

MultiVerse: Causal Reasoning using Importance Sampling in Probabilistic Programming



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MultiVerse is a probabilistic programming engine prototype for natively modelling & inferring **causal queries**. It makes causal inference more efficient by **enhancing inference rather than the model**.

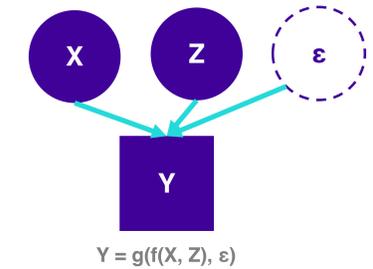
A COUNTERFACTUAL PROBABILISTIC PROGRAMMING ENGINE

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|---|-------------------------|----------------------------------|--|
| 1 | $assume\ P(X, Y)$ | Prior World | $s_j \sim proposal$ |
| 2 | $observe(Y = \hat{Y})$ | Posterior World | s_j, w_j |
| 3 | $do(x_i = \tilde{x}_i)$ | Intervened Posterior | $interv(s_j) = s'_j, w_j$ <small>(including propagation, where descendants are updated)</small> |
| 4 | $predict(Y')$ | Counterfactual Prediction | $\frac{\sum s'_y w_y}{\sum w_y}$ + python™ |

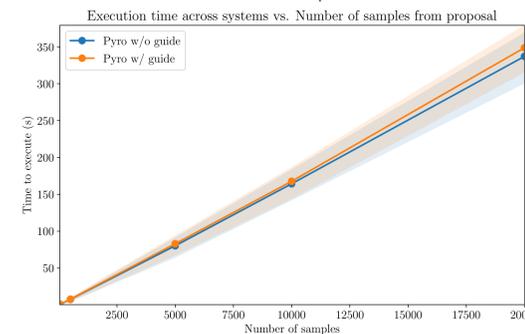
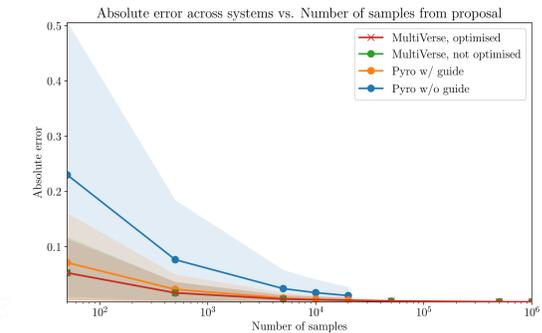
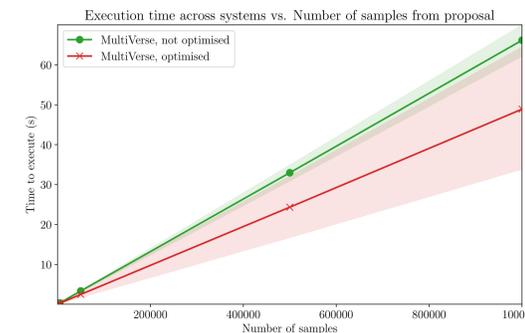
THE COUNTERFACTUAL QUERY:

$$P(Y' | Y = \hat{Y}, do(x_i = \tilde{x}_i))$$

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)?



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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