

A Shift in Perspective on Causality in Domain Generalization



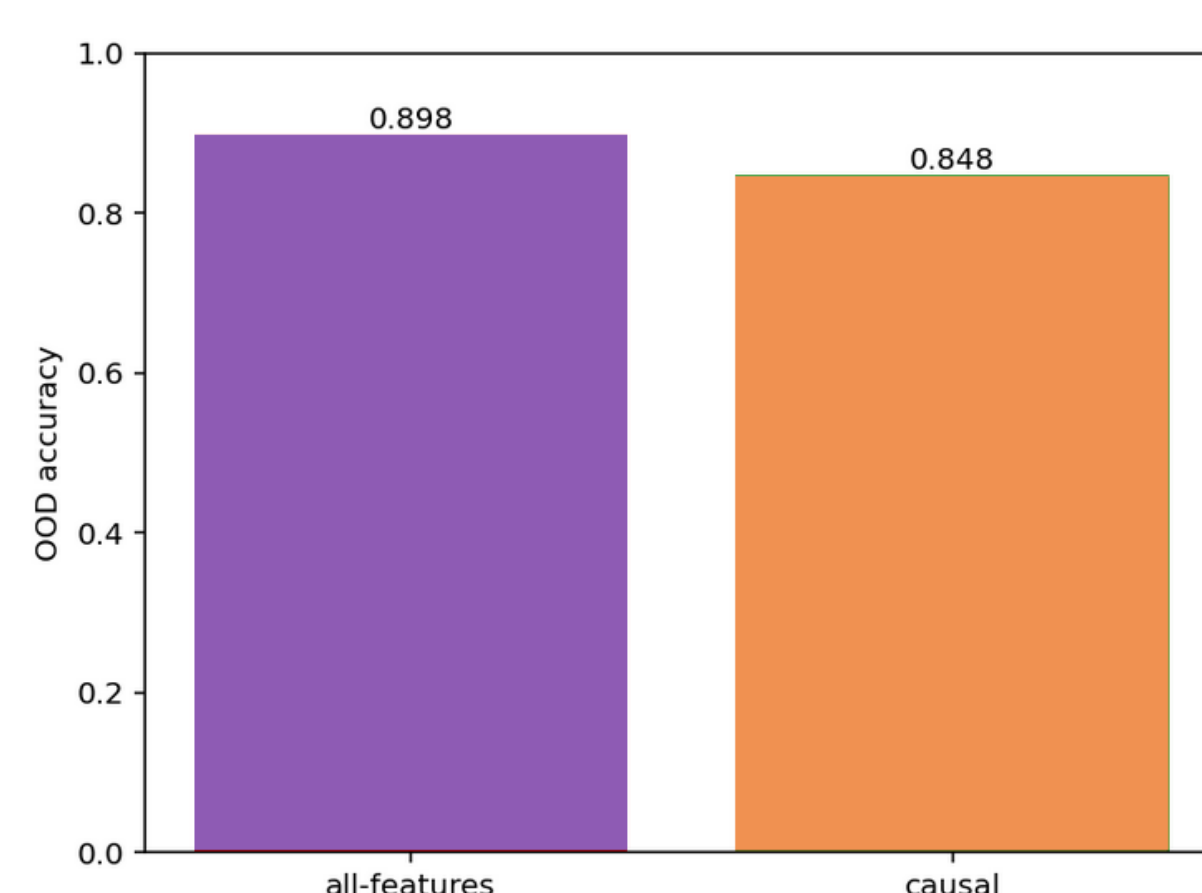
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Causality and Generalization

- Generalization is that the relationship between model **inputs** and the prediction **target** is **stable across environments**.
- Distribution of **the target variable conditioned parents** is **invariant** under changes to the rest of the system.

What Could Go Wrong ?

“Using **only target’s Causal Parents** as model inputs for prediction could be robust to *all the changes*.”



In reality this is **NOT** the case:
Prediction with **causal features** is often overshadowed by models which use **all features**.

Why This is Happening ?

