Chapter 1
$\mathcal{LOE}$ - Logic of Entities

1.1 Basic Concepts

Exercise 1.1 (**$\mathcal{LOE}$ Theory**) Answer to the following questions:

1. What is the purpose of the Logic of Entities?
2. What are the key elements of the Logic of Entities?
3. What is the difference between an object property and a data property in an Entity Graph?
4. What is the form of facts in a domain of the Logic of Entities?
5. What is the form of assertions in a language of the Logic of Entities?
6. What is the form of a theory in the Logic of Entities?
7. What is the form of an interpretation function in the Logic of Entities?
8. What is entailment in the Logic of Entities?
9. What are the reasoning problems in the Logic of Entities?
10. Do we have negative facts in the Logic of Entities?

1.2 Translations

Exercise 1.2 (Define a $\mathcal{LOE}$ model from natural language) Define a domain D and a model M for the following text in natural language: The Eiffel Tower is located in the city of Paris. The Eiffel Tower is a place that has been visited by Alice and Bill.

Exercise 1.3 (Build a $\mathcal{KG}$) Design a knowledge graph for the previous exercise.

Exercise 1.4 (Define a $\mathcal{LOE}$ model from natural language) Given the following text in natural language, design a corresponding knowledge graph and then a theory in LOE.

- The Mona Lisa was created by Leonardo da Vinci.

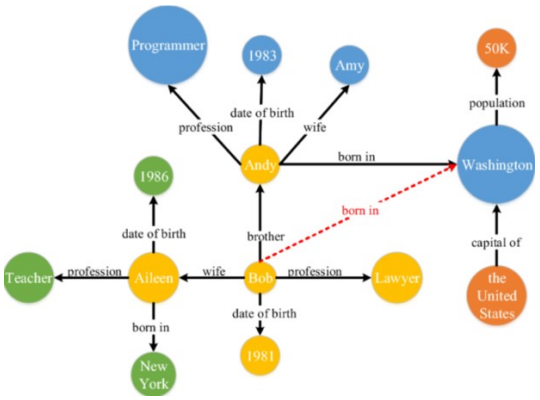
- "La Joconde a Washington" is about The Mona Lisa.
- Bob is a person born on 14 July 1990.
- Bob is a friend of Alice and is interested in The Mona Lisa.

Exercise 1.5 (Define a $\mathcal{LOE}$ model from natural language) Define the intended model in set theory and the corresponding interpretation function from the theory in the previous point.

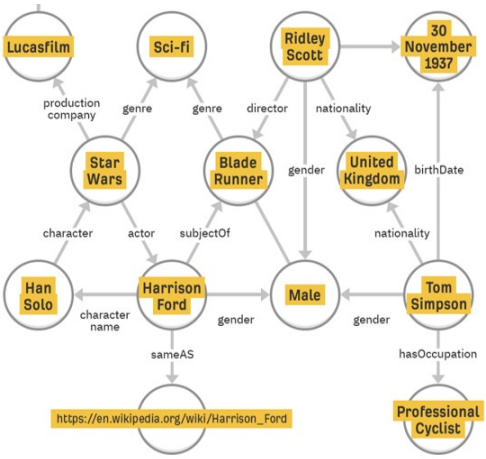
Exercise 1.6 (Informal Model) Design a knowledge graph from a triple store.

	Head	Relation	Tail
1	London	capital_city_of	United Kingdom
2	United Kingdom	is_a	Country
3	United Kingdom	located_in	Europe
4	Europe	is_a	Continent
5	Paris	capital_city_of	France
6	France	is_a	Country
7	France	located_in	Europe

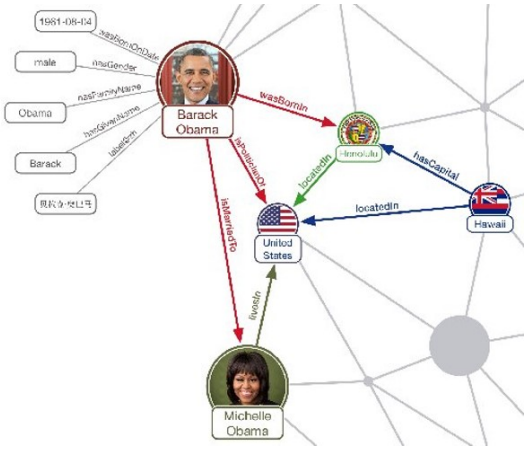
Exercise 1.7 (Define a theory from a knowledge graph) Given the following knowledge graph, define a theory for it.



