HW2: An End-to-End Exact PBE

Technical Analysis: Predict price direction using current prices

Patterns: Special forms that signal whether to buy or sell

Goal: Synthesize a program (a model) detecting a pattern

P₀ = LLV(Close, W);
BP₀ = LLVBars(Close, W);
P₁ = HHV(Close, BP₀);
BP₁ = HHVBars(Close, BP₀);
P₂ = LLV(Close, BP₁);
BP₂ = LLVBars(Close, BP₁);
P₃ = HHV(Close, BP₂);
BP₃ = HHVBars(Close, BP₂);
P₄ = LLV(Close, BP₃);
BP₄ = LLVBars(Close, BP₃);
P₅ = HHV(Close, BP₄);
BP₅ = HHVBars(Close, BP₄);
P₆ = LLV(Close, BP₅);
Filter = P₀ < P₁ AND P₂ < P₁ AND P₁ < P₃ AND P₅ < P₃ AND P₄ < P₅ AND P₆ < P₅;

Buy? Sell?
Time-Series Patterns from Charts

• Goal: an exact PBE that learns patterns in time-series charts

• Time-series charts are used in many domains including financial analysis, medicine, and seismology.
Time-Series Patterns from Charts

• Experts use these charts to predict important events (e.g., trend changes in a stock price) indicated by special patterns.
There is a lot of study on common patterns and there are many softwares that enable these experts to write a program that alerts upon detecting their customized pattern.
Time-Series Patterns from Charts

• Unfortunately, writing programs is a complex task for these experts, who are not programmers

• Goal: learn the specifications from chart examples, then synthesize a program

\[
P_0 = \text{LLV}(\text{Close}, W);
BP_0 = \text{LLVBars}(\text{Close}, W);
P_1 = \text{HHV}(\text{Close}, BP_0);
BP_1 = \text{HHVBars}(\text{Close}, BP_0);
P_2 = \text{LLV}(\text{Close}, BP_1);
BP_2 = \text{LLVBars}(\text{Close}, BP_1);
P_3 = \text{HHV}(\text{Close}, BP_2);
BP_3 = \text{HHVBars}(\text{Close}, BP_2);
P_4 = \text{LLV}(\text{Close}, BP_3);
BP_4 = \text{LLVBars}(\text{Close}, BP_3);
P_5 = \text{HHV}(\text{Close}, BP_4);
BP_5 = \text{HHVBars}(\text{Close}, BP_4);
P_6 = \text{LLV}(\text{Close}, BP_5);
\text{Filter} = P_0 < P_1 \text{ AND } P_2 < P_1 \text{ AND } P_1 < P_3 \text{ AND } P_5 < P_3 \text{ AND } P_4 < P_5 \text{ AND } P_6 < P_5;
\]
Time-series Patterns

• A chart is a function over time
  • $p_i$ is the price at time point $i$

• A pattern is a conjunction over $Q = \{ p_i < p_j | i \neq j \}$
  • $\varphi_{HS} = (p_0 < p_2) \land (p_2 < p_1) \land (p_1 < p_3) \land (p_2 < p_4) \land (p_4 < p_5) \land (p_6 < p_5) \land (p_5 < p_3) \land (p_6 < p_0)$
Exact PBE for Time-series Patterns

• We will assume a slightly different setting
• The learning begins from the user who provides an initial chart example $e$
• Then, the set of predicates is:
  \[ Q_e = \{ p_i < p_j | e \models p_i < p_j \} \]
• The conjunctive formula is over $Q_n$
• Note that $Q_{e,\land}$ cannot contain cyclic constraints
  \[ p_i < p_j \in Q_{e,\land} \Rightarrow p_j < p_i \notin Q_{e,\land} \]
Questions

1. Define C-SPEX, a variation of D-SPEX for learning conjunctions
   • Hint: What is the search space? How do the lemma change?

2. Let $e$ be a chart example and $Q_e = \{ p_i < p_j \mid e \models p_i < p_j \}$
   a) Define how to compute the children of a node. What is the time complexity?
      • Hint: represent the constraints in a graph whose nodes are $p_i$
   b) Define how to find the witnesses. What is the time complexity?
      • Hint: topological sorting
   c) Determine how many membership queries C-SPEX can present.
      • Hint: the bound is much better...