ICE-DT:
Synthesizing Invariants using Implications and Decision Tree Learning

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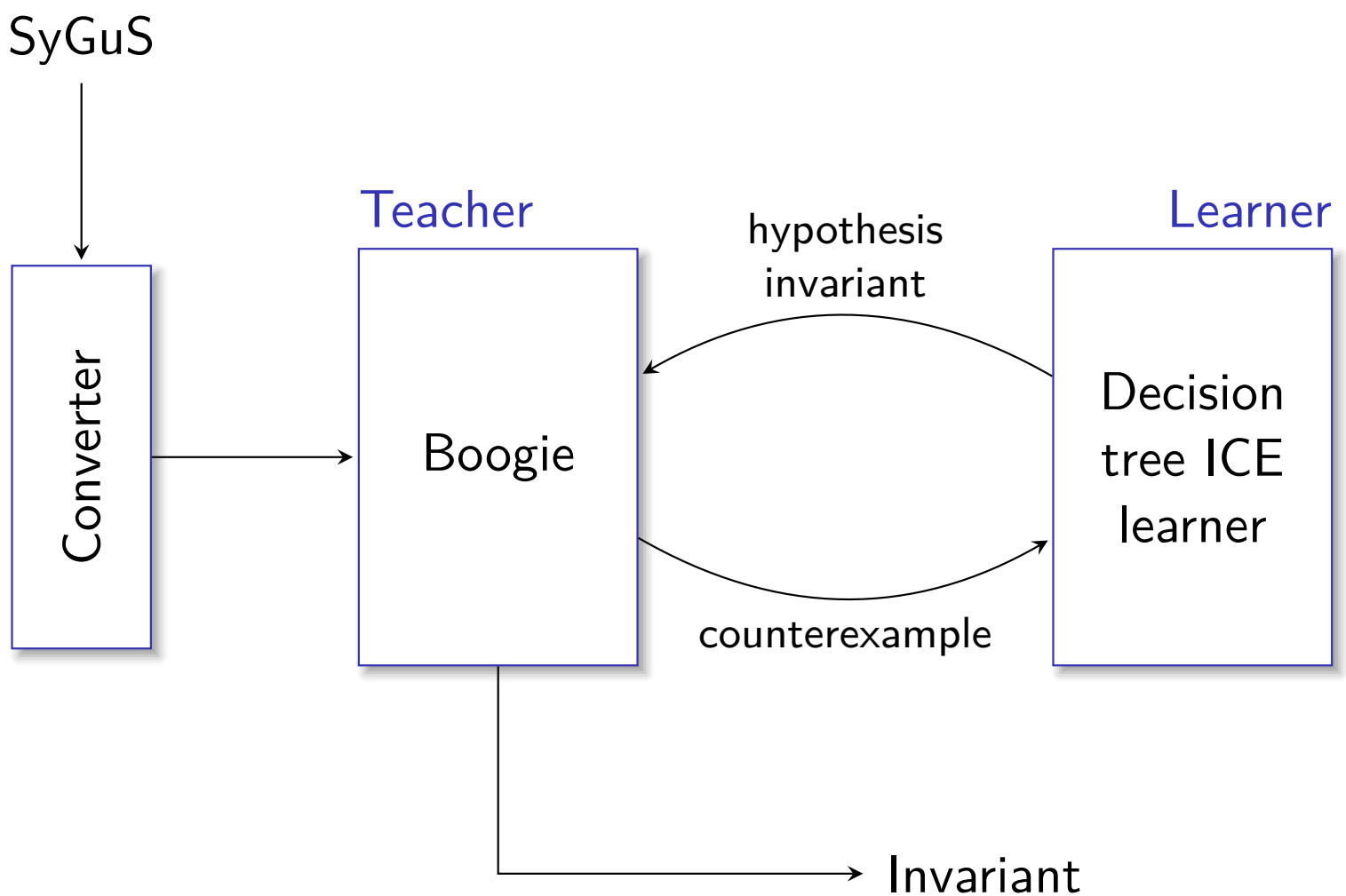
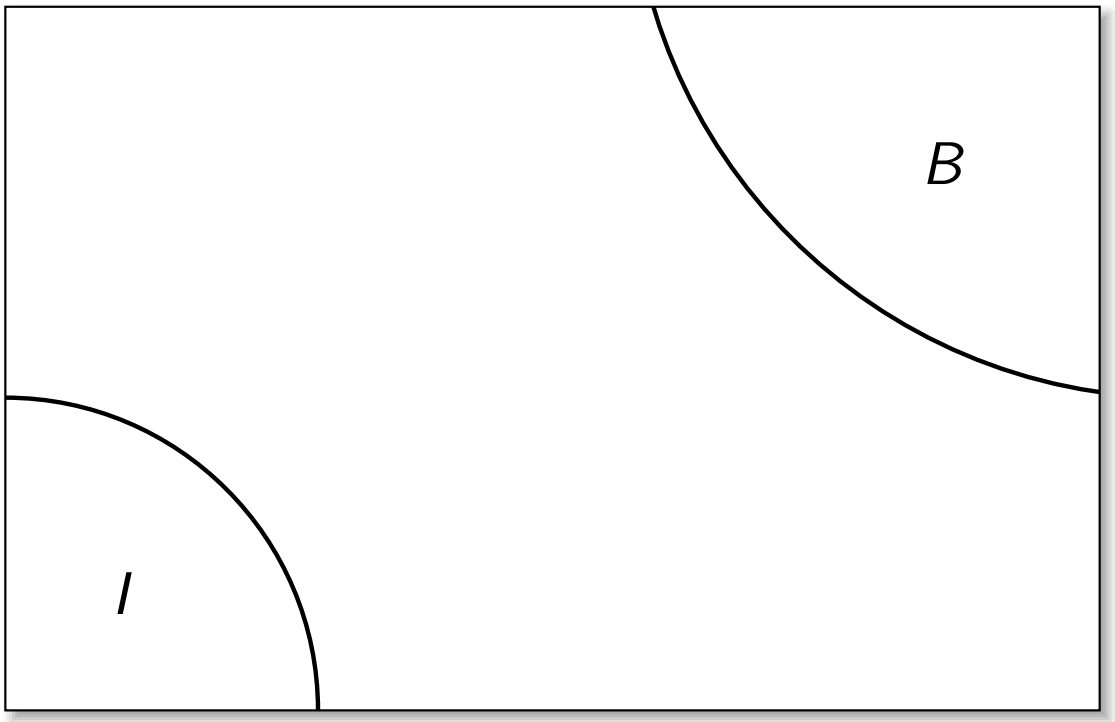
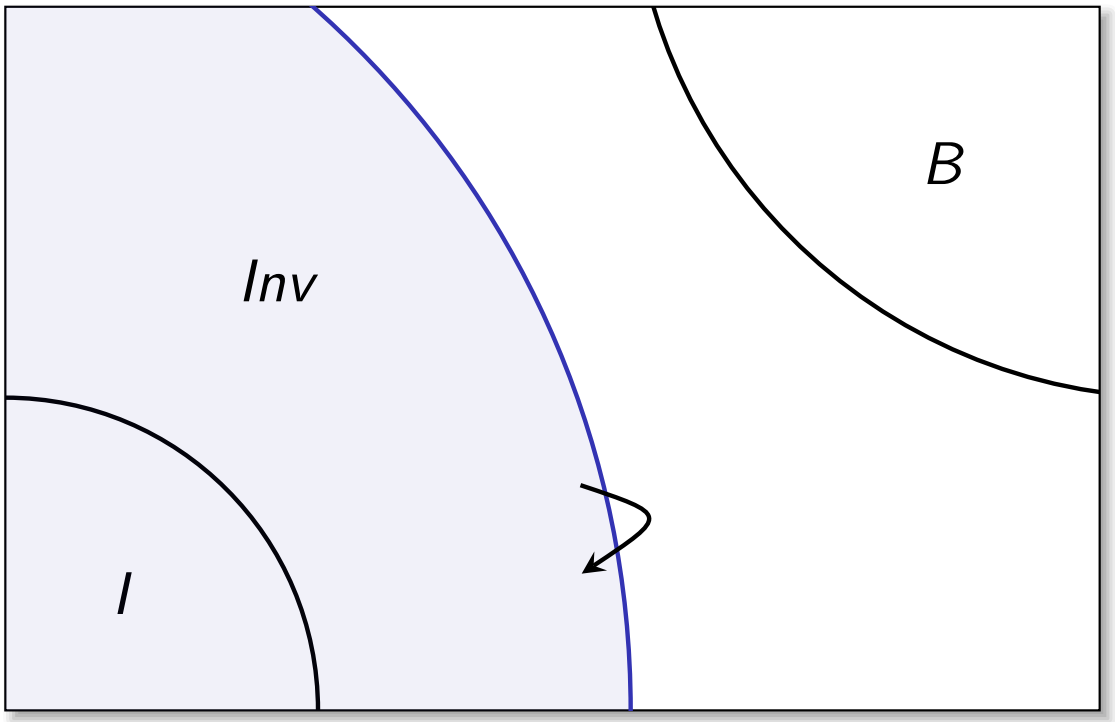
Overview


