The Introduction To Artificial Intelligence

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The Introduction to Artificial Intelligence

- Part I Brief Introduction to AI & Different AI tribes
- Part II Knowledge Representation & Reasoning

The Introduction to Artificial Intelligence

- **Brief Review**

1.3 Knowledge Representation & Reasoning

Predicate Logic

- Definition: A statement of form $P(x_1, x_2, \cdots, x_n)$ is the value of the propositional function P. Here, $(x_1, x_2, \cdots, x_n)$ is an n-tuple and P is a predicate.

- You can think of a propositional function as a function that

  (1) Evaluates to true or false

  (2) Take one or more arguments

  (3) Expresses a predicate involving the argument(s).

  (4) Becomes a proposition when values are assigned to the arguments.

1.3 Knowledge Representation & Reasoning

Predicate Logic

- Consider the previous example. Does it make sense to assign to x the value "blue"?

- Intuitively, *the universe of discourse* is the set of all things we wish to talk about; that is, the set of all objects that we can sensibly assign to variable in a propositional function.

- What would be the universe of discourse for propositional function $P(x) =$ "The test will be on x the 23rd" be ?

1.3 Knowledge Representation & Reasoning

Quantifiers

- A predicate becomes a proposition when we assign it fixed values.

- However, another way to make a predicate into a proposition is to *quantify* it. That is, the predicate is true (or false) for *all* possible values in the universe of discourse or for *some* value(s) in the universe of discourse.

- Such *quantification* can be done with two quantifiers: the *universal* quantifier and the *existential* quantifier.

1.3 Knowledge Representation & Reasoning

Quantifiers

- Definition: The universal quantification of a predicate $P(x)$ is the proposition "$P(x)$ is true for all values of x in the universe of discourse". We use the notation

$$\forall x P(x)$$

which can be read "for all x".

- If the universe of discourse is finite, say $\{n_1, n_2, \cdots, n_k\}$, then the universal quantifier is simply the conjunction of all elements:

$$\forall x P(x) \Leftrightarrow P(n_1) \wedge P(n_2) \wedge P(n_3) \wedge \cdots \wedge P(n_k)$$

1.3 Knowledge Representation & Reasoning

Quantifiers

- Definition: The *existential quantification* of a predicate $P(x)$ is the proposition "There exist an x in the universe of discourse such $P(x)$ is true". We use the notation

$$\exists x P(x)$$

which can be read "there exist an x".

- Again, If the universe of discourse is finite, say $\{n_1, n_2, \cdots, n_k\}$, then the *existential* quantifier is simply the disjunction of all elements:

$$\exists x P(x) \Leftrightarrow P(n_1) \vee P(n_2) \vee P(n_3) \vee \cdots \vee P(n_k)$$

1.3 Knowledge Representation & Reasoning

Mixing Quantifiers

- Existential and universal quantifiers can be used together to quantify a predicate statement; for example,

$$\forall x \exists y P(x, y)$$

is perfectly valid.

- $\forall x \ \forall y$ is the same as $\forall y \ \forall x$
- $\exists x \ \exists y$ is the same as $\exists y \ \exists x$

- However, you must be careful – it must be read left to right.
- For example, $\forall x \exists y P(x, y)$ is not equivalent to $\exists y \forall x(x, y)$.
- Thus, ordering is important.

1.3 Knowledge Representation & Reasoning

Mixing Quantifiers

- Just as we can use negation with proposition, we can use them with quantified expressions.
- Let $P(x)$ be a predicate. Then the following hold.

$$\neg \forall x P(x) \equiv \exists x \neg P(x)$$

$$\neg \exists x P(x) \equiv \forall x \neg P(x)$$

- This is essentially a quantified version of De Morgan's Law (in fact if the universe of discourse if finite, it is exactly De Morgan's law)
- $\forall x P(x) \Leftrightarrow P(n_1) \wedge P(n_2) \wedge P(n_3) \wedge \cdots \wedge P(n_k)$
- $\exists x P(x) \Leftrightarrow P(n_1) \vee P(n_2) \vee P(n_3) \vee \cdots \vee P(n_k)$

1.3 Knowledge Representation & Reasoning

- Translation from English to logic

Formula	Description
$\forall x \; frog(x) \Rightarrow green(x)$	All frogs are green
$\forall x \; frog(x) \land brown(x) \Rightarrow big(x)$	All brown frogs are big
$\forall x \; likes(x, cake)$	Everyone likes cake
$\neg\forall x \; likes(x, cake)$	Not everyone likes cake
$\neg\exists x \; likes(x, cake)$	No one likes cake
$\exists x \; \forall y \; likes(y, x)$	There is something that everyone likes
$\exists x \; \forall y \; likes(x, y)$	There is someone who likes everything
$\forall x \; \exists y \; likes(y, x)$	Everything is loved by someone
$\forall x \; \exists y \; likes(x, y)$	Everyone likes something
$\forall x \; customer(x) \Rightarrow likes(bob, x)$	Bob likes every customer
$\exists x \; customer(x) \land likes(x, bob)$	There is a customer whom bob likes
$\exists x \; baker(x) \land \forall y \; customer(y) \Rightarrow mag(x, y)$	There is a baker who likes all of his customers

1.3 Knowledge Representation & Reasoning

- What is knowledge representation?
- Propositional Logic
- Predicate Logic
- *Production-rule System*
- Frame-Based System
- State Space System
- Knowledge graph

1.3 Knowledge Representation & Reasoning

Production-rule System

- It was first proposed by the American mathematician E. Post in 1943.

- In 1972, Newell and Simon developed rule-based production systems in the study of human cognitive models.

- to represent facts, rules and their uncertainty measures, and is suitable for representing factual knowledge and regular knowledge.

1.3 Knowledge Representation & Reasoning

Production-rule System

- Production representation of certainty rule knowledge

Basic Form: IF P THEN Q

Or: $P \rightarrow Q$

For example:

IF an animal can fly AND can lay eggs THEN it is a bird.

- Production representation of uncertainty rule knowledge

Basic Form: IF P THEN Q (Certification factor)

Or: $P \rightarrow Q$ (Certification factor)

For example:

IF have a fever THEN catch a cold (0.6).

1.3 Knowledge Representation & Reasoning

Production-rule System

- Proposition

  E.g., Snow is white.   John likes AI.

- Representation in computer:

  Ternary:

  (attribute, object, value), (relation, object1, object2)

  E.g., (color, snow, white)   (like, John, AI)

  Quaternion:

  (attribute, object, value, certification factor), (relation, object1, object2, certification factor)

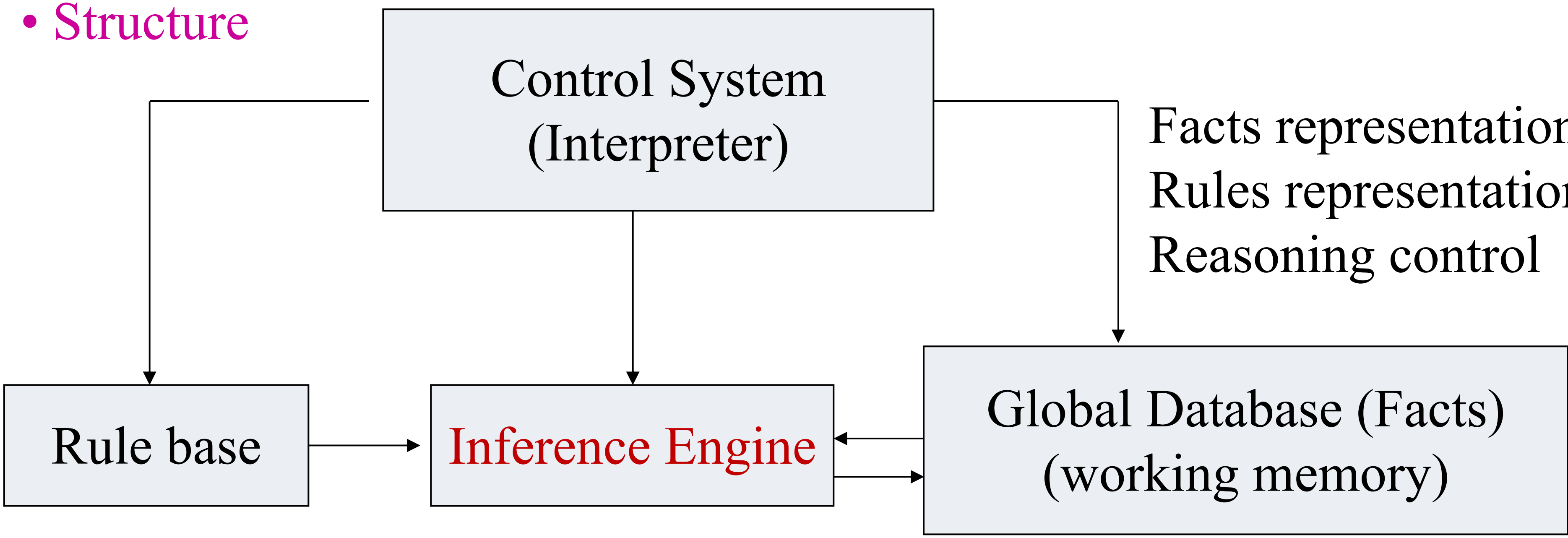
  E.g.: Mr. Li may be 40 years old. (age, Mr. Li, 40, 0.8)