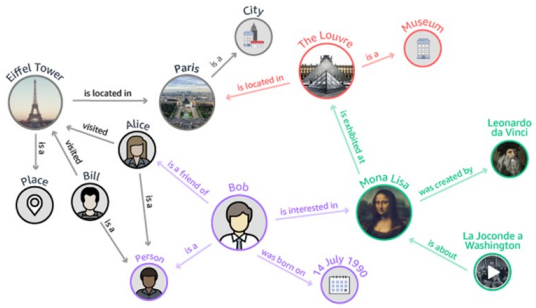
Exercise 1.8 ($\mathcal{LOE}$ knowledge graphs) Define a theory and an interpretation function for the knowledge graph. Provide some examples of queries, as formulas in the logic of entities:



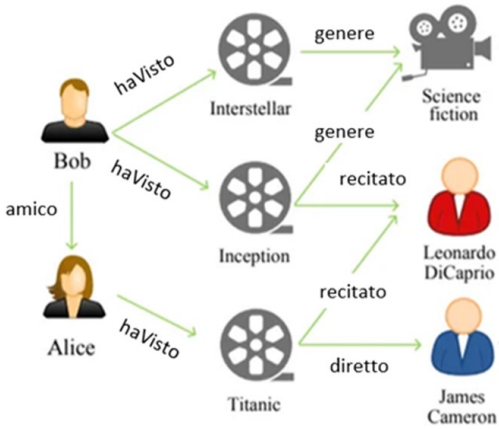
Exercise 1.9 (*$\mathcal{LOE}$* **knowledge graphs)** Define a theory and an interpretation function for the knowledge graph. Provide some examples of queries, as formulas in the logic of entities:



Exercise 1.10 (*$\mathcal{LOE}$* **knowledge graphs)** Define a theory and an interpretation function for the knowledge graph. Provide some examples of queries, as formulas in the logic of entities:



Exercise 1.11 ($\mathcal{KG}$ **to** $\mathcal{LOE}$) Consider the knowledge graph ($\mathcal{KG}$), represented in informal graph form in the figure, where nodes represent entities or data values (whose name is the node label) and arcs represent relationships between nodes (whose name is the arc label). Assume that we need to formalize this $\mathcal{KG}$ into an Entity Graph (EG), as formalized in the Logic of Entities ($\mathcal{LOE}$).



Indicate which of the following statements are TRUE (one or more):

1. Alice saw an entity directed by James Cameron
2. The node label ”Interstellar” cannot be formalized in as a data value
3. The node label ”Science fiction” must be formalized in as a data value
4. The node labels ”Bob” and ”Alice,” must be formalized in as an entity
5. The labels ”Bob” and ”Alice” must be formalized in as entities with etype ”Person”
6. The node labels ”LeonardoDiCaprio” and ”JamesCameron” must be formalized in as an entity
7. The label ”hasSeen” must be formalized in $\mathcal{LOE}$ as an object property

1.3 Reasoning

1.3.1 Entailment

Exercise 1.12 (Define a model from a LOE theory) Given a theory, define a linguistic model for it:

- profession(A, P)
- dateOfBirth(A, 1993)
- wife(A, C)
- bornIn(A, W)
- brotherOf(B, A)

Exercise 1.13 (Model Checking) Decide whether `M`:

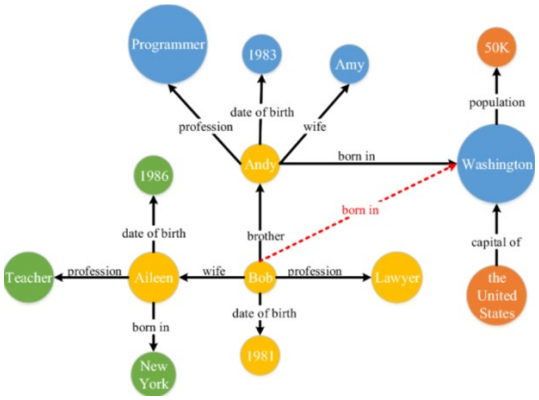
- Andy is born on 1929.
- Andy is born in New York City.
- Andy is married with Carol.
- The profession of Andy is the programmer.
- Andy's brothers is called Bob.

