Logical Reasoning Styles and Their Applications

Jacqueline Mitchell (CSCI 698 Teaching Video)

Three Statements

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If x > 0, then y = x + 1 is definitely greater than 0.

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Q: What is the **structural** difference between these statements?

How are these Statements Different?

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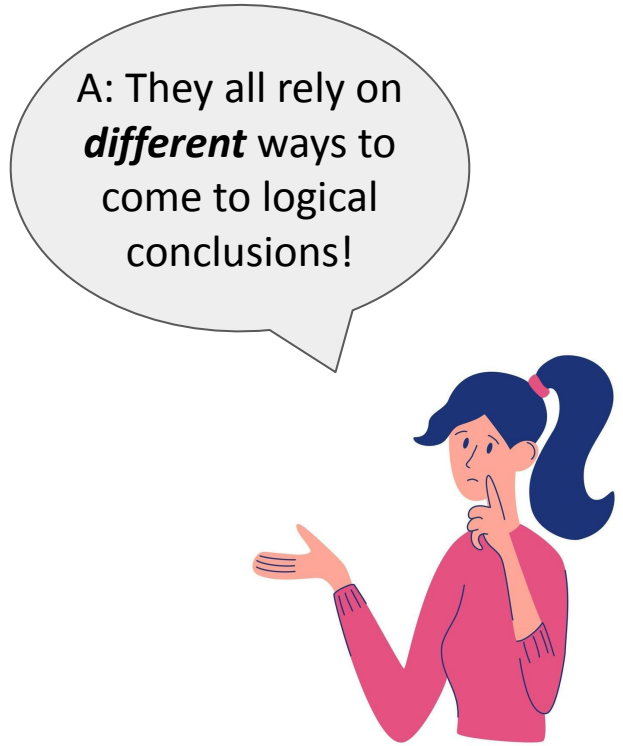

Why is Classifying Reasoning Important?

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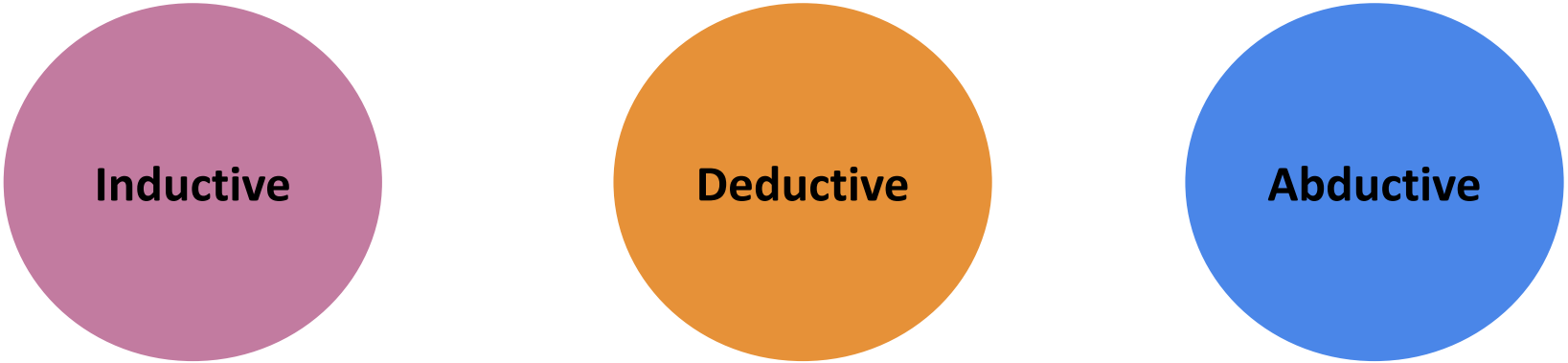
Different logical reasoning styles underpin many logical processes in CS

Our Roadmap

Three Types of Reasoning



Inductive Reasoning

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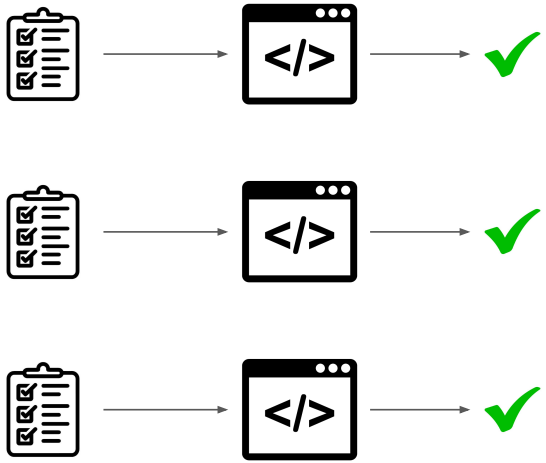