  Lao Wang and Lao Li are unlikely friends. (friends, Wang, Li, 0.1)

1.3 Knowledge Representation & Reasoning

Production-rule System

- Structure

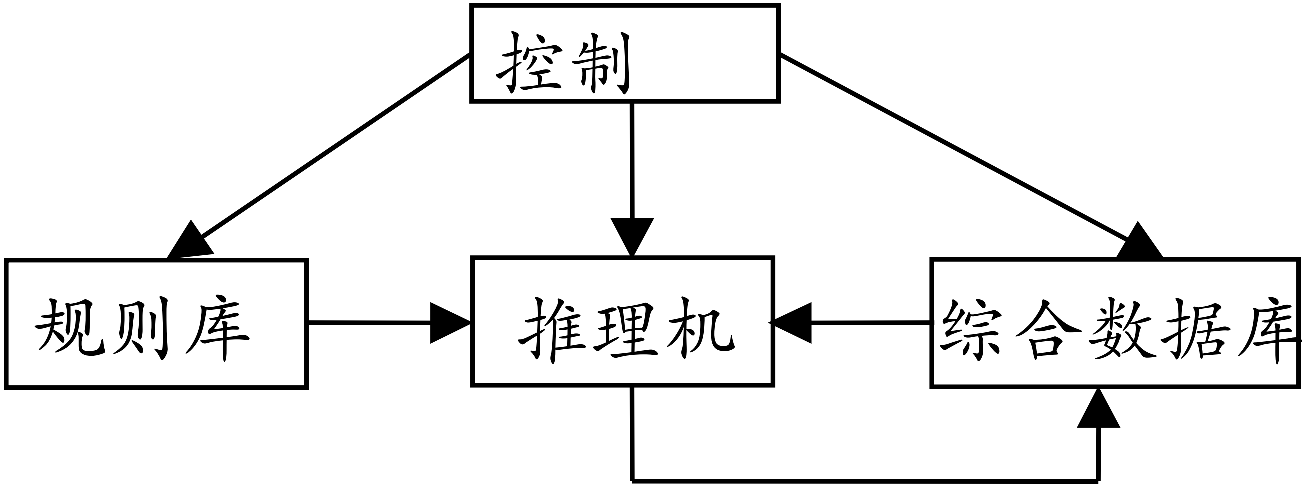


- Procedure

Rule Matching → Conflict Resolution → Rule Execution

Stop Conditions

1.3 Knowledge Representation & Reasoning



产生式系统的基本结构

1.3 Knowledge Representation & Reasoning

产生式系统

控制系统要做以下工作：

（1）从规则库中选择与综合数据库中的已知事实进行匹配。

（2）匹配成功的规则可能不止一条，进行冲突消解。

（3）执行某一规则时，如果其右部是一个或多个结论，则把这些结论加入到综合数据库中；如果其右部是一个或多个操作，则执行这些操作。

（4）对于不确定性知识，在执行每一条规则时还要按一定的算法计算结论的不确定性。

（5）检查综合数据库中是否包含了最终结论，决定是否停止系统的运行。

1.3 Knowledge Representation & Reasoning

- Production-rule System --- Example, ANIMAL RECOGNITION SYSTEM
  - A production system for the recognition of seven animals: tiger (老虎), leopard (豹子), zebra (斑马), giraffe (长颈鹿), ostrich (鸵鸟), penguin (企鹅) and albatross (信天翁)

1.3 Knowledge Representation & Reasoning

- Production-rule System --- Example, ANIMAL RECOGNITION SYSTEM
  - Rule base

r_1: IF The animal has hair Then The animal is a mammal

r_2: IF The animal has milk Then The animal is a mammal

r_3: IF The animal has feathers Then The animal is a bird

r_4: IF The animal can fly AND can lay eggs Then The animal is a bird

r_5: IF The animal eats meat Then The animal is a carnivore

r_6: IF The animal has canine teeth AND has claws AND eye on the front Then The animal is a carnivore

r_7: IF The animal is a mammal AND has hoofed Then The animal is an ungulate

1.3 Knowledge Representation & Reasoning

- Production-rule System --- Example, ANIMAL RECOGNITION SYSTEM

  - Rule base

r_8: IF The animal is a mammal AND is ruminant Then The animal is an ungulate

r_9: IF The animal is a mammal AND is a carnivore AND in tan AND has dark spots on the body Then The animal is a leopard

r_{10}: IF The animal is a mammal AND is a carnivore AND in tan AND has black stripe on the body Then The animal is a tiger

r_{11}: IF The animal is an ungulate AND has long neck AND has long legs AND has dark spots on the body Then The animal is a giraffe

r_{12}: IF The animal is an ungulate AND has dark spots on the body Then The animal is a zebra

1.3 Knowledge Representation & Reasoning

Production-rule System --- Example, ANIMAL RECOGNITION SYSTEM

r_9: IF 该动物是哺乳动物 AND 是食肉动物 AND 是黄褐色 AND 身上有暗斑点 THEN 该动物是金钱豹

r_{10}: IF 该动物是哺乳动物 AND 是食肉动物 AND 是黄褐色 AND 身上有黑色条纹 THEN 该动物是虎

r_{11}: IF 该动物是有蹄类动物 AND 有长脖子 AND 有长腿 AND 身上有暗斑点 THEN 该动物是长颈鹿

r_{12}: IF 该动物有蹄类动物 AND 身上有黑色条纹 THEN 该动物是斑马

r_{13}: IF 该动物是鸟 AND 有长脖子 AND 有长腿 AND 不会飞 AND 有黑白二色 THEN 该动物是鸵鸟

r_{14}: IF 该动物是鸟 AND 会游泳 AND 不会飞 AND 有黑白二色 THEN 该动物是企鹅

r_{15}: IF 该动物是鸟 AND 善飞 THEN 该动物是信天翁

1.3 Knowledge Representation & Reasoning

Production-rule System --- Example, ANIMAL RECOGNITION SYSTEM

- 设已知初始事实存放在综合数据库中：

  该动物身上有暗斑点、长脖子、长腿、奶、蹄

- 推理机构的工作过程：

  （1）从规则库中取出r1，检查其前提是否可与综合数据库中的已知事实匹配。匹配失败则r1不能被用于推理。然后取r2进行同样的工作。匹配成功则r2被执行。

  ·综合数据库：该动物身上有暗斑点、长脖子、长腿、奶、蹄、哺乳动物

  （2）分别用r3、r4、r5、r6综合数据库中的已知事实进行匹配，均不成功。r7匹配成功，执行r7。

  ·综合数据库：该动物身上有暗斑点、长脖子、长腿、奶、蹄、哺乳动物、有蹄类动物

  （3）r11匹配成功，并推出“该动物是长颈鹿”

mammals, ungulates

(3) r_{11} is matched successfully, and "This animal is a giraffe" is launched.

