

# Outline

- Introduction of Abductive Learning  
反绎学习介绍
- Application of Abductive Learning  
反绎学习应用
- Deficiency of Abductive Learning  
反绎学习不足
- Improvement of Abductive Learning  
反绎学习改进



# Introduction of Abductive Learning

- Logical Reasoning and Machine Learning

逻辑推理与机器学习

- Logical Reasoning: Mainly Utilize Knowledge

逻辑推理：知识

- Machine Learning: Employ Evidence and Fact

机器学习：证据与事实

- Human Decision: Based on Knowledge and Factual Evidence

人类决策：基于知识和实证

- In the history of artificial intelligence, logical reasoning and machine learning have developed almost **independently**.

逻辑推理与机器学习几乎是完全**独立发展**。

# Introduction of Abductive Learning

- Logical Reasoning and Machine Learning  
逻辑推理与机器学习

- The main obstacle is:

- 主要的阻碍是：

- ◆ Logical reasoning is generally **based on first-order logical representations**

- 逻辑推理通常**基于一阶逻辑表示**

- ◆ Machine learning is often **based on feature representations**

- 机器学习往往**建立在特征表示的基础上**

# Introduction of Abductive Learning

- Examples of First-order Logical Representations

## 一阶逻辑表示举例

- “Haidilao is a restaurant with a long wait.”

$LongWait(Haidilao) \wedge Restaurant(Haidilao)$

- “Haidilao is the only hotpot restaurant in Montreal.”

$Hotpot(Haidilao) \wedge Restaurant(Haidilao) \wedge Montreal(Haidilao)$

$\wedge \forall x.(Hotpot(x) \wedge Restaurant(x) \wedge Montreal(x)) \Rightarrow x = Haidilao$

- “I do not like a restaurant with a long wait.”

$\forall x.Restaurant(x) \wedge LongWait(x) \Rightarrow \neg Like(x)$

- We can conclude:

*I do not like any hotpot restaurant in Montreal.*

# Introduction of Abductive Learning

- Examples of Feature Representations  
特征表示举例

- “I love speaking French every day! ❤️” (我爱天天讲法语 ❤️)  
*Sentiment Polarity: Positive* (情感极性: 积极)
- “J ‘aime parler français tous les jours! 🥖” (我爱天天讲法语 🥖)  
*Sentiment Polarity: Positive* (情感极性: 积极)
- “Montreal is a French and English-speaking city 🏙”  
(蒙特利尔是一个英法双语城市)  
*Sentiment Polarity: Neutral* (情感极性: 中性)
- “I really love speaking French every day! 😊”  
(我可真爱天天讲法语 😊)  
*Sentiment Polarity: Negative* (情感极性: 消极)

# Introduction of Abductive Learning

- Deductive, Inductive, and Abductive  
演绎, 归纳与反绎

■ Deductive: Starting from **general rules**, draw **a specific and guaranteed conclusion**.

(Theorem Proving)

演绎：从**一般规则**出发，得出一个**有保证的具体结论**。

(定理证明)



# Introduction of Abductive Learning

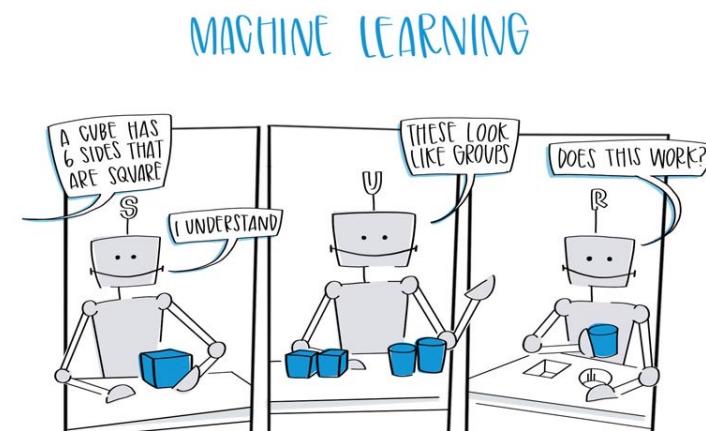
- Deductive, Inductive, and Abductive  
演绎, 归纳与反绎

■ Inductive: Starting from specific **observation phenomena** and obtaining **a generalized conclusion**. The conclusion is **likely to be valid** but **not necessarily accurate**, which reflects accumulated experience.

(Machine Learning)

归纳：从具体**观测现象**出发，获得一个**泛化结论**。它**很可能成立但不一定准确**，所反映的是累积的经验。

(机器学习)