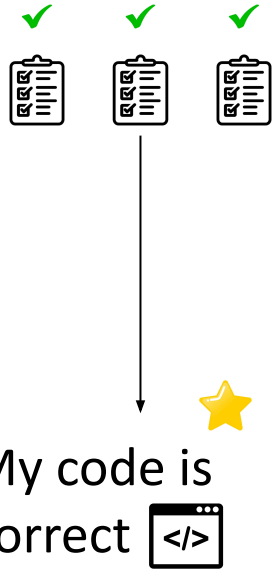

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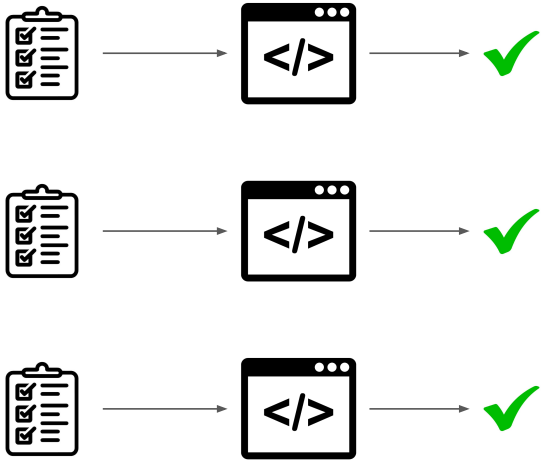