1.3 Knowledge Representation & Reasoning

Production-rule System

■ 产生式表示法的优点

(1) 自然性

(2) 模块性

(3) 有效性

(4) 清晰性

■ 产生式表示法的缺点

(1) 效率不高

(2) 不能表达结构性知识

■ 适合产生式表示的知识

(1) 领域知识间关系不密切，不存在结构关系。

(2) 经验性及不确定性的知识，且相关领域中对这些知识没有严格、统一的理论。

(3) 领域问题的求解过程可被表示为一系列相对独立的操作，且每个操作可被表示为一条或多条产生式规则。

1.3 Knowledge Representation & Reasoning

- What is knowledge representation?
- Propositional Logic
- Production-rule System
- *Frame-Based System*
- State Space System
- Knowledge graph

1.3 Knowledge Representation & Reasoning

Frame-Based System

- In 1975, Minsky proposed the frame theory: the various knowledge of people is stored in memory in a structure similar to the frame.

- A structured knowledge representation method has been applied in many systems.

Frame-Based System

- **框架**（frame）：一种描述所论对象（一个事物、事件或概念）属性的数据结构。
- 一个框架由若干个被称为“槽”（slot）的结构组成，每一个槽又可根据实际情况划分为若干个“侧面”（faced）。
- 一个槽用于描述所论对象某一方面的属性。
- 一个侧面用于描述相应属性的一个方面。
- 槽和侧面所具有的属性值分别被称为槽值和侧面值。

1.3 Knowledge Representation & Reasoning

Frame-Based System

<Frame name>

Slot Name1: Facet Name 11

Facet Name 12

⋮

Facet Name 1m

Slot Name 2: Facet Name 21

Facet Name 22

⋮

Facet Name 2m facet value 2m1, ⋯, facet value 2mpm

⋮

<框架名>

槽名1: 侧面名$_{11}$ 侧面值$_{111}$, …, 侧面值$_{11P1}$

¦ ¦

侧面名$_{1m}$ 侧面值$_{1m1}$, …, 侧面值$_{1mPm}$

槽名n: 侧面名$_{n1}$ 侧面值$_{n11}$, …, 侧面值$_{n1P1}$

¦

侧面名$_{nm}$ 侧面值$_{nm1}$, …, 侧面值$_{nmPm}$

约束: 约束条件$_1$

¦

约束条件$_n$

1.3 Knowledge Representation & Reasoning

Frame-Based System

Frame name: < Teacher>

Name: Unit (the first name, the last name)

Age: Unit (-year-old)

Sex: Range (male, female),   if missing, male

Title: Range (professor, associate professor, lecturer, assistant), if missing, lecturer.

Department: Organization

Address: <address frame >

Salary: <salary frame>

The date of starting work: Unit (year-month)

Deadline of work: Unit (year-month), if missing, today

1.3 Knowledge Representation & Reasoning

Frame-Based System

Frame name: < Teacher-1>

Name: Bing Xia

Age: 36

Sex: female

Title: associate professor

Department: Department of Computer Science

Address: <adr-1>

Salary: <sal-1>

The date of starting work: 1988.09)

Deadline of work: 1996.07

框架名：〈教师-1〉
姓名：夏冰
年龄：36
性别：女
职称：副教授
部门：计算机系软件教研室
住址：〈adr-1〉
工资：〈sal-1〉
开始工作时间：1988，9
截止时间：1996，7

1.3 Knowledge Representation & Reasoning

Frame-Based System

- **将下列一则地震消息用框架表示：** “某年某月某日，某地发生6.0级地震，若以膨胀注水孕震模式为标准，则三项地震前兆中的波速比为0.45，水氡含量为0.43，地形改变为0.60。
- **解**：地震消息用框架如下图所示

框架名：〈地震〉
地　　点：某地
日　　期：某年某月某日
震　　级：6.0
波 速 比：0.45
水氡含量：0.43
地形改变：0.60

1.3 Knowledge Representation & Reasoning

Frame-Based System

- It is easy to express structural knowledge, and can express the internal structural relations of knowledge and the relations between knowledge.

- One frame can inherit the slot value of another frame, and can also be supplemented and modified.

- is consistent with the thinking activity of people when they observe things

1.3 Knowledge Representation & Reasoning

- What is knowledge representation?
- Propositional Logic
- Production-rule System
- Frame-Based System
- State Space System
- Knowledge graph

1.3 Knowledge Representation & Reasoning

State Space System

- State space: A system of symbols to represent knowledge or questions by state variables and operational symbols.

$$(S, O, S_0, G)$$

- S: The state set
- O: The operations set
- S_0: Contain the initial state
- G: Some specific states or path information description satisfying certain condition

1.3 Knowledge Representation & Reasoning

State Space System

- The solution path from node S_0 to note G
- One solution: one finite O sequence, like

$$S_0 \xrightarrow{O_1} S_1 \xrightarrow{O_2} S_2 \xrightarrow{O_3} \cdots \xrightarrow{O_k} G$$

- This means $O_1, \cdots O_k$ is a solution path of state space

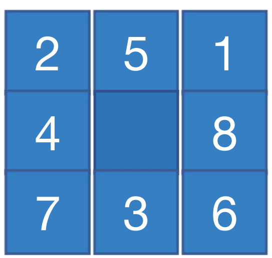
1.3 Knowledge Representation & Reasoning

State Space System

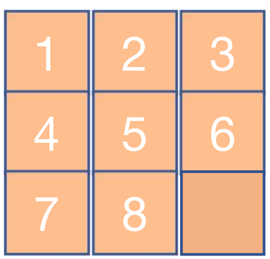
- A simple Example: The 8-puzzle

HOW to find a path from the initial state to the goal ?

Start



Goal



1.3 Knowledge Representation & Reasoning

State Space System

- A simple Example: The 8-puzzle

Start

S_0:

2	5	1
4		8
7	3	6

Goal

G:

1	2	3
4	5	6
7	8	

O: move up, down, left, right (4 operations)