SyGuS
Converter
Teacher
Boogie
hypothesis
invariant
counterexample
Learner
Decision
tree ICE
learner
Invariant

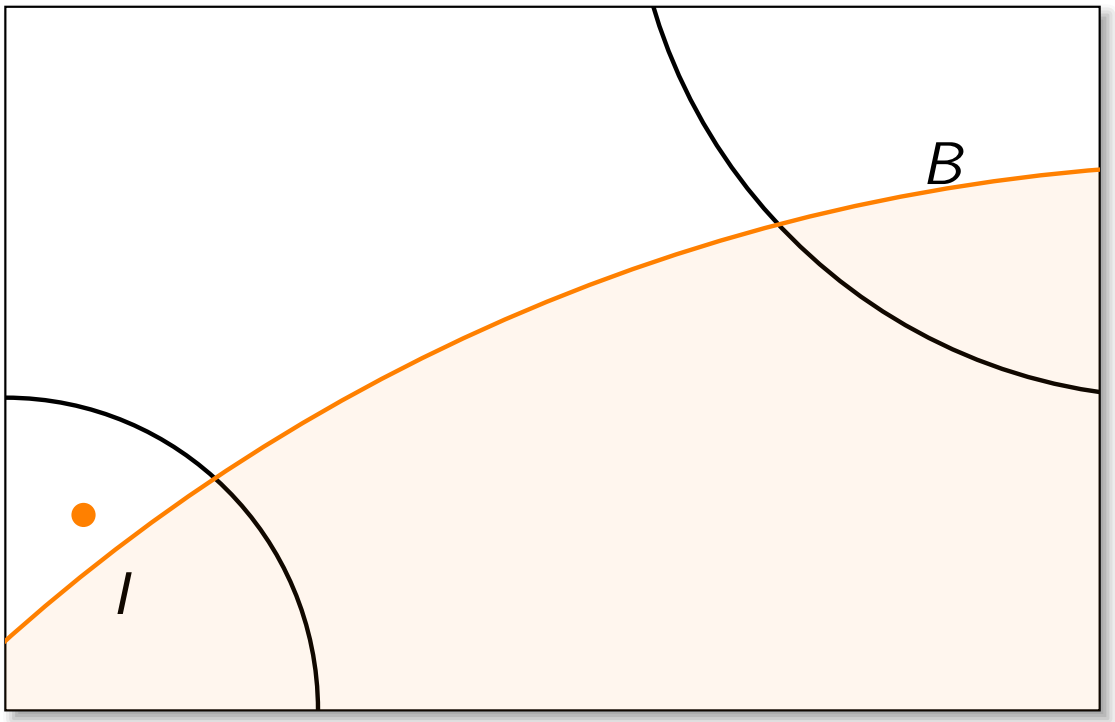
ICE Learning





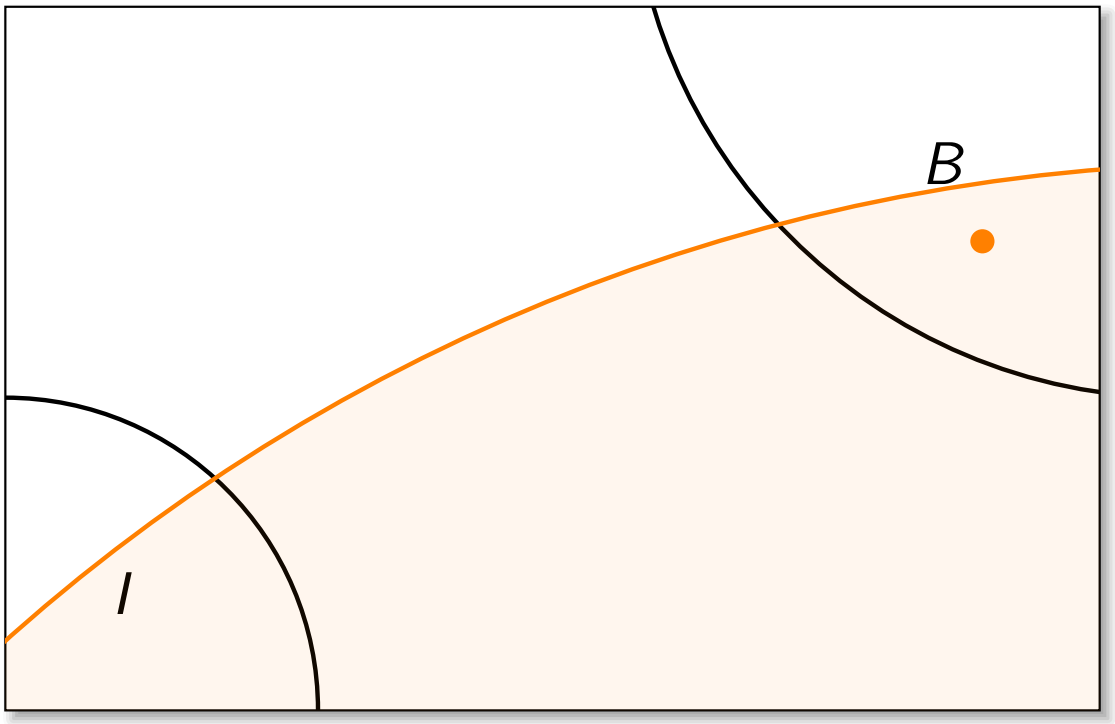