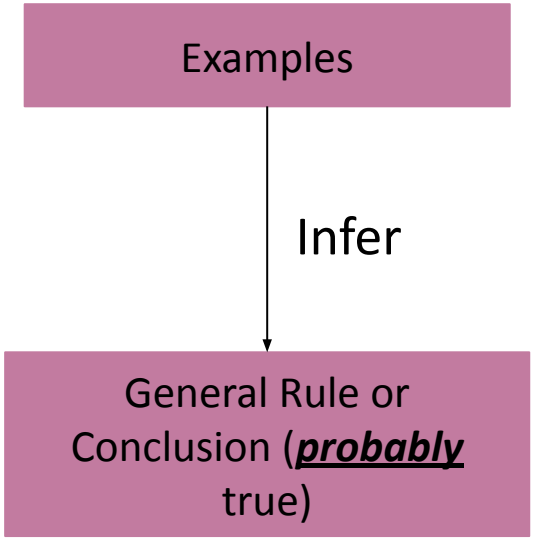

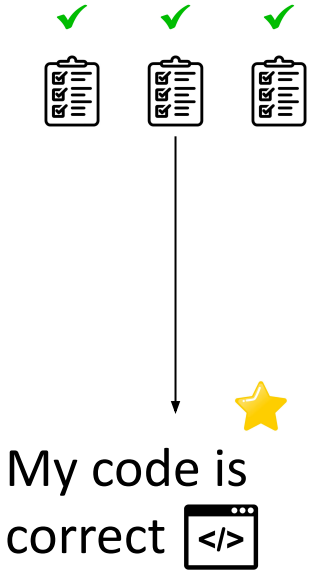

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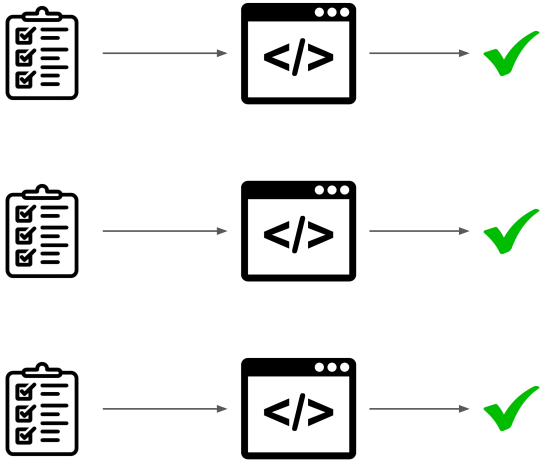
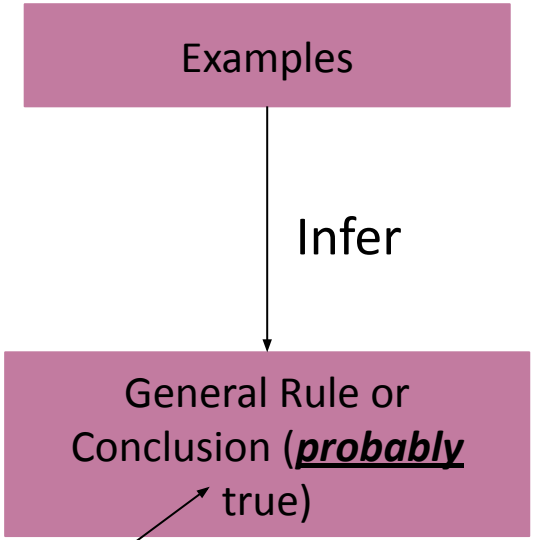
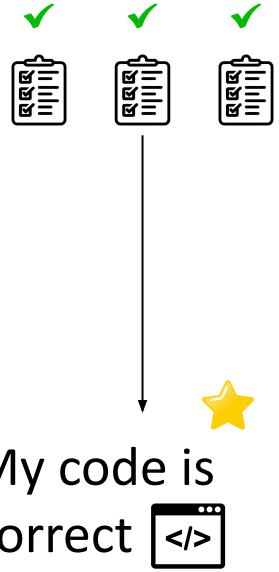
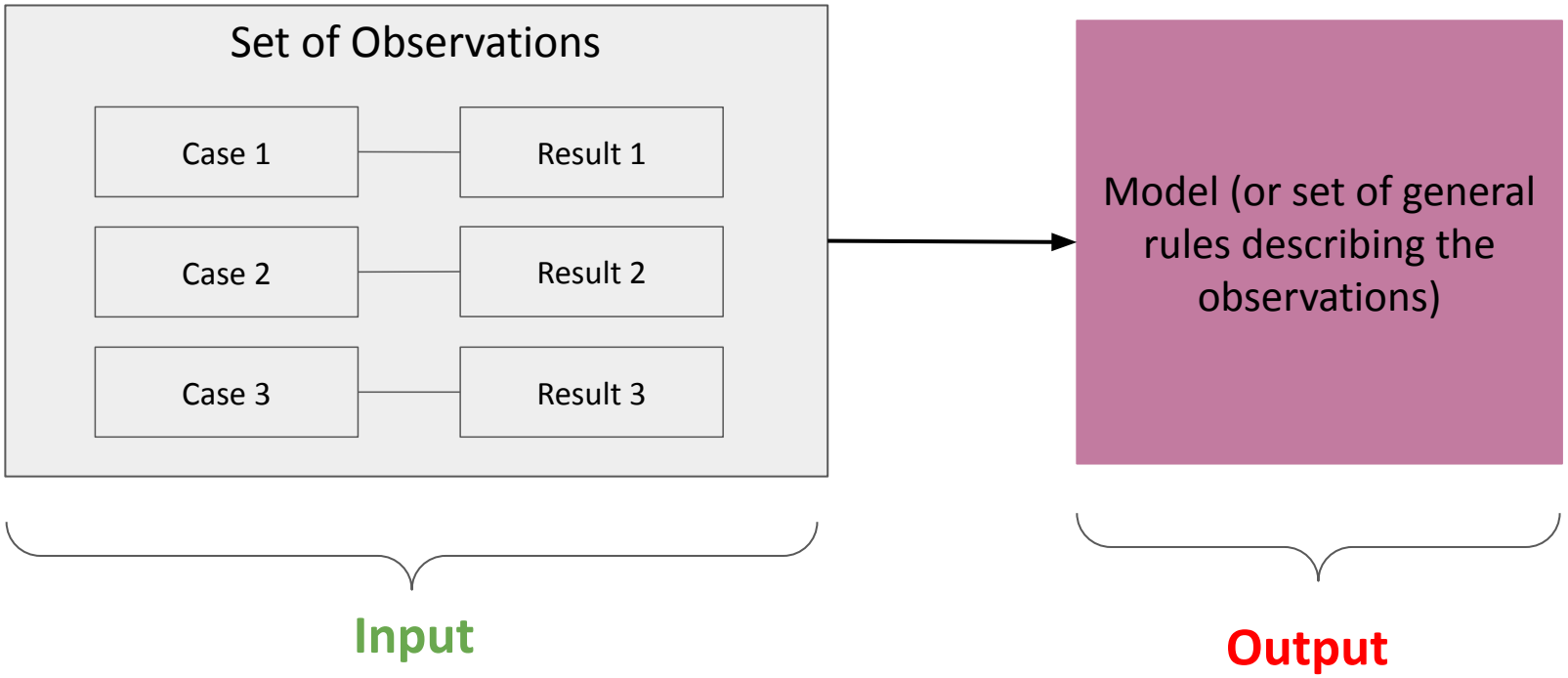