S: The state set

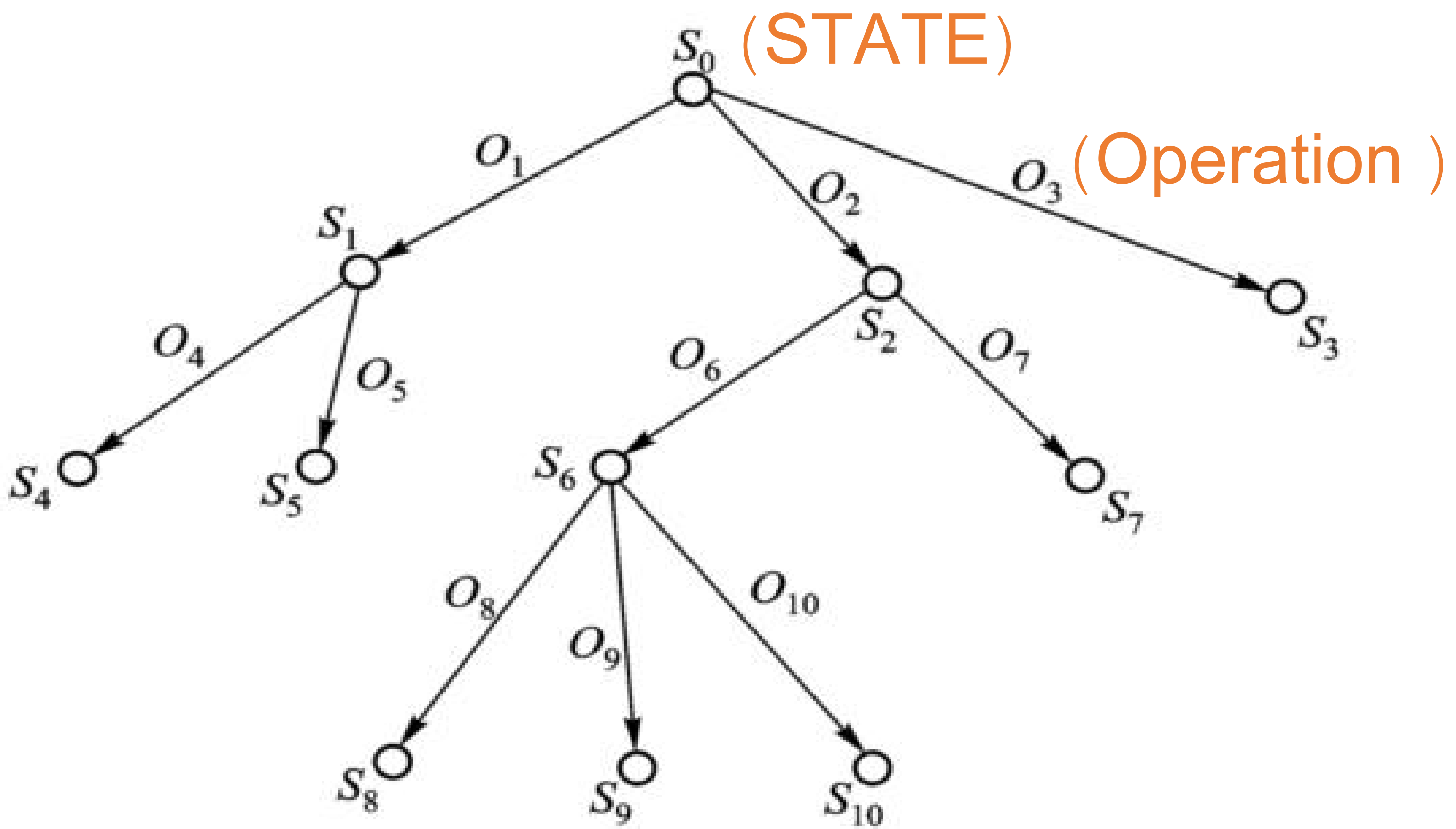
1.3 Knowledge Representation & Reasoning

State Space System

- The state space can be described by a directed graph. The nodes in the graph represent the states of the problem, and the arcs or edges of the graph represent the relationships between the states.
- The initial state is the root of the graph.
- In state space system, to find one finite operation sequence from one state to anther is equivalent to find a path in the directed graph.

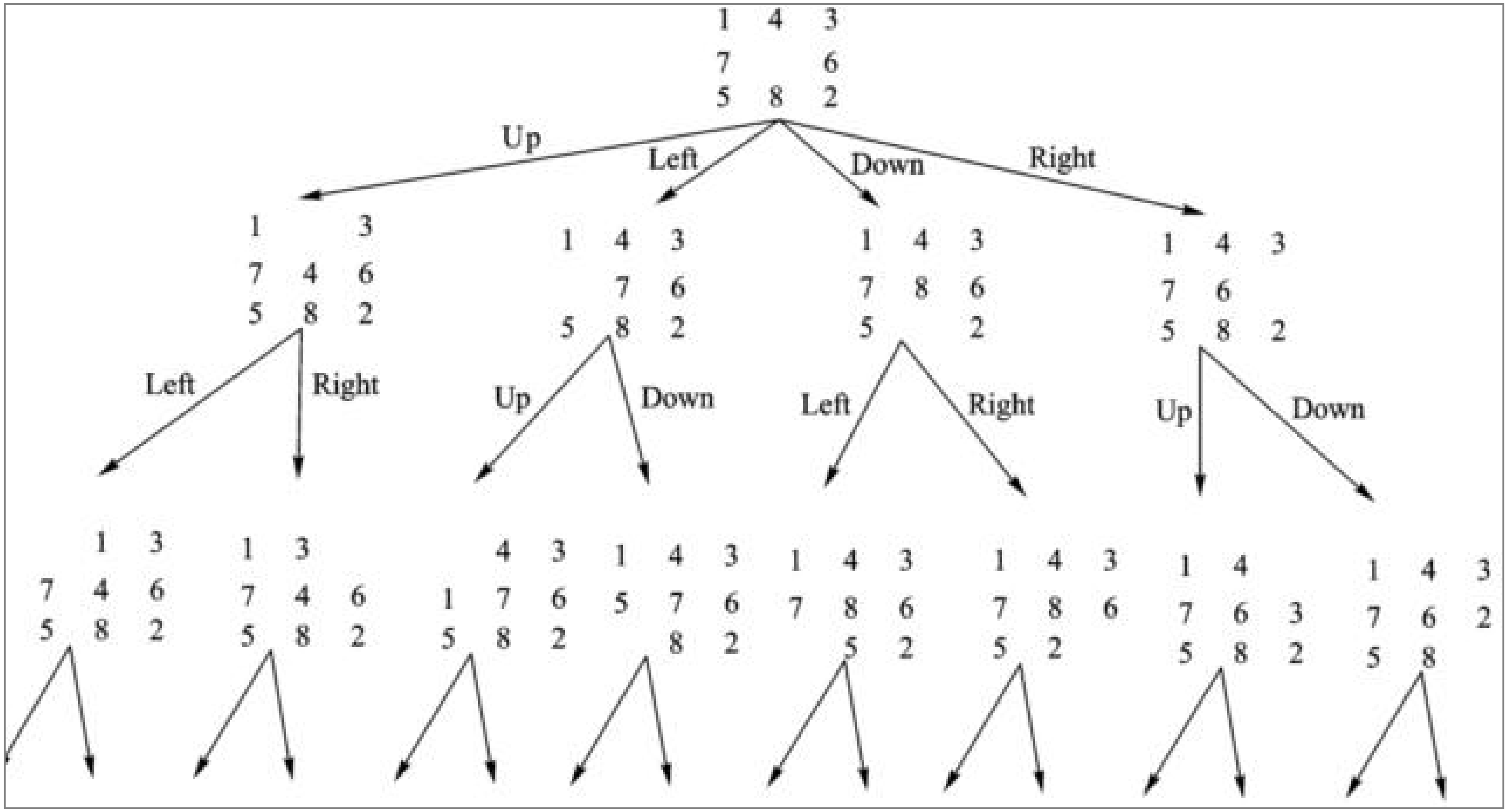
1.3 Knowledge Representation & Reasoning

- State Space System Based on Graph



1.3 Knowledge Representation & Reasoning

State Space System Based on Graph



Directed graph of the 8-puzzle

1.3 Knowledge Representation & Reasoning

State Space System -- Example 2

- Traveling salesman problem (TSP)
  - A salesman travels from his starting point to several cities to sell his product, and then returns to his starting point. Each city is required to walk once, and only once
  - "Given a list of cities and the distances between each pair of cities, what is the shortest possible route that visits each city exactly once and returns to the origin city?"