Invariant

1. $I \subseteq Inv$
2. $Inv \cap B = \emptyset$
3. $Post(Inv) \subseteq Inv$



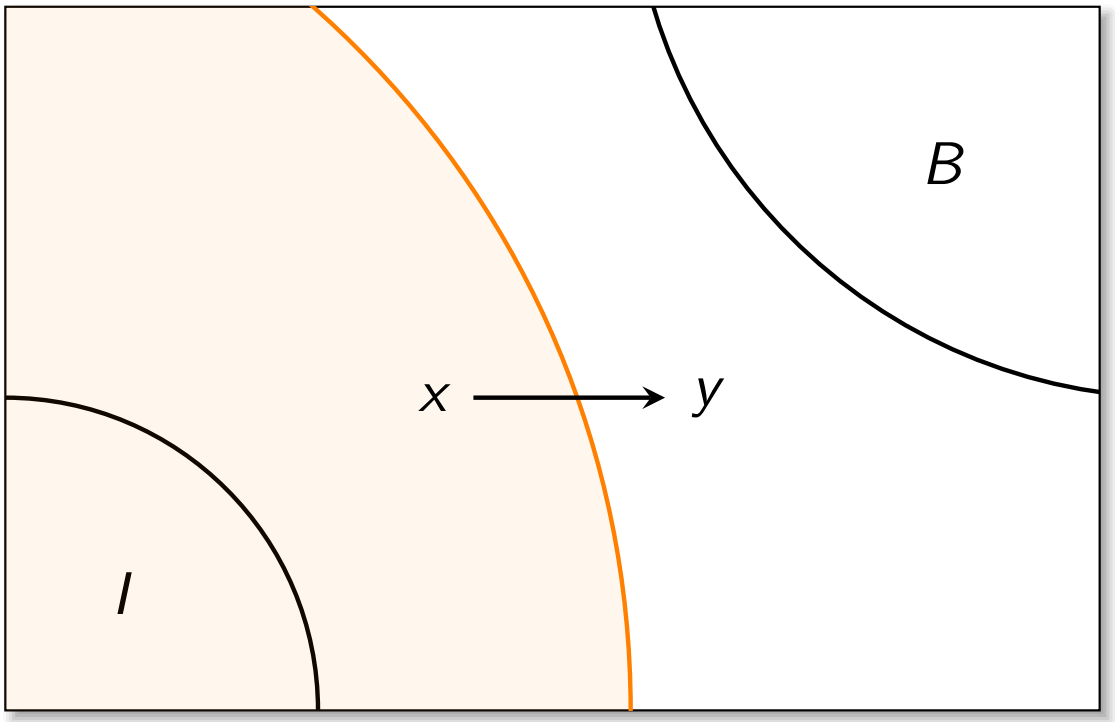
Teacher

1. Return positive counterexample $x \in I \setminus Inv$



Teacher

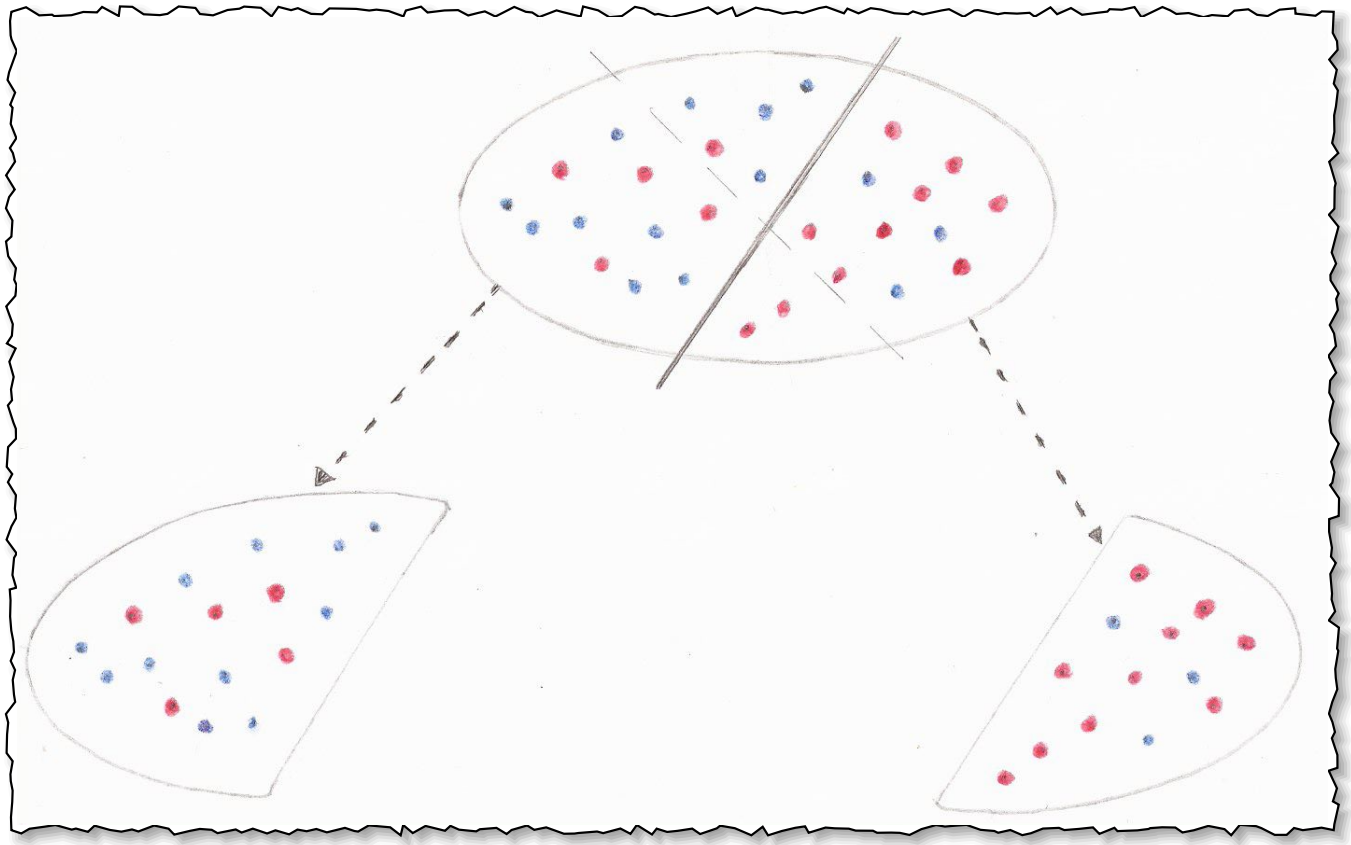
1. Return positive counterexample $x \in I \setminus Inv$
2. Return negative counterexample $x \in B \cap Inv$