Need not be true! (There could be some failing test case)

(More Generally) Inductive Reasoning



Examples of **Inductive** Reasoning in Computer Science

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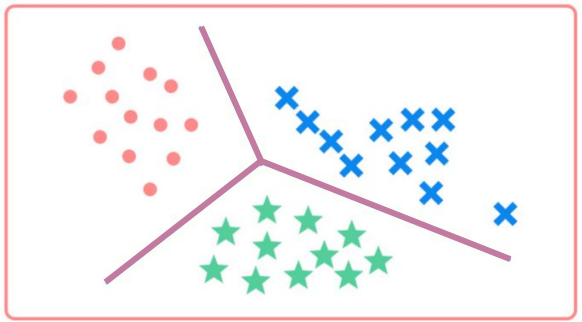
Machine Learning →
Supervised Learning



Supervised learning

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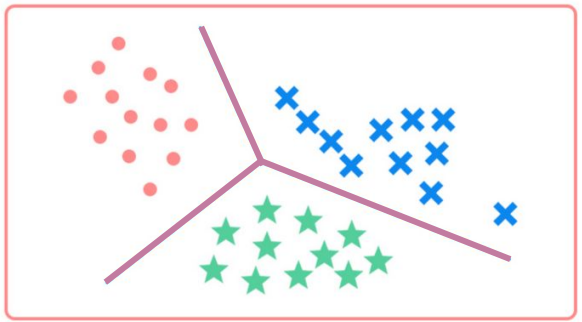
Machine Learning → Supervised Learning



Supervised learning

Inductive Logic Programming

Existing Knowledge

```
parent(alice, bob)
parent(bob, charles)
```

Examples

Positive

```
grandparent(alice, charles)
```

Negative

```
grandparent(bob, charles)
```

```
grandparent(X, Y) :- parent(X, Z), parent(Z, Y)
```

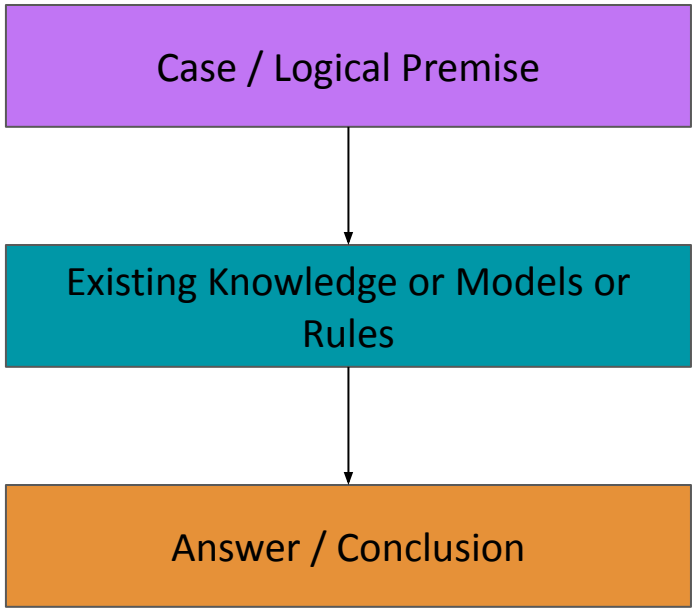
Deductive Reasoning

If x > 0, then y = x + 1 is definitely greater than 0.

