}$
(b) $\exists \mathtt{multipleOf}.\mathsf{Self}$
(c) $\exists \mathtt{multipleOf}.\exists \mathtt{hasSuccessor}^{-}.\exists \mathtt{hasSuccessor}^{-}.\{\mathtt{zero}\}$
(d) $\geqslant 10\, \mathtt{lessThan}^{-}.\mathtt{Prime}$
(e) $\neg \mathtt{Prime} \sqcap \leqslant 2\, \mathtt{multipleOf}.\top$
(f) $\exists \mathtt{lessThan}.\mathtt{Prime}$
(g) $\forall \mathtt{multipleOf}.(\exists \mathtt{hasSuccessor}^{-}.\{\mathtt{zero}\} \sqcup \exists \mathtt{multipleOf}.\exists \mathtt{hasSuccessor}^{-}.\exists \mathtt{hasSuccessor}^{-}.\{\mathtt{zero}\})$

(a) 语义：所有前驱均为正数的自然数
形式扩展：$\{x \in N \mid \forall y: (x,y) \in hasSuccessor^{-I} \Rightarrow y \in Positive^{I}\}$

(b) 语义：存在自身为倍数的自然数
形式：$\{x \in N \mid \exists y: (x,y) \in multipleOf^{I} \wedge y = x\}$

(c) 语义：存在某数z，使得x是z的倍数，且0是z的后继的后继
形式：$\{x \in N \mid \exists z: (x,z) \in multipleOf^{I} \wedge (z,y),(y,0) \in hasSuccessor^{-I}\}$

(d) 语义：存在至少10个质数小于该自然数
形式：$\{m \in N \mid |\{n \in N \mid (m,n) \in lessThan^{-I}, n \in Prime^{I}\}| \geqslant 10\}$

(e) 语义：非质数且因数数量不超过2的自然数

形式：$\{x \in \mathbb{N} \mid x \notin \mathrm{Prime}^{I} \wedge |\{y \mid (x,y) \in \mathrm{multipleOf}^{I}\}| \leq 2\}$

(f) 语义：存在一个质数大于该自然数

形式：$\{x \in \mathbb{N} \mid \exists y: x < y \wedge y \in \mathrm{Prime}^{I}\}$

(g) 语义：任意因子为1或2的倍数的自然数

形式：$\{x \in \mathbb{N} \mid \forall y: (x,y) \in \mathrm{multipleOf}^{I} \Rightarrow (y = 1 \vee y = 2k)\}$

5. Decide whether the following axioms are satisfied by the interpretation $\mathcal{I}$ from Exercise 4.

(a) $\texttt{hasSuccessor} \sqsubseteq \texttt{lessThan}$
(b) $\exists\texttt{hasSuccessor}^{-}.\exists\texttt{hasSuccessor}^{-}.\{\texttt{zero}\} \sqsubseteq \texttt{Prime}$
(c) $\top \sqsubseteq \forall\texttt{multipleOf}^{-}.\{\texttt{zero}\}$
(d) $\mathsf{Dis}(\texttt{divisileBy}, \texttt{lessThan}^{-})$
(e) $\texttt{multipleOf} \circ \texttt{multipleOf} \sqsubseteq \texttt{multipleOf}$
(f) $\top \sqsubseteq \leqslant 1\texttt{hasSuccessor}.\texttt{Positive}$
(g) $\texttt{zero} \not\approx \texttt{zero}$
(h) $\leqslant 1\texttt{multipleOf}^{-}.\top(\texttt{zero})$
(i) $\top \sqsubseteq \forall\texttt{lessThan}.\exists\texttt{lessThan}.(\texttt{Prime} \sqcap \exists\texttt{hasSuccessor}.\exists\texttt{hasSuccessor}.\texttt{Prime})$

(a) 成立

$\forall n \in N$ 有 $(n, n+1) \in hasSuccessor^{\mathcal{I}}$ 且 $n < n+1$ 因此

$(n, n+1) \in lessThan^{\mathcal{I}}$

(b) 成立

0的后继的后继是2是素数

(c) 不成立

0的所有倍数都为0

(d) 不成立.

$\forall (x, y) \in multipleOf^{\mathcal{I}}$ $x = ky$ $\overset{k=(1,2,\cdots)}{x \geqslant y}$ $(x, y) \in lessThan^{-\mathcal{I}}$ 有交集

来自华为笔记

(e) 成立

若 x multipleOf z 且 z multipleOf y 则 $x=a\cdot z$ $z=b\cdot y$

因此 $x=a\cdot b\cdot y$ 即 x multipleOf y

(f) 成立

每个自然数n的后继唯一，且 $n+1>0$，所以每个元素至多有一个通过 hasSuccessor 指向的正数

(g) 不成立

任何个体等于自身

(h) 成立

是0的倍数的自然数只有0，只有一个

(i) 成立

对于x，若 $x<y$，存在 $z>y$ 使z是素数且 $z+2$ 也是素数，总能找到

6. Show using the $\mathcal{ALC}$ tableaux algorithm that the following knowledge base is unsatisfiable.

$$
\begin{aligned}
\texttt{Bird} &\sqsubseteq \texttt{Flies} \\
\texttt{Penguin} &\sqsubseteq \texttt{Bird} \\
\texttt{Penguin} \sqcap \texttt{Flies} &\sqsubseteq \bot \\
&\texttt{Penguin}(\texttt{tweety})
\end{aligned}
$$

编号 ① Bird ⊑ Flies 所有鸟都会飞

② Penguin ⊑ Bird 所有企鹅都是鸟

③ Penguin ⊓ Files ⊑ ⊥ 所有企鹅都不会飞

④ Penguin (tweety) tweety是企鹅

由④、② ⇒ Bird (tweety) ⑥

由①、⑥ ⇒ Flies (tweety) ⑦

由③、④ ⇒ ¬Flies (tweety) ⑧

而 ⑦与⑧矛盾，所以不可满足