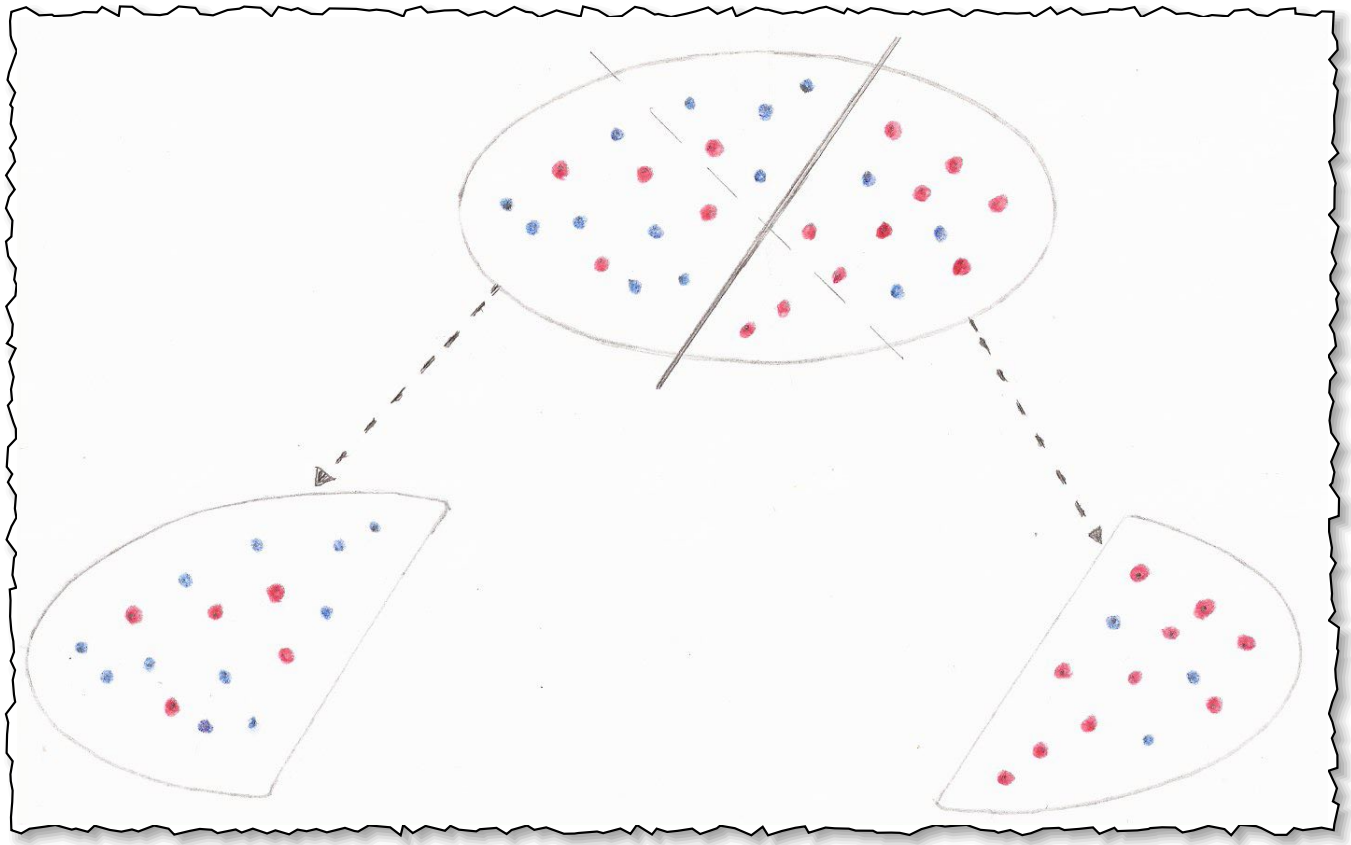
Teacher

1. Return positive counterexample $x \in I \setminus Inv$
2. Return negative counterexample $x \in B \cap Inv$
3. Return implication counterexample $x \to y$ with $x \in Inv$, $y \notin Inv$