1.3 Knowledge Representation & Reasoning

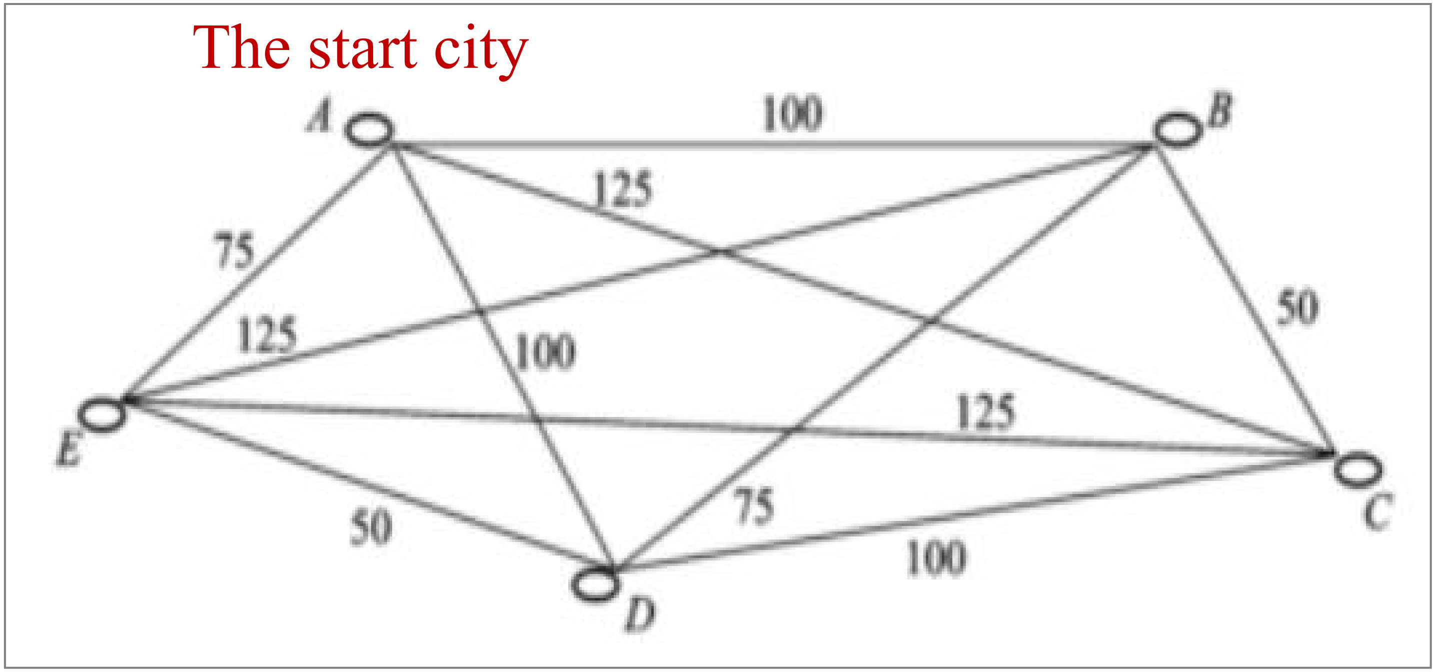
State Space System -- Example 2

- State Space Graph of Traveling Salesman Problem (TSP)
  - Nodes : Cities
  - Edges : Distance or traveling fees between two cities
  - Root node: the start city

1.3 Knowledge Representation & Reasoning

State Space System -- Example 2

- State Space Graph of Traveling Salesman Problem (TSP)

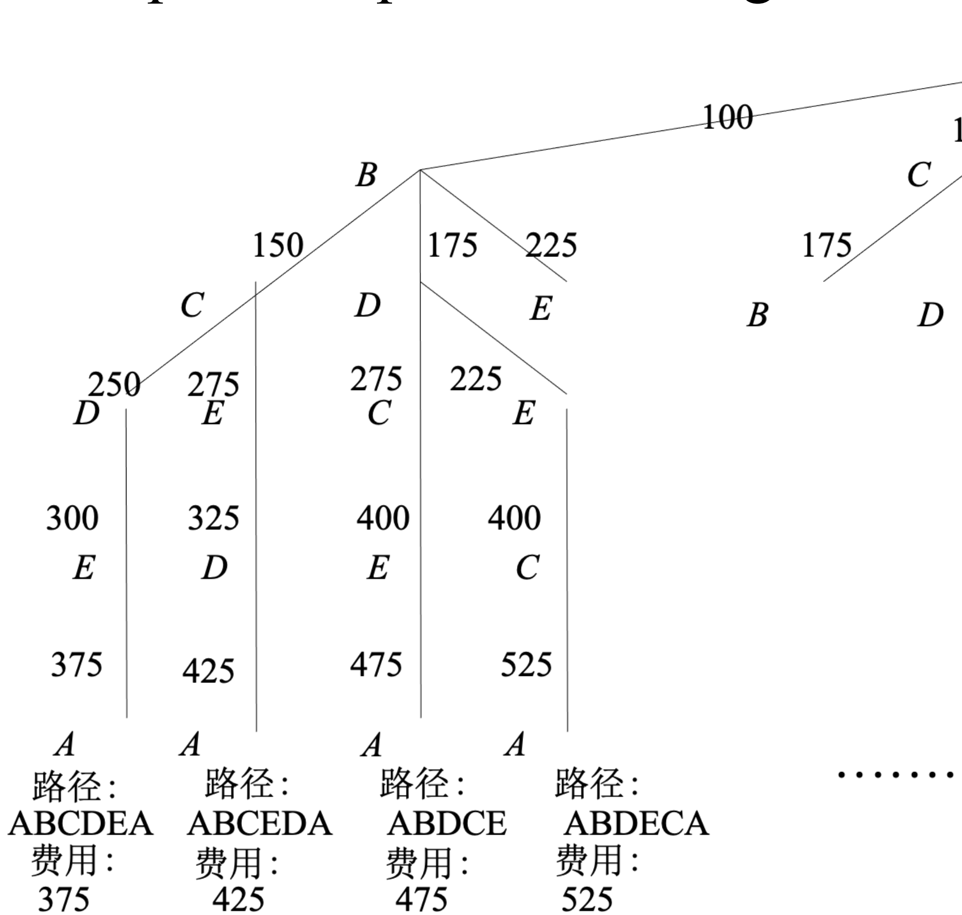


- Possible path: (A,B,C,D,E,A)

1.3 Knowledge Representation & Reasoning

State Space System -- Example 2

- State Space Graph of Traveling Salesman Problem (TSP)



1.3 Knowledge Representation & Reasoning

- What is knowledge representation?
- Propositional Logic
- Production-rule System
- Frame-Based System
- State Space System
- *Knowledge graph*

1.3 Knowledge Representation & Reasoning

Knowledge graph

- 知识图谱旨在以结构化的形式描述客观世界中存在的概念、实体、及其之间的复杂关系------这与Gruber教授在1993年给出的本体知识表示的概念一致。

1.3 Knowledge Representation & Reasoning

Knowledge graph -本体知识表示

- **本体的定义**

  · 本体一词来源于哲学领域。本体论是研究“存在”的科学，即是图解释存在是什么、世间所有存在的共同特征是什么。

  · 借由本体论中的基本元素---概念及概念间的关联，计算机领域产生了本体的知识表示方法。

  · 计算机领域中，本体是指一种“形式化的、对于共享概念体系的明确且详细的说明，本体显示地定义了领域中的概念、关系和公理及其之间的关系。

1.3 Knowledge Representation & Reasoning

Knowledge graph -本体的特征

(1) **概念化** 本体是对客观世界中存在事物或现象以及它们之间关系的概念化抽象;

(2) **精确性** 本体中的概念、关系以及各种约束被精确地定义;

(3) **形式化** 本体表示是为了方便人机交互和计算机推理,因此其定义是形式化且及其可以理解和推理计算的;