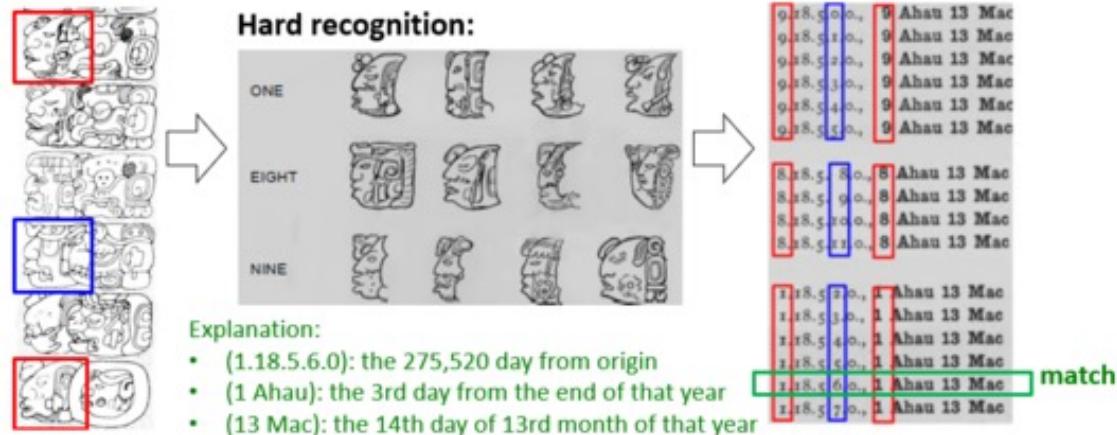


# Introduction of Abductive Learning

- Deductive, Inductive, and Abductive  
演绎, 归纳与反绎

- Abductive: Starting from an **incomplete observation**, hope to obtain the **most likely explanation** for a set of concerns.  
(Abductive Learning)

反绎 : 从一个**不完备的观察**出发, 希望得到一个关于某一个关心集合的**最有可能的解释**。  
(反绎学习)



# Introduction of Abductive Learning

- Deductive, Inductive, and Abductive  
演绎, 归纳与反绎

- Zhou et al. believe that the current development of artificial intelligence technologies emphasizes algorithms, computing power, and data, while **the utilization of knowledge is insufficient.**

周志华教授认为，目前人工智能技术的发展强调算法、算力和数据，而**对知识的利用却不够。**

- Advanced **AI technology** is a seamless **fusion of machine learning and logical reasoning.**

**先进的人工智能技术是机器学习和逻辑推理无缝融合。**

# Introduction of Abductive Learning

- Deductive, Inductive, and Abductive  
演绎, 归纳与反绎

- Humans often solve practical problems **based on the combination of perception and reasoning**, where perception corresponds to the data–driven process through the machine learning, and reasoning belongs to the knowledge–driven process according to the logical reasoning.

人类通常**基于感知和推理的结合**以解决实际问题，其中感知对应通过机器学习实现数据驱动的过程，而推理对应通过逻辑推理实现知识驱动的过程。

# Introduction of Abductive Learning

- Deductive, Inductive, and Abductive  
演绎, 归纳与反绎

- However, in the previous artificial intelligence studies, either the intensity of the machine learning was retained, and the logical reasoning was not fully utilized, or the intensity of the logical reasoning was kept, and the machine learning was not fully implemented, resulting in less outstanding research results.

然而在以往的人工智能研究中，要么保留了机器学习的强度，没有充分利用逻辑推理，要么保留了逻辑推理的强度，没有充分利用机器学习，这些导致研究取得的效果不突出。

# Introduction of Abductive Learning

- Deductive, Inductive, and Abductive  
演绎, 归纳与反绎

- Abductive learning aims to construct a framework that **integrates logical reasoning and machine learning** in a relatively balanced state and synergistically works together.

反绎学习旨在构建一个将**逻辑推理和机器学习**以相对均衡的状态**融合**在一起并协同发挥效用的框架。

- Machine learning requires numerous labelled data, and in the architecture system, logical reasoning will **reduce dependence on labelled data**.

机器学习需要大量的标签数据，而在这个框架系统下，逻辑推理将会**减少对标签数据的依赖**。

# Introduction of Abductive Learning

- Deductive, Inductive, and Abductive  
演绎, 归纳与反绎

- On the one hand, logical reasoning can effectively **utilize domain knowledge**.

一方面, 逻辑推理能够有效地**利用领域知识**。

- On the other hand, logical reasoning can also **improve domain knowledge** by employing data.