Decision Tree learning

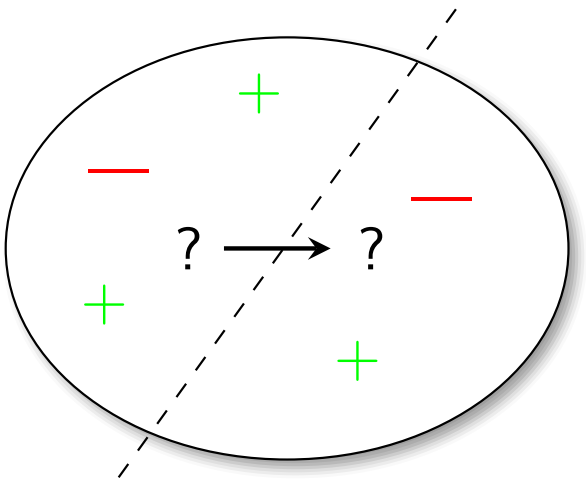


Decision Tree learning



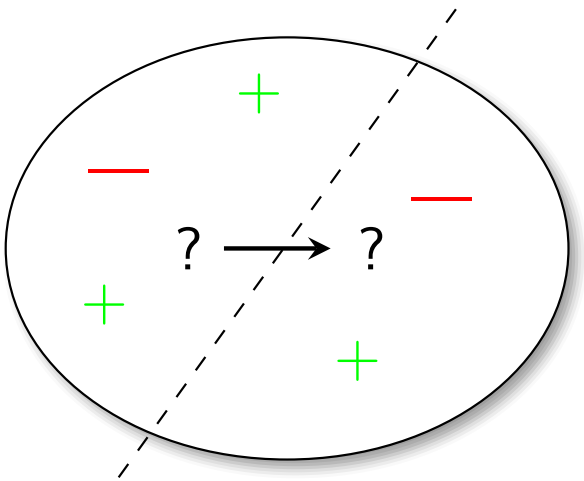
- *Attributes*: octagonal constraints of the form $\pm x \pm y$
- Resulting predicate: $\bigvee_i \bigwedge_j (\pm x_1^{i,j} \pm x_2^{i,j} \leq c^{i,j})$
- No pruning, no boosting, etc.

Decision Tree Learning in the Presence of Implications



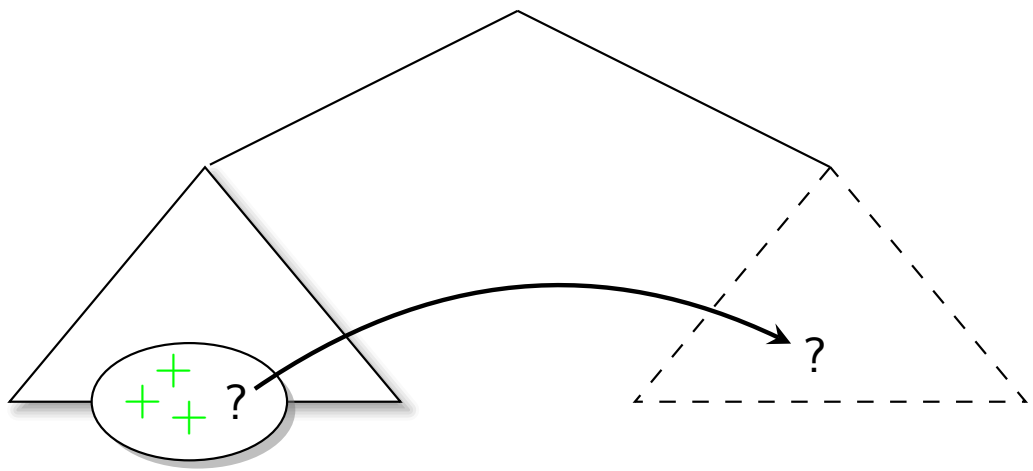
Information gain plus penalizing the cut of implications

Decision Tree Learning in the Presence of Implications

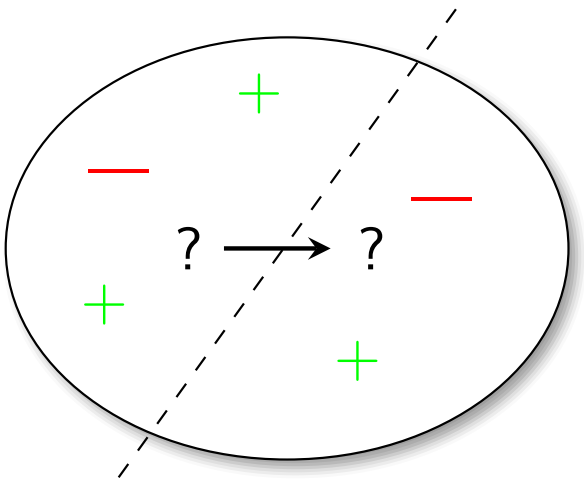


Information gain plus penalizing the cut of implications

Propagate implications



Decision Tree Learning in the Presence of Implications



Information gain plus penalizing the cut of implications

Propagate implications