(4) **共享性** 本体的表示要建立在领域内的共同认知基础上,可以有效促进知识共享。

1.3 Knowledge Representation & Reasoning

- Knowledge graph -本体的组成

(1) **概念** 也称为类，是某一领域内相同性质对象集合的抽象表示形式。如描述大学领域中本体中，教师、学生和课程等是必要的概念。

(2) **实例** 实例是概念中的特定元素，往往对应客观世界的具体事物。

(3) **关系** 也称属性，是指概念与概念或概念与实例之间的关系类型，如授课关系定义了教师和所教课程之间的关系；

(4) **公理** 公理描述领域内总是成立（为真）的陈述，是对所定义领域规则的描述。

1.3 Knowledge Representation & Reasoning

Knowledge graph

- 知识图谱旨在以结构化的形式描述客观世界中存在的概念、实体、及其之间的复杂关系------这与Gruber教授在1993年给出的本体知识表示的概念一致。

- 知识图谱可以看作本体知识表示在互联网大数据时代的知识表示的一个实际应用

1.3 Knowledge Representation & Reasoning

- Knowledge graph

1.3 Knowledge Representation & Reasoning

- Knowledge graph

1.3 Knowledge Representation & Reasoning

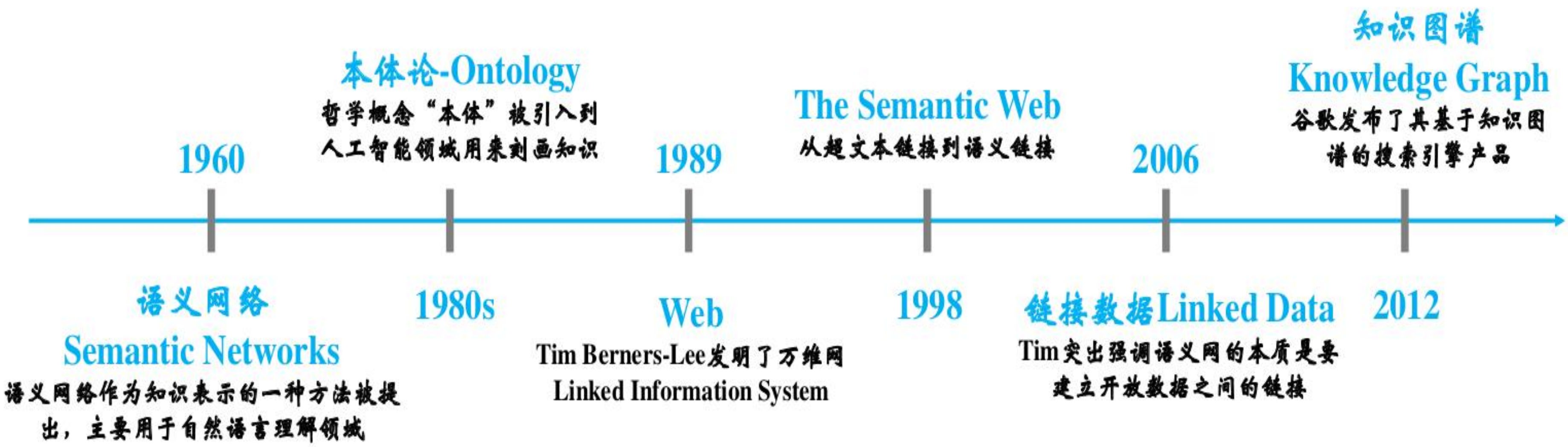
Knowledge graph

- **知识图谱旨在以结构化的形式描述客观世界中存在的概念、实体、及其之间的复杂关系。**
- **概念**　人们在认识世界的过程中形成的对客观事物的概念化表示，如人、计算机、学校
- **实体**　客观世界中的具体事物，如画家达·芬奇、Thinkpad、浙江理工大学
- **关系**　描述概念、实体之间客观存在的关联，如作品描述了蒙娜丽莎和达·芬奇之间的关系，品牌描述了Thinkpad和笔记本之间的关系，毕业院校描述了个人与其所在院校的关系。

1.3 Knowledge Representation & Reasoning

Knowledge graph

- 知识图谱的概念最初由Google于2012年提出，目的是利用网络多源数据构建的知识库来增强语义搜索、提升搜索质量



1.3 Knowledge Representation & Reasoning

Knowledge graph

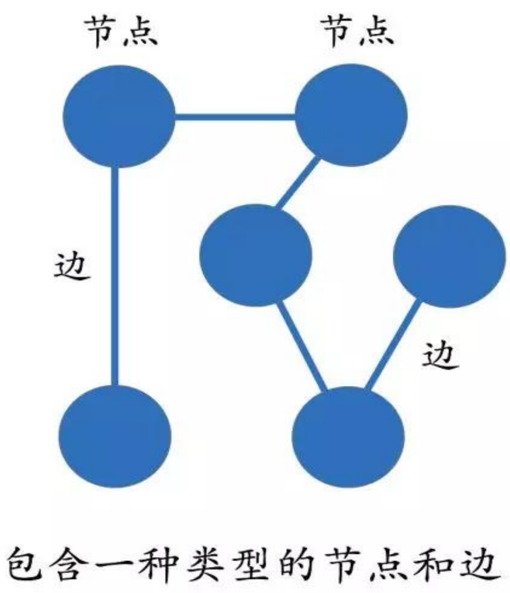
- 从学术的角度，我们可以对知识图谱给一个这样的定义：**“知识图谱本质上是语义网络（Semantic Network）的知识库”**。

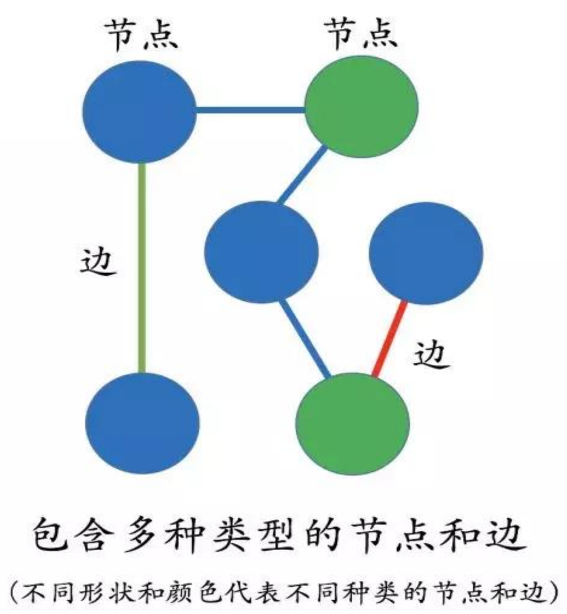
- 从实际应用的角度出发，其实**可以简单地把知识图谱理解成多关系图（Multi-relational Graph）。**

1.3 Knowledge Representation & Reasoning

Knowledge graph

- a multi-relational graph: consist of vertex (节点) and edge (边)
- The vertexes and edges could be different from other vertexes and edges.