另一方面, 逻辑推理也可以通过利用数据来**改善领域知识**。

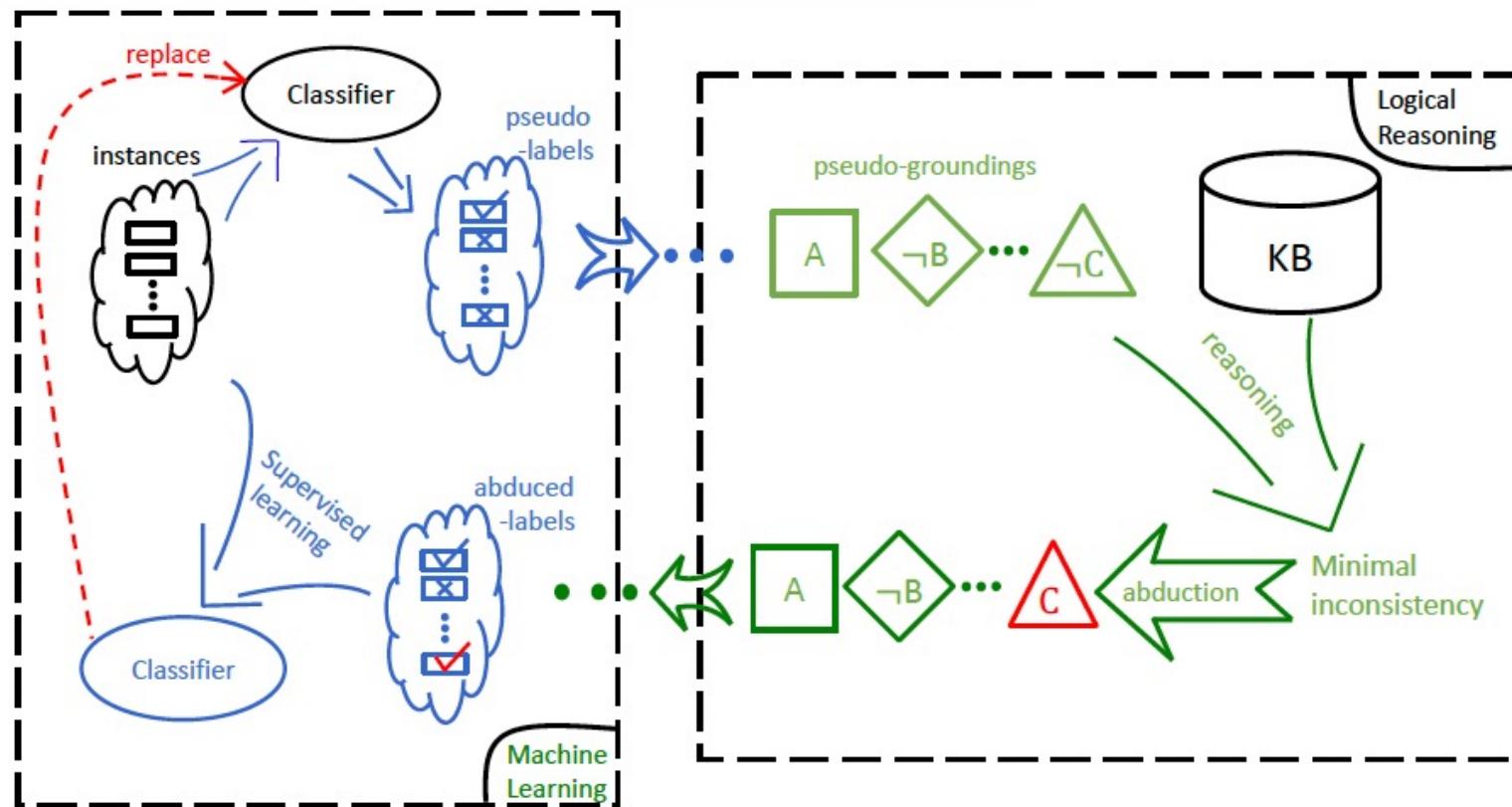
- In the bidirectional way interaction between machine learning and logical reasoning, **new knowledge can be discovered**.

在这种机器学习与逻辑推理的双向互动中, 甚至可以**发现新的知识**。

# Introduction of Abductive Learning

- Abductive Learning

反绎学习



# Introduction of Abductive Learning

- Abductive Learning

反绎学习

- The abductive learning technique consists of three parts:

- ◆ The **background knowledge** represented by first-order logical clauses
- ◆ The **machine learning** perception model
- ◆ The **abductive reasoning** module.

反绎学习方法包括三个部分：以一阶逻辑子句表示的**背景知识**，**机器学习感知模型**和**反绎推理模块**。

# Introduction of Abductive Learning

- Abductive Learning

反绎学习

- Based on the background knowledge of first-order logic, the abductive reasoning module selectively **infers certain facts as well as assumptions** from the original logical facts observed by the machine learning model, and **makes reasonable explanations** for the observed facts, hence **obtaining the final output**.

反绎推理模块根据一阶逻辑背景知识对机器学习模型观察到的原始逻辑事实，有选择地**反绎推理某些事实和假设**，对观察事实**做出合理的解释**，从而得出最终的输出。

# Introduction of Abductive Learning

- Abductive Learning

反绎学习

- The most significant challenge of abductive learning is **the problem of simultaneously training the machine learning model and the logical reasoning module.**

反绎学习最大的挑战是**机器学习模型和逻辑推理模块同时训练的问题。**

- Abductive learning solves the problem of simultaneous training by **utilizing logical reasoning and consistency optimization.**

反绎学习通过**使用逻辑推理和一致性优化**来解决同时训练的问题。

# Introduction of Abductive Learning

- Abductive Learning

反绎学习

- The machine learning model **learns the original logical facts from data** (at this point, the machine learning model may contain incorrect perception of the original logical facts).

机器学习模型**从数据中学习原始逻辑事实**（此时的机器学习模型对原始逻辑事实的感知可能存在错误）。

- The logical reasoning module **abducts the logical facts according to the background knowledge of the logical clauses** to maximize the consistency between the logical facts and the logical knowledge.

