THE COUNTERFACTUAL QUERY:

\[ P(Y' | Y = \bar{Y}, \text{do}(x_i = \bar{x}_i)) \]

What would have happened in the posterior representation of a world (given observations) if, in that posterior world, one or more things had been forced to change (intervened upon)?

A COUNTERFACTUAL PROBABILISTIC PROGRAMMING ENGINE

1. **assume** \( P(X,Y) \)  
   **Prior World**  
   \( s_j \sim \text{proposal} \)

2. **observe** \( Y = \bar{Y} \)  
   **Posterior World**  
   \( s_j, w_j \)

3. **do** \( x_i = \bar{x}_i \)  
   **Intervened Posterior**  
   \( \text{interv}(s_j) = s'_j, w'_j \)  
   (including propagation, where descendants are updated)

4. **predict** \( Y' \)  
   **Counterfactual Prediction**  
   \[ \sum s'_j w'_j / \sum w_y \]

**FAST and “SMART” NATIVE COUNTERFACTUAL INFERENCE IN A PPL**

Ask me how to:
- Represent causal models as prob. prog-s
- Propagate the effect of interventions
- Make proposals “smart” in causal models
- Extend to other approximate inference

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