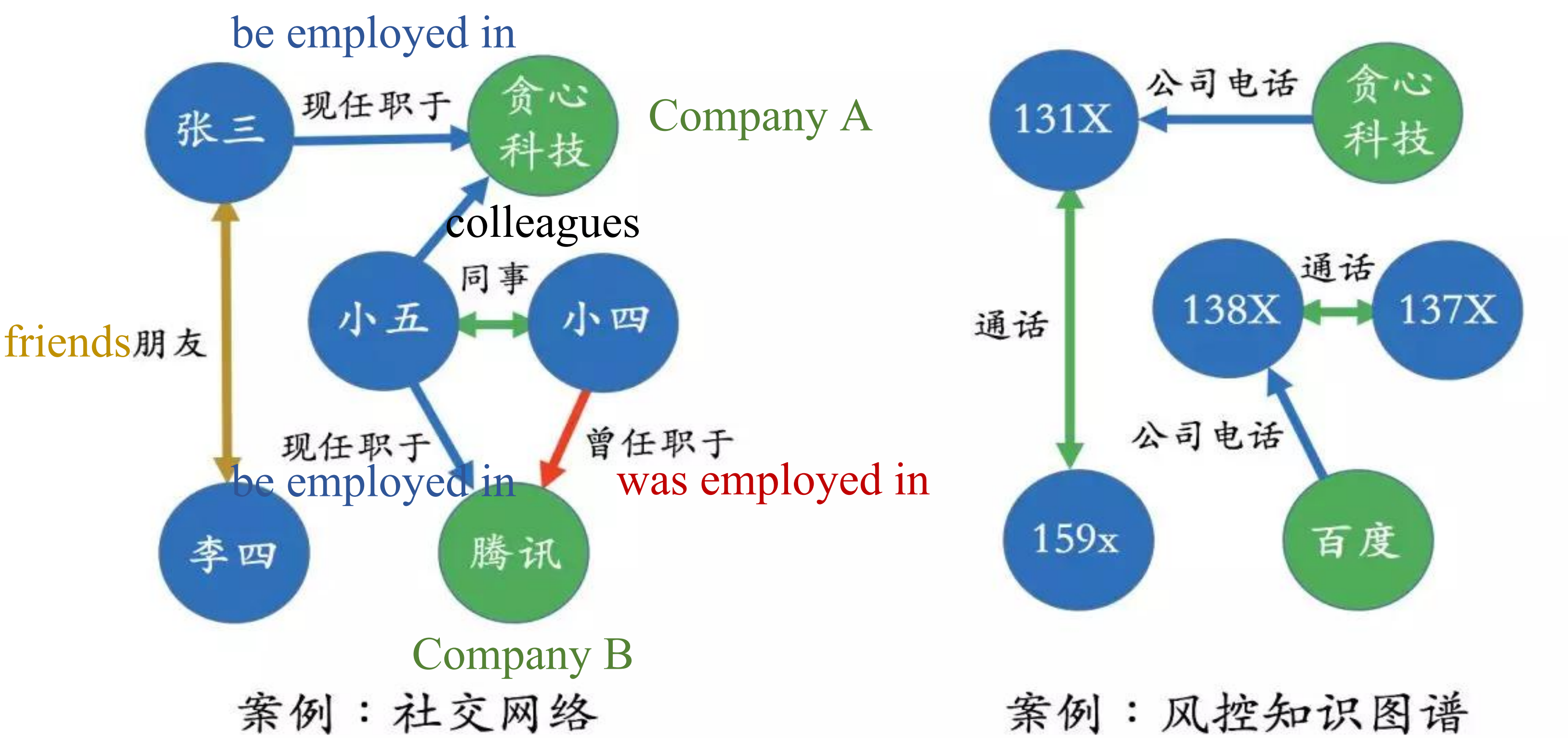




1.3 Knowledge Representation & Reasoning

Knowledge graph

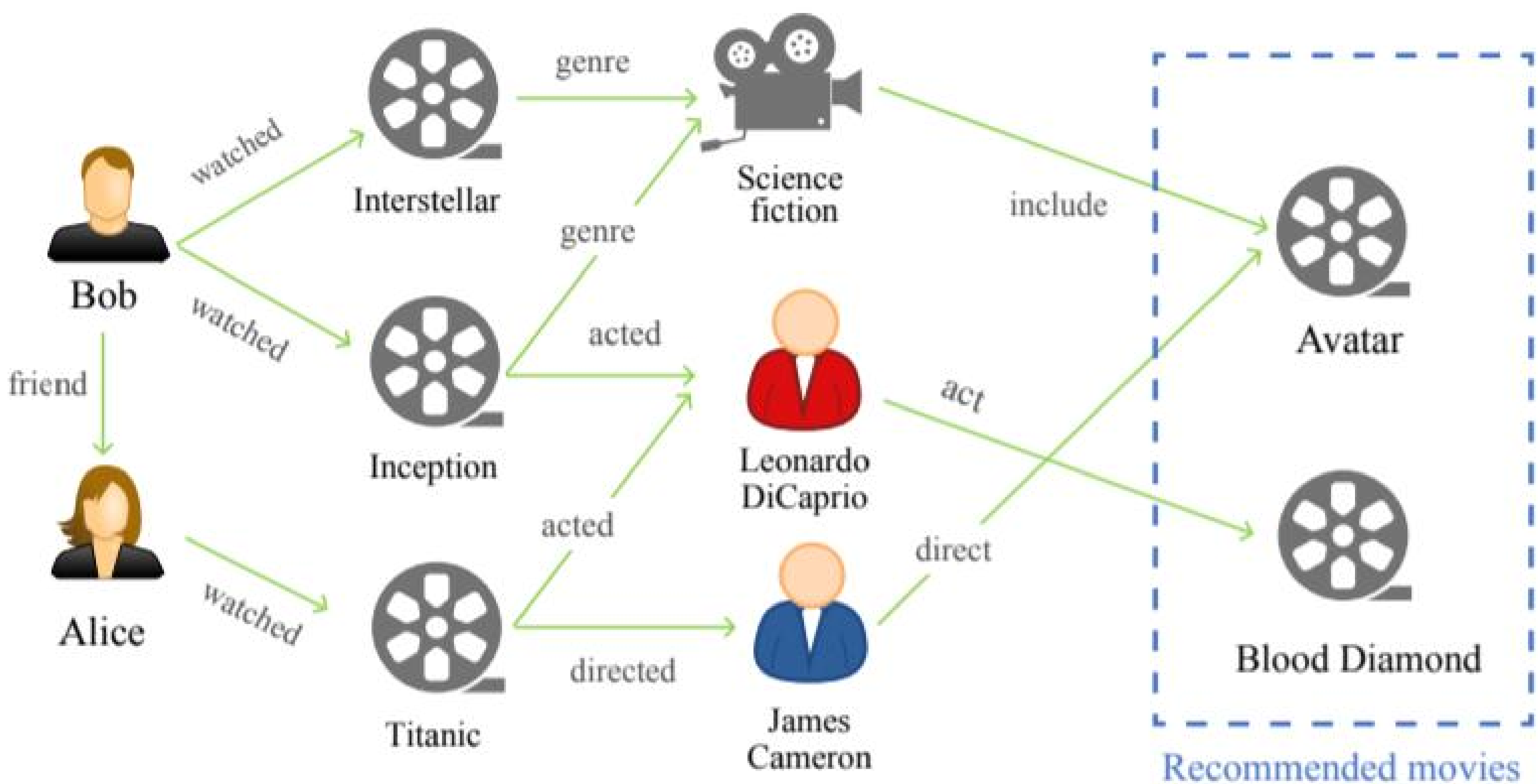
- In knowledge graph, we always use "entity" to represent the vertexes while the 'relation' is used to describe the edges.



1.3 Knowledge Representation & Reasoning

Knowledge graph ---- Example

A sample knowledge graph for movie recommendation task



1.3 Knowledge Representation & Reasoning

Knowledge graph ---- Example

•we can see one KG (movie KG) that not only contains user-item connections (here person-movies) but also user-user interactions and item attributes.

•“Avatar” could be recommended to,

— Bob: as it belongs to the Sci-fi movie same as Interstellar and Inception (which is already watched by Bob)

— Alice: as it is directed by James Cameron (Titanic)

•“Blood Diamond” could be recommended to,

— Bob: as DiCaprio acted in Inception as well

•This simple thought exercise should showcase how a lot of real-world interactions can be easily represented in form of facts using KG. And then we can leverage KG-based algorithms for a downstream use case like generating recommendations.

1.3 Knowledge Representation & Reasoning

Knowledge graph

- 按照知识图谱的覆盖面来看，主要分为：
  - 通用知识图谱
  - 行业知识图谱

1.3 Knowledge Representation & Reasoning

通用知识图谱

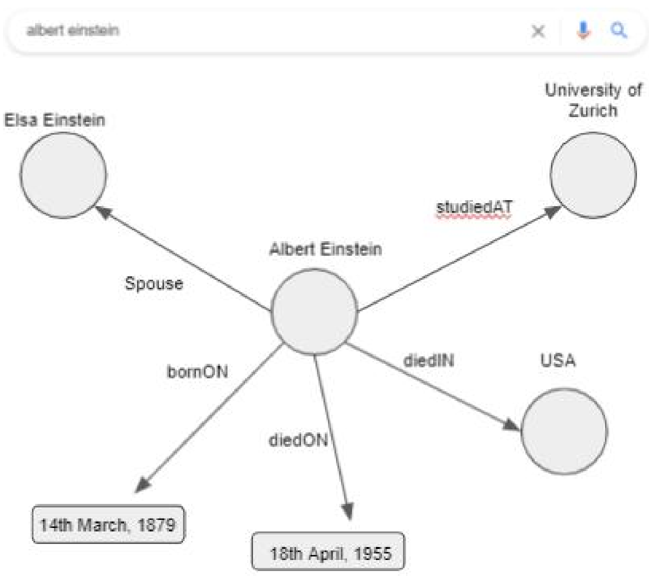
- Google所提出的知识图谱是面向全领域的通用知识图谱
- 通用知识图谱主要应用于面向互联网的搜索、推荐、问答等业务场景
- 通用知识图谱，它强调的是广度，因而强调更多的是实体，很难生成完全的全局性的本体层的统一管理