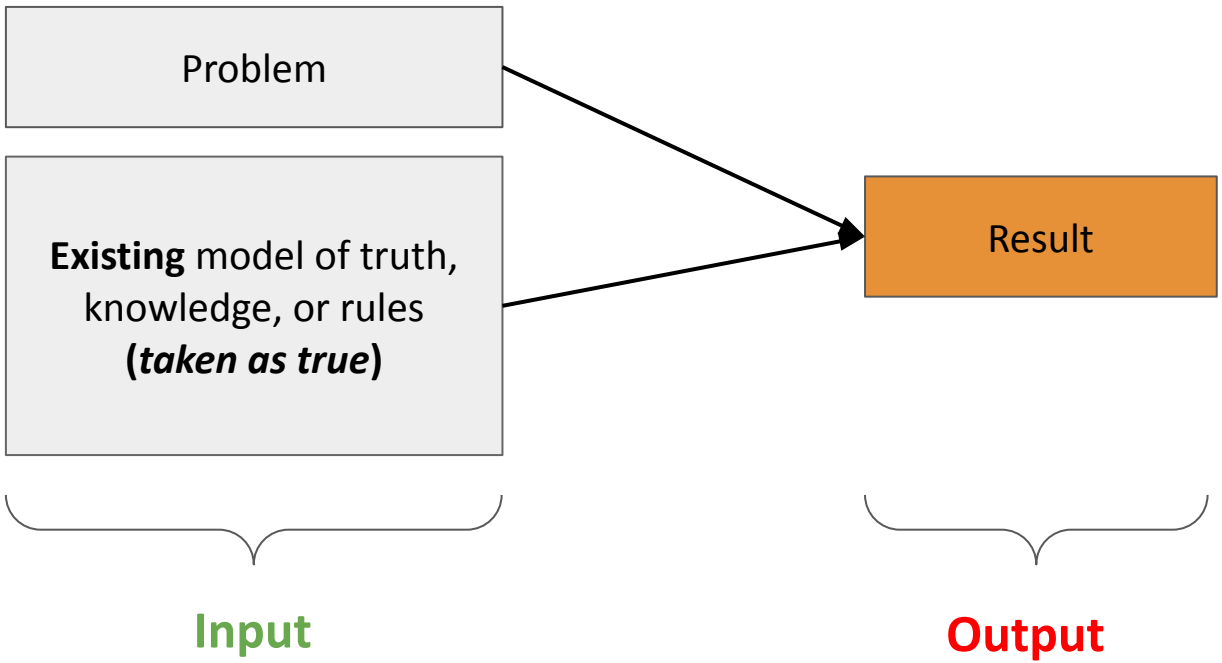
We assume that x > 0.

Based on this, we want to know the sign of y = x + 1.

We use the mathematical properties of real numbers to **infer that y > 0**, because we're adding a positive number to another positive number



(More Generally) **Deductive** Reasoning



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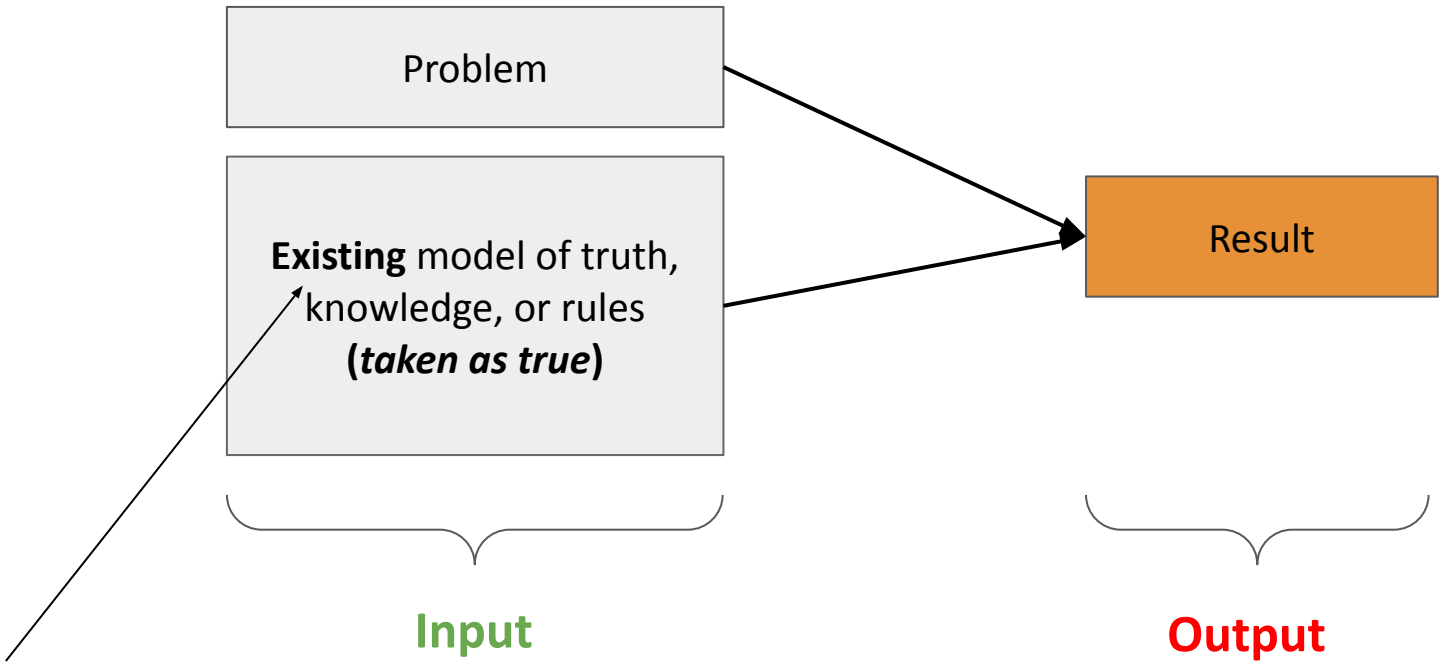