is a model for the theory $\mathcal{T}$:

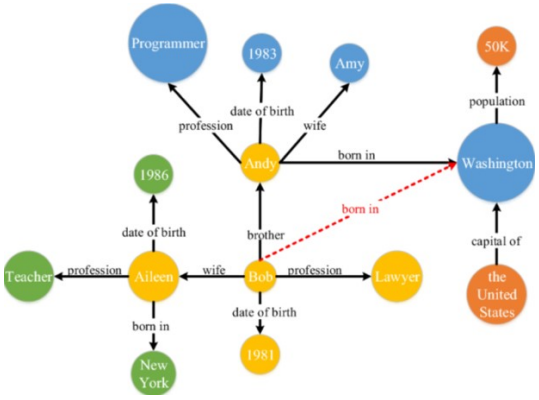
- profession(A, P)
- dateOfBirth(A, 1929)
- wife(A, C)
- bornIn(A, W)
- brotherOf(B, A)

Exercise 1.14 (Query answering on a knowledge graph (model checking)) Answering a query q on the basis of a knowledge graph $\mathcal{KG}$ is basically model checking: $\mathcal{KG} \models$ q. So, check if:

- $\mathcal{KG}$? = bornin(Andy, Washington)
- $\mathcal{KG}$? = profession(Bob, Lawyer)
- $\mathcal{KG}$? = wife(Andy, Aileen)



Exercise 1.15 (Finding entities on a knowledge graph (instance retrieval)) Get the results for: $\mathcal{KG}$? = wife(a, b) and $\mathcal{KG}$? = person (p).



1.3.2 Correctness and Completeness

Exercise 1.16 Let there be a table, shown below, showing the grades, represented by an integer, of an exam (not explicitly stated). State for which of the domains `D = <E, {C}, {R}>` of the Logic of Entities below, there is an interpretation function that correctly formalizes the contents of the table. Assume that there are no synonyms.

Student	**Domicile**	**Mark**
MarioRossi	Trento	27
StefaniaBianchi	Napoli	30

1. The domain `D` is composed as follows
   - `E` = MarioRossi, StefaniaBianchi, Trento, Naples, twenty-seven, thirty,
   - {`C`} = Student, entity, integer, dtype
   - {`R`} = Residence, Mark
2. The domain `D` is composed as follows
   - `E` = MarioRossi, StefaniaBianchi, Trento, Naples, 27, 30
   - {`C`} = Student, city, entity, integer, dtype
   - {`R`} = Residence, Mark
3. The domain `D` is composed as follows
   - `E` = MarioRossi, StefaniaBianchi, Trento, Naples, 27, 30
   - {`C`} = Student, entity, integer, dtype
   - {`R`} = Residence, Mark
4. The domain `D` is composed as follows
   - `E` = MarioRossi, StefaniaBianchi, Trento, Naples, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30
   - {`C`} = Student, entity, integer, dtype
   - {`R`} = Residence, Mark
5. The domain `D` is composed as follows
   - `E` = MarioRossi, StefaniaBianchi, Trento, 27, 30
   - {`C`} = Student,integer, entity, dtype
   - {`R`} = Residence, Mark
6. The domain `D` is composed as follows
   - `E` = MarioRossi, StefaniaBianchi, Bolzano, Rome, 27, 30
   - {`C`} = Student,integer, entity, dtype
   - {`R`} = Residence, Mark
7. The domain `D` is composed as follows
   - `E` = MR, SB, TN, NA, 27, 30,
   - {`C`} = Student, Residence, integer, entity, dtype
   - {`R`} = Mark
8. The domain `D` is composed as follows
   - `E` = MarioRossi, StefaniaBianchi, Trento, Naples, 27, 30,

- {C} = Student, integer, entity, dtype