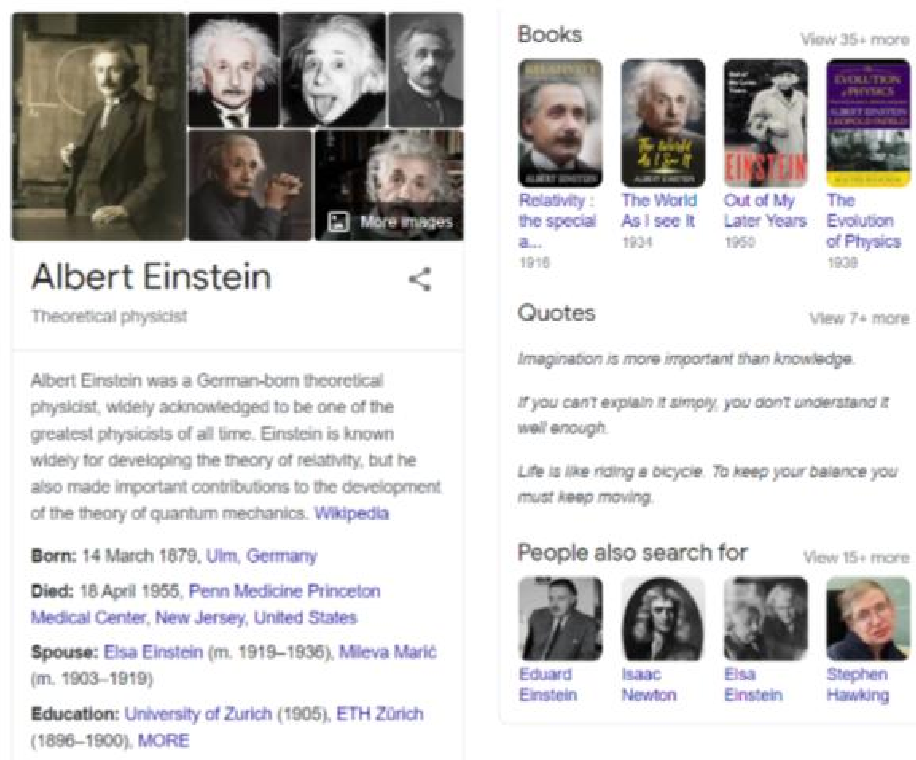
1.3 Knowledge Representation & Reasoning

Knowledge graph

➢Universal knowledge graph

Google Knowledge Panel





1.3 Knowledge Representation & Reasoning

Knowledge graph

- 按照知识图谱的覆盖面来看，主要分为：
  - 通用知识图谱
  - 行业知识图谱

1.3 Knowledge Representation & Reasoning

- **行业知识图谱相对通用知识图谱拥有如下特性：**

· 面向**特定领域**的知识图谱

· 用户目标对象需要考虑行业中各种级别的人员，不同人员对应的操作和业务场景不同，因而需要一定的**深度**与**完备性**。

· 行业知识图谱对准确度要求非常高，通常用于辅助各种**复杂的分析应用**或**决策支持**。

· 有**严格与丰富的数据模式**，行业知识图谱中的实体通常属性比较多且具有行业意义

1.3 Knowledge Representation & Reasoning

行业知识图谱

号称"硅谷最神秘科技公司"的Palantir是行业知识图谱领域的典型代表，其软件允许客户对大量的敏感数据进行语义关联分析，以防止欺诈，确保数据安全等。

http://www.palantir.com

1.3 Knowledge Representation & Reasoning

- **行业数据的特点包括：**

·**数据来源多**：内部数据、互联网数据、第三方数据。

·**数据类型多**：包含结构化、半结构化、非结构化数据，且后两者越来越多。

·**数据模式无法预先确定**：模式在数据出现之后才能确定；数据模式随数据增长不断演变。

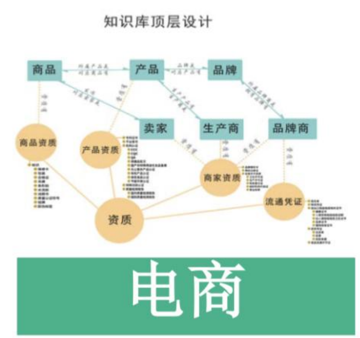
·**数据量大**：在大数据背景下，行业应用的数据的数量通常都以亿级别计算，存在通常在TB、PB级别甚至更多。

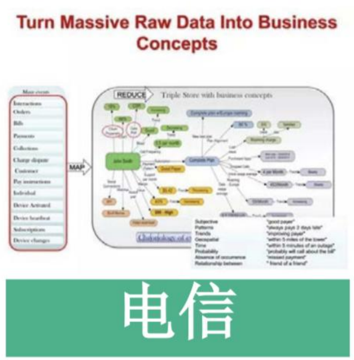
1.3 Knowledge Representation & Reasoning

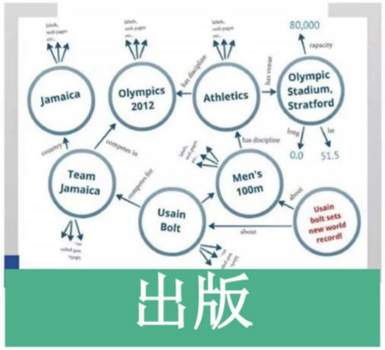
☐ Knowledge graph

➢Domain knowledge graph (行业知识图谱)

Finance biomedical library and information e-commerce







agriculture government Telecommunications publish

1.3 Knowledge Representation & Reasoning

▪ 通用知识图谱vs行业知识图谱

- ✓ 面向通用领域
- ✓ 以常识性知识为主
- ✓ “结构化的百科知识”
- ✓ 强调知识的广度
- ✓ 使用者是普通用户

- ✓ 面向某一特定领域
- ✓ 基于行业数据构建
- ✓ “基于语义技术的行业知识库”
- ✓ 强调知识的深度
- ✓ 潜在使用者是行业人员

1.3 Knowledge Representation & Reasoning

- 思考：在通用知识图谱/行业知识图谱构建过程中需要考虑哪些非技术因素?

1.3 Knowledge Representation & Reasoning

知识图谱使能可解释人工智能

鲨鱼为什么那么可怕？
因为它们是食肉动物

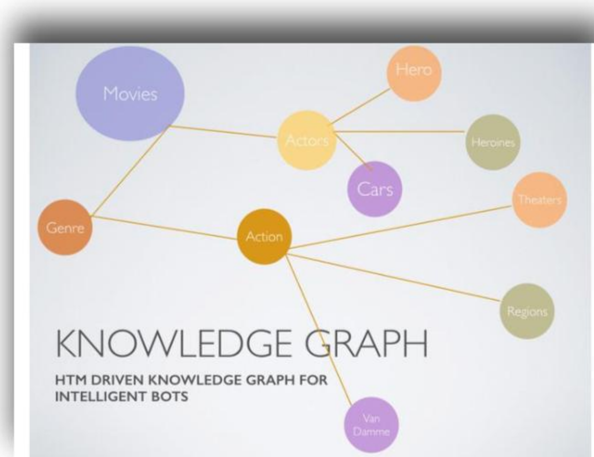
→ 概念

鸟儿为何能够飞翔？
因为它们有翅膀

→ 属性

为什么他们要住在一起?
因为他们是夫妻。

→ 关系



解释取决于人类认知的基本框架；
概念、属性、关系是认知的基石

"Concepts are the glue that holds our mental world together"
--Gregory Murphy

Summary

1. Proposition : A proposition is a declarative sentence that is either true or false.
2. Logical connectives: AND, OR, IMPALICATION, NOT, BICONDITIONAL
3. Truth Table
4. Tautology, Contradiction, Contingency
5. Logically equivalent
6. Predicate Logic
7. Quantification, the universal quantifier & existential quantifier
8. Mixing quantifier
9. Production-rule system
10. Frame-based system
11. State space system
12. Knowledge graph