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Logic Programming

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parent(alice, bob)
parent(bob, charles)
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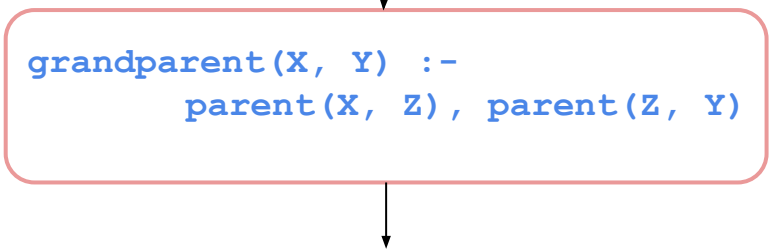

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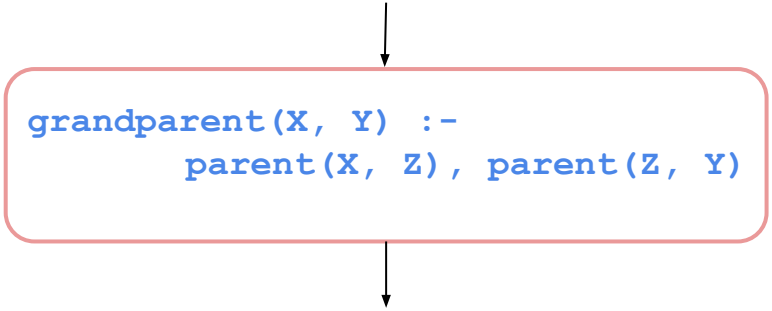

```
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```