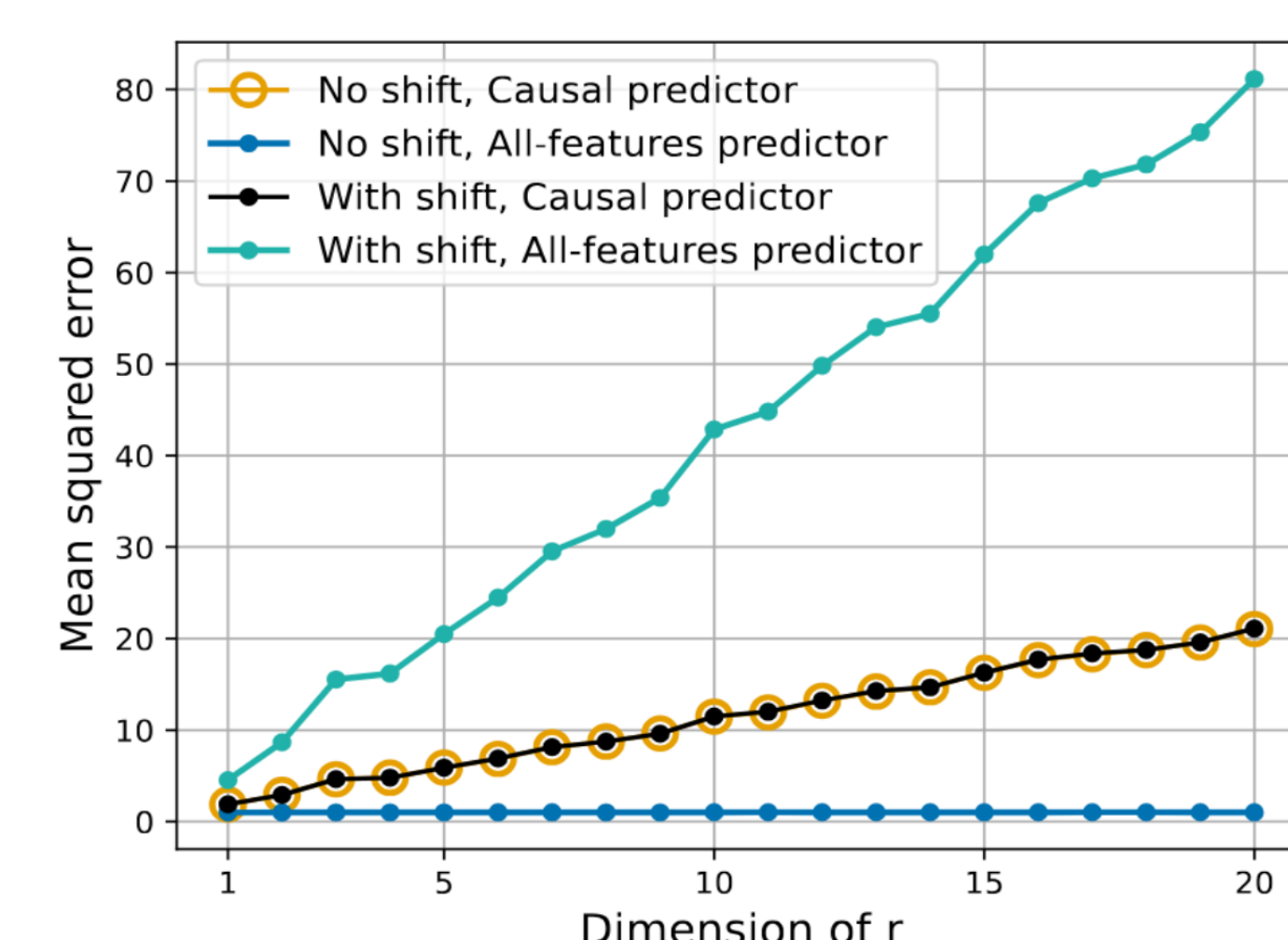
Causal mechanisms should remain invariant across domains = **Causal features should NOT exhibit concept shift**

Impact of Concept Shift:

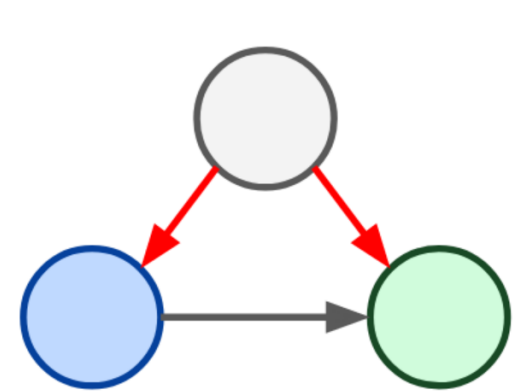
A synthetic dataset: $y = \alpha x + s\mathbf{b}^T\mathbf{r} + N(0,1)$

Two cases: $s = 1$ (*no concept shift*) and $s = -1$ (*with concept shift*).

Linear regression using **causal feature** x , or **all features** (x and r).



Latent Confounding



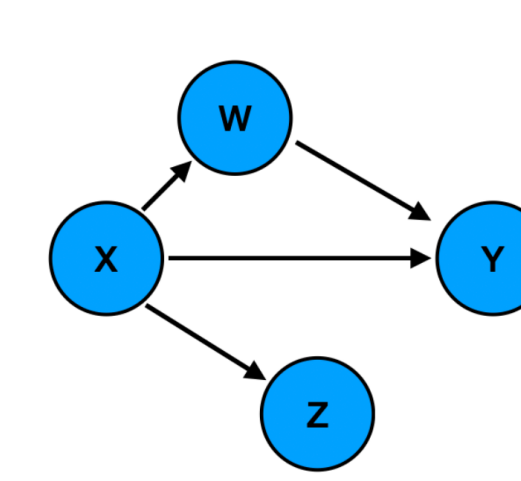
May be **unobserved confounder** variables influence the target.

Non-Causal \neq Unstable



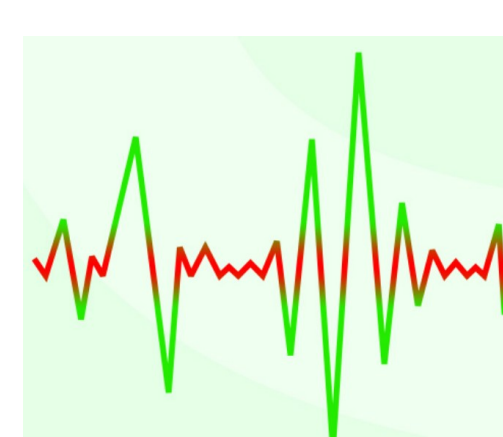
Concepts like **stability** are **context-dependent**.

Discovery & Prediction