逻辑推理模块**根据背景知识逻辑子句对逻辑事实进行反绎推理**，使逻辑事实与逻辑知识之间的一致性达到最大。

# Introduction of Abductive Learning

- Abductive Learning

反绎学习

- Based on the optimization goal of maximizing the consistency of the logical knowledge, **the original logical facts are corrected**, and the corrected logical facts are **returned to the machine learning model and retrained**.

基于逻辑知识的最大化一致性优化目标，**修正原始逻辑事实，将修正后的逻辑事实返回机器学习模型并重新训练。**

- Meanwhile, enhance the background knowledge and improve the performance of machine learning model.

**同时完善背景知识，提高机器学习模型的性能。**

# Introduction of Abductive Learning

## ● Abductive Learning

### 反绎学习

- The abductive learning architecture ensures the effectiveness of collaborative operation between machine learning and logical reasoning.

反绎学习架构保证了机器学习与逻辑推理的协作运行的实效性。

- The machine learning model is equipped with an **initial classifier approach**.

机器学习模块中装有一个**初始分类器**。

- The logical reasoning module contains a **knowledge base mechanism**.

逻辑推理模块中含有一个**知识库装置**。

# Introduction of Abductive Learning

- Abductive Learning

反绎学习

- Under the continuous collaborative operation of both sides, **the result of the initial classifier is completely consistent with the information in the knowledge base**, and the entire process of abductive learning is completed in a real sense.

在两边不断协同运作下，最终使得**初始分类器的结果与知识库的知识完全一致**，整个反绎学习的过程至此真正意义上完成。

- If modifications to the knowledge base are allowed, the information of the entire knowledge base is updated and refined.

如果允许对知识库进行修改，则整个知识库的知识将会得到更新与精化。

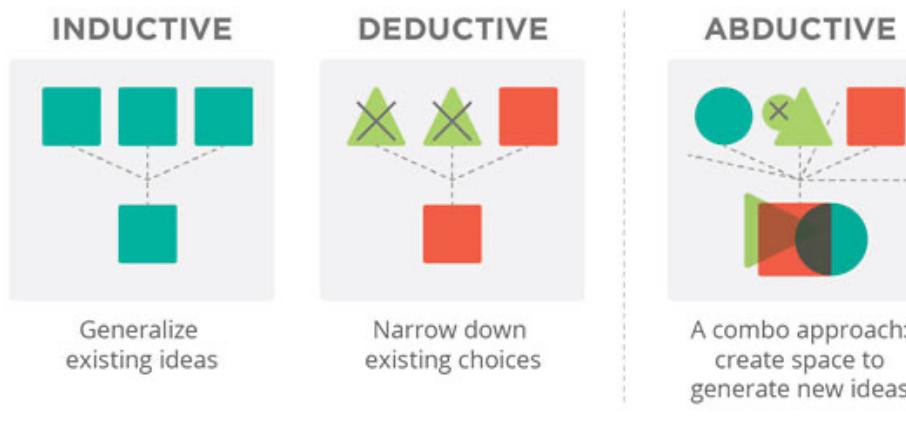
# Introduction of Abductive Learning

- **Abductive Learning**

反绎学习

- In this sense, abductive learning is **open** and able to respond to external modifications promptly, rather than a closed system, which adapts to the needs of the development of artificial intelligence.

在这一意义上，反绎学习是**开放的**，能够实时应对外界的变  
化，不是一个封闭的系统，适应了人工智能发展的需要。



# Introduction of Abductive Learning

- Abductive Learning

反绎学习

- Abductive learning can **infer multiple assumptions as possible explanations** based on observed facts.

反绎学习基于观察到的事实能够**推断出多种假设作为其可能的解释**。

- Complex problems are transformed into **learning tasks**, establishing the goal of maximizing the consistency of optimization, and discovering functions that can infer the incorrect logic based on the original facts.

复杂的问题就转化成为**学习任务**，建立最大化一致性优化目标和寻找一个可以根据原始事实推测出错误逻辑的函数。

# Application of Abductive Learning

## ● Theft Judicial Sentencing

### 盗窃司法量刑

(2015)X刑初字第XX号	案号
贵州省凯里市人民法院刑事判决书(2015)凯刑初字第X号公诉机关贵州省凯里市人民检察院。	法院
被告人王X，男，1996年12月10日出生于X身份证号码：X，苗族，初中文化，农民，住凯里市X。因涉嫌犯盗窃罪，于2014年11月16日被刑事拘留……。	被告人信息
经审理查明，2014年11月15日15时许，被告人王X同包X窜至……，将被害人兰X的……盗走。被盗摩托车已发还给被害人。	案情描述
上述事实，被告人王X在庭审过程中亦无异议，并自愿认罪，……。本院认为，被告人王X以非法占有为目的……，构成盗窃罪。庭审中，被告人王X能如实供述其犯罪事实……，可对其酌情从轻处罚。	判决要素
据此，依照《中华人民共和国刑法》第二百六十四条、第十七条第一款……、第五十三条之规定，	涉及法条
判决如下：被告人王X犯盗窃罪，判处有期徒刑六个月，处罚金人民币2000元。	刑期、罚金

*Example of the structure of an adjudication document.*

# Application of Abductive Learning

- Theft Judicial Sentencing

## 盗窃司法量刑

被告人代X伙同“老雷”窜至XX县XX镇XX路被害人吴X家，使用工具将大门打开后，二人窜入被害人吴X家二楼房间行窃。

被告人代X窜至被害人吴X的屋内用事先准备好的剪刀将被害人吴X家卧室的挂锁撬坏，进入房间内将挂在门后的人手提包内的人民币3650元现金盗走。Label: [tool, indoor]

*Example of the case description fragment.*

# Application of Abductive Learning

- Theft Judicial Sentencing

盗窃司法量刑

- The adjudication documents contain **high-density** distribution of sentencing circumstances and are described in various ways.  
裁判文书包含了**高密度**分布的量刑情节，并且描述方式多样。
- With the support of only annotated information, once the model lacks the ability to represent sentence-level semantic information and logical reasoning capability, it is difficult to **capture the characteristics of the sentencing plot while considering the logical relationships between circumstances.**  
在仅有标注信息的支撑下，一旦模型缺乏表征句子级别语义信息的能力以及逻辑推理能力，就很难**在捕捉量刑情节特征的同时兼顾情节间的逻辑关系。**

# Application of Abductive Learning

- Theft Judicial Sentencing

盗窃司法量刑

- Training is extremely difficult due to the **lack of labelled data batches in specialized areas.**

由于**专业领域标注数据批的缺乏**，训练变得极其困难。

- The **existence of numerous domain knowledge** hopes that the system can employ inference to constrain the fitting of the model so that the recognition result is more in line with the actual process.

**大量领域知识的存在**希望模型能够利用推理去约束模型的拟合，使识别结果更符合实际流程。

# Application of Abductive Learning

- Theft Judicial Sentencing

盗窃司法量刑

- Proposed a learning technique that can effectively improve the quality of labels.

提出一种能**有效提高标签质量**的学习方法。

- By utilizing the characteristics of sentencing circumstances appearing multiple times in different descriptions in the text content and the logical relationship between sentencing circumstances in the adjudication documents.

利用裁判文书中量刑情节以不同描述方式，且多次出现在文本中的特性，以及量刑情节间的逻辑关系。

# Application of Abductive Learning

- Theft Judicial Sentencing

盗窃司法量刑

- Aim to evaluate the credibility of identifying sentencing circumstances based on the quality issues of the labels themselves and combined with **abductive learning**.

针对标签本身的质量问题，结合**反绎学习**来评估量刑情节识别的可信程度。

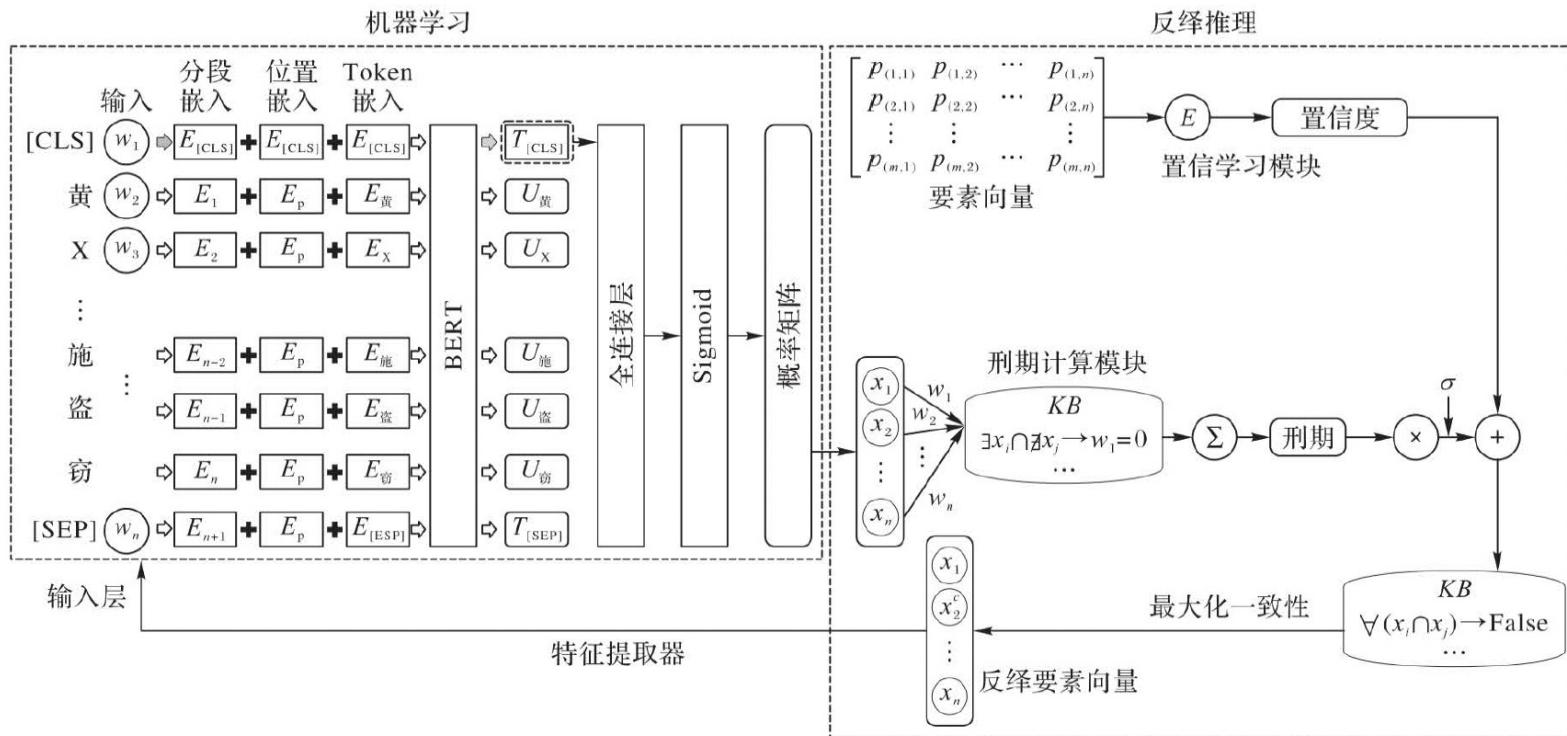
- To represent incorrect labels and correct them, thereby effectively improving the quality of the labels.

以此来表征错误的标签并修正，从而有效提高标签的质量。

# Application of Abductive Learning

- Theft Judicial Sentencing

盗窃司法量刑



*Model framework of sentencing circumstance recognition in adjudication documents based on abductive learning.*

# Application of Abductive Learning

## ● Theft Judicial Sentencing

### 盗窃司法量刑

案情描述	涉及量刑情节	情节说明
本案中,涉案赃物已发还被害人,被告人自愿认罪并取得被害人谅解,依法可从轻处罚	no_damage attitude forgive	被告人具有“退赔、认罪、取得谅解”情节
被告人刘X入户盗窃、为吸毒而盗窃,有前科一次,均应酌情从重处罚;被告人刘X能在庭审中自愿认罪,应依法从轻处罚	indoor attitude again	被告人具有“入户盗窃、认罪、累犯”情节

*Examples of description of sentencing circumstances in adjudication documents*

逻辑描述	规则	说明
“入户”盗窃是指以非法占有为目的,进入他人生活的与外界相对隔离的住所实施盗窃的行为;“扒窃”是在公共场所或者公共交通工具上盗窃他人随身携带的财物	$\exists(\text{indoor} \cap \text{theft}) \rightarrow \text{False}$	由于“入户”“扒窃”的场景没有交集,在单次盗窃中,两种情节不共存

*Part of sentencing circumstances rules*

# Application of Abductive Learning

## ● Theft Judicial Sentencing

### 盗窃司法量刑

Domain knowledge for calculating the punishment in sentencing:

```
penalty(X, Y) ← base_penalty(X, Z1) ∧ weight(X, Z2) ∧ Y = Z1(1 + Z2).  
base_penalty(X, Y) ← money(X, m) ∧ Y = 0.7m + 5.7.  
weight([], 0) ←  
weight([X|Xs], Y) ← element_weight(X, Z1) ∧ weight(Xs, Z2) ∧ Y = Z1 + Z2.
```

Punishment weights for different sentencing elements:

<i>element_weight(recidivism, 29%).</i>	<i>element_weight(confession, -11%).</i>
<i>element_weight(pickpocket, 14%).</i>	<i>element_weight(burglary, 3%).</i>

*Sample sentence rules in the knowledge base.*

# Application of Abductive Learning

## ● Theft Judicial Sentencing

### 盗窃司法量刑

规则：

(大部分规则根据《刑法》及《最高人民法院、最高人民检察院关于办理盗窃刑事案件适用法律若干问题的解释》得到)

盗窃金额	刑期
数额较大 (起点: 一千) or 入户盗窃 or 扒窃	三年以下
数额巨大 (起点: 三万) or 其他严重情节	三年以上十年以下
数额特别巨大 (起点: 三十万) or 其他特别严重情节	十年以上

- 曾因盗窃受过刑事处罚 → “数额较大” 标准可以按照规定的百分之五十确定
- 入户盗窃数额达“数额巨大”百分之五十的 → 可以认定为“其他严重情节”
- 入户盗窃数额达“数额特别巨大”百分之五十的 → 可以认定为“其他特别严重情节”
- 未成年人 or 自首 → 从轻处罚或减轻处罚 (在法定量刑幅度的下一个量刑幅度内处罚)
- 自首 → 认错态度好
- 入户盗窃与扒窃不可能同时发生
- 没有关键词“自首” → 没有自首
- .....

} 由常识及法律定义得到

} 匹配规则

*Sample sentence rules in the knowledge base.*

# Application of Abductive Learning

## ● Theft Judicial Sentencing

### 盗窃司法量刑

#### 案例分析

被告人江某，男，…

xx检察院指控：2018年4月x日下午1点左右，被告人江某到xx小卖部买烟和水时，发现收银台上放得有一部玫瑰金vivoX9手机，江某趁人不备将该手机盗走。经认定：被盗手机价格为人民币1598元。现该手机已追回并发还被害人。本院认为，…江某归案后如实供述其犯罪事实，有坦白情节，…判决如下：  
被告人江某犯盗窃罪，判处有期徒刑七个月，并处罚金人民币一千元。

真实刑期：7个月

预测刑期：5.6个月

被告人石某，男，…

公诉机关指控，2018年4月x日15时许，被告人石某在xx大药房买药时，趁被害人吴某不注意，将其摆放在收银台处的一部黑色iPhone8智能手机盗走…被盗手机价值人民币4625元。经审理查明，…已将被盗手机追回发还被害人吴某。被告人石某…当庭认罪、悔罪。  
本院认为，…判决如下：  
被告人石某犯盗窃罪，判处拘役三个月，并处罚金人民币2000元。

真实刑期：3个月（可能偏轻）

预测刑期：7.1个月

*Results in the experiments.*

# Application of Abductive Learning

## ● Theft Judicial Sentencing

### 盗窃司法量刑

#### 案例分析

被告人李某，男，…因犯盗窃罪于2017年11月x日被判处有期徒刑六个月…

经审理查明，2018年9月x日凌晨4时许，被告人李某到xx网咖上网…趁被害人熟睡之机，将其放在左侧裤子口袋内的一部VIVO Y55手机盗走…经鉴定，被盗VIVO Y55手机价值人民币1080元…

本院认为，…被告人李某归案后如实供述犯罪事实，认罪认罚，系坦白…判决如下：

被告人李某犯盗窃罪，判处有期徒刑七个月，并处罚金人民币1000元。

真实刑期：7个月

预测刑期：8.5个月

被告人蒋某，男，…2018年2月x日因犯盗窃罪被判处有期徒刑六个月…

经审理查明：2018年5月x日16时许，被告人蒋某在xx店门口扒窃被害人王某的一个粉红色钱包，包内有现金600余元人民币及银行卡等物品…上述事实，被告人蒋某在开庭审理过程中不持异议，并自愿认罪…

本院认为…判决如下：

被告人蒋某犯盗窃罪，判处有期徒刑一年，并处罚金3000元。

真实刑期：12个月（可能偏重）

预测刑期：8.1个月

*Results in the experiments.*

# Application of Abductive Learning

## ● Theft Judicial Sentencing

### 盗窃司法量刑

#### 案例分析

##### 刑期可能偏重案例

被告人夏某，男，…因犯盗窃罪于2017年6月x日被判处有期徒刑一年零三个月…

公诉机关指控，2018年11月x日凌晨，被告人夏某在xx区，将龚某家1对母牛盗走。当日10时许，夏某在xx镇欲将所盗黄牛卖与他人时被发现，弃牛逃跑。被盗黄牛已由xx区公安局发还龚某。经认定，龚某家被盗黄牛价值人民币8250元。被告人夏某于2018年11月x日自动到公安局投案，如实供述了自己的罪行。…

本院认为…判决如下：

被告人夏某犯盗窃罪，判处有期徒刑一年四个月，并处罚金人民币二千元。

真实刑期：16个月

预测刑期：10.6个月

*Results in the experiments.*

# Application of Abductive Learning

## ● Theft Judicial Sentencing

### 盗窃司法量刑

#### 案例分析

##### 刑期可能偏重案例

被告人全某，男，... 2014年1月x日因犯盗窃罪被本院判处有期徒刑三年...

公诉机关指控：2019年3月x日4时许，被告人全某在xx以推门入室的方式进入被害人郑某的家中，将被害人郑某放置在厨房的食用菜油5斤、食用猪油3斤、火腿肠一根窃走。经鉴定，被盗食用菜油5斤、食用猪油3斤合计价值人民币54元...

本院认为... 判决如下：

被告人全某犯盗窃罪，判处有期徒刑十个月，并处罚金人民币1000元。

真实刑期：10个月

预测刑期：8个月

*Results in the experiments.*

# Application of Abductive Learning

## ● Theft Judicial Sentencing

### 盗窃司法量刑

#### 案例分析

##### 刑期可能偏重案例

被告人周某，男，… 2015年10月x日因犯盗窃罪被判处有期徒刑二年…

公诉机关指控，2018年5月x日4时许，被告人周某在本市xx巷子里，将被害人杨某停放在路边的黑色越野车副驾驶右后车窗用钢筋撬碎后潜入车内，将副驾驶箱子里的两个红包内的现金人民币700元盗走。… 庭审中，被告人周某对起诉指控的事实无异议…

本院认为… 判决如下：

被告人周某犯盗窃罪，判处有期徒刑一年二个月，并处罚金人民币二千元。

真实刑期：14个月

预测刑期：7.3个月

*Results in the experiments.*

# Application of Abductive Learning

## ● Theft Judicial Sentencing

### 盗窃司法量刑

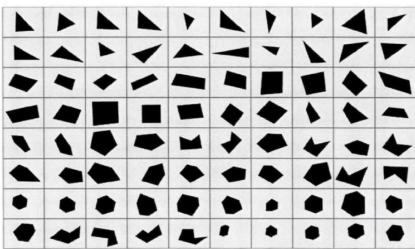
基准刑 = 0.64m+6 (m: 盗窃总金额, 单位: 千元)	
加刑减刑规则	加刑减刑规则
If 累犯 then 基准刑+27%	If 自首 then 基准刑-10%
If 扒窃 then 基准刑+15%	If 得到被害人谅解 then 基准刑-14%
If 入户盗窃 then 基准刑+6%	If 认错态度好 then 基准刑-14%
If 未成年 then 基准刑-15%	If 赃物已追回发还 then 基准刑-7%

*Example of sentence calculation rules.*

- It is interpretable, easy to understand and check.  
具有可解释性，容易理解与检查。
- Provide interpretable assistance to judicial decisions.  
给司法判决带来具有可解释的帮助。

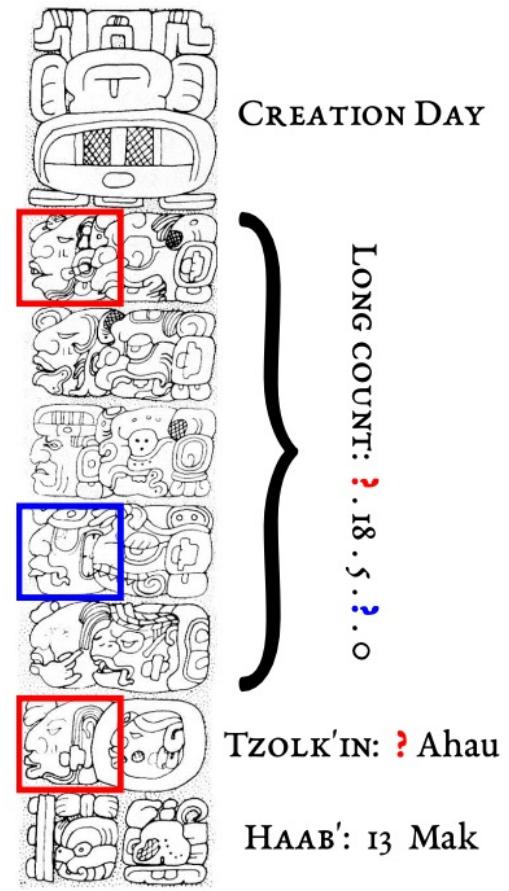
# Application of Abductive Learning

- Quality Monitoring of Table Tennis Swing  
乒乓球挥拍质量监测
- Handwritten Character Recognition  
手写字符识别
- Polygon Concept Learning  
多边形概念学习
- Interpretation of Maya Scriptures  
玛雅经文解读



1	3	9	6	1					
0	8	6	9	8					
9	2	0	2	0					
3	7	6	9	3					

1	-	-	7	0					
7	1	0	1	1					
7	-	1	0	-					
1	0	1	0	1					



# Deficiency of Abductive Learning

- Quality Monitoring of Table Tennis Swing → Sports Rules  
乒乓球挥拍质量监测 → 体育规则
- Handwritten Character Recognition → Standard Dictionary  
手写字符识别 → 规范词典
- Polygon Concept Learning → Polygon Shape Definition  
多边形概念学习 → 多边形形状定义
- Interpretation of Maya Scriptures → Mayan Script Archives  
玛雅经文解读 → 玛雅文字档案
- Theft Judicial Sentencing → Laws and Regulations  
盗窃司法量刑 → 法条法规
- All the above studies require **strict one-on-one definitions or regulations as constraints.**  
以上所有研究均需要**严格的一对一的定义或规范作为制约。**

# Deficiency of Abductive Learning

- However, many research fields in reality **do not have this constraint.**

然而在现实中的诸多研究领域均不具备此约束。

- Natural Language Processing

自然语言处理

- Computer Vision

计算机视觉

- This leads to limitations in the research field that abductive learning can explore.

这导致了反绎学习所能研究领域的受限。

# Deficiency of Abductive Learning

- Example: Sentiment Analysis in Natural Language Processing  
例如，在自然语言处理中的情感分析问题：
  - “**Happy**” can be positive, neutral, and negative.  
“**开心**”一词可以为积极，中性，甚至消极多重定义。
- Positive: I am very **happy** to see you!  
积极：我跟**开心**见到你！
- Neutral: This is my border collie, and her name is **Happy**.  
中性：这是我的边牧，她的名字叫**开心**。
- Negative: I ‘m only **happy** when the Earth explodes!  
消极：只有地球爆炸我才**开心**

# Deficiency of Abductive Learning

- Abductive learning eliminates the manpower and material resources required to process massive labelled data.  
反绎学习省去了处理海量标签数据的人力与物力。
- However, abductive learning requires **comprehensive knowledge bases related to research fields**, such as the knowledge base of laws as well as regulations, the knowledge base of Maya scriptures, etc., which require enormous experts with relevant domain experience and knowledge to design and construct them specifically.  
然而反绎学习**需要领域相关的完备知识库**，如法条法规知识库，玛雅经文知识库等，需要大量具有相关领域经验及知识的专家进行专门设计与构建。
- The quality of experimental results greatly depends on the completeness of the knowledge base.  
实验结果的质量极大依赖于知识库的完备程度。

# Improvement of Abductive Learning

## ● Abductive Reasoning

溯因推理