```
grandparent(alice, charles)
```

Hoare Logic

```
Program P:   x := x + 1
```

Goal: Prove {x=n} P {x = n+1}

{x+1=n+1} P {x = n+1}

x = n ⇒ x + 1 = n + 1

{x=n} P {x = n+1}

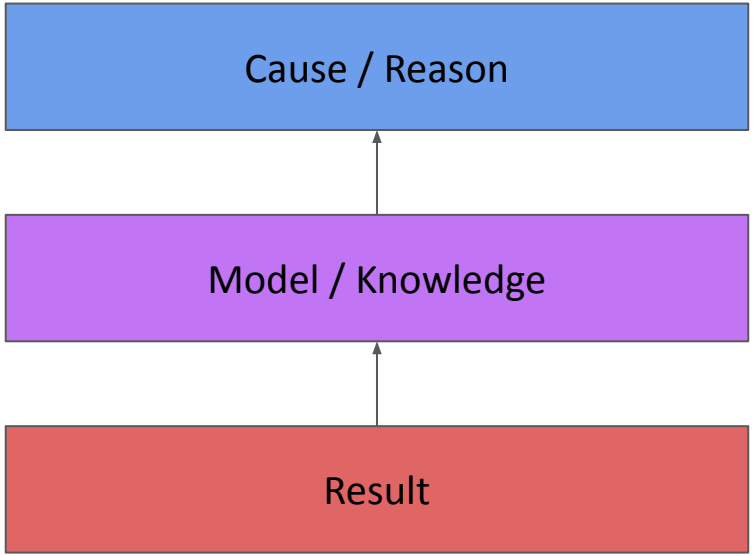
We deduced our goal (with Hoare logic + arithmetic)

Abductive Reasoning

The program crashed after I changed this line of code, so that must be the bug.

My program crashed, after I changed line 10!

Based on my experience as a programmer (and the compiler), the bug must be on line 10.



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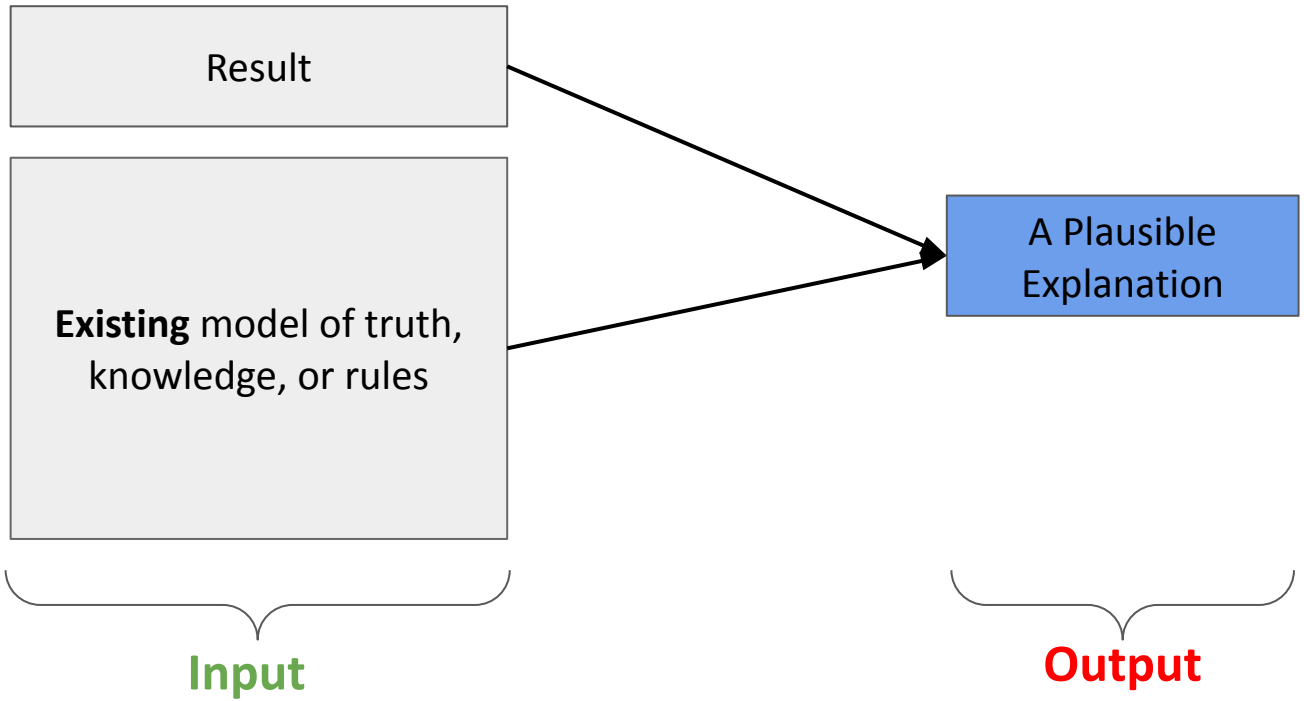

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The discount code I just introduced must be causing a bug.

The failing test has to do with discount codes.

I added a new feature. One of my test cases now fails.

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Abductive Logic Programming

Rules:

```
alarm :- smoke
smoke :- fire
```

Observation:

```
There is an alarm.
```

Abducible Predicates:

```
{fire, rain}
```

We heard an alarm. From fire, we can infer smoke, and from smoke, we can infer alarm. So we think it is plausible that there was a fire.

Summary

- **Inductive reasoning** turns observations into plausible hypotheses, models, or rules.

- **Deductive reasoning** takes a premise, existing knowledge/models/rules, and then derives a logical conclusion.

- **Abductive reasoning** takes an outcome, existing knowledge/models/rules, and then tries to explain why the outcome occurred.

Conclusion

- We learned about three kinds of reasoning:
  - Inductive
  - Deductive
  - Abductive

- We saw examples of the various types of reasoning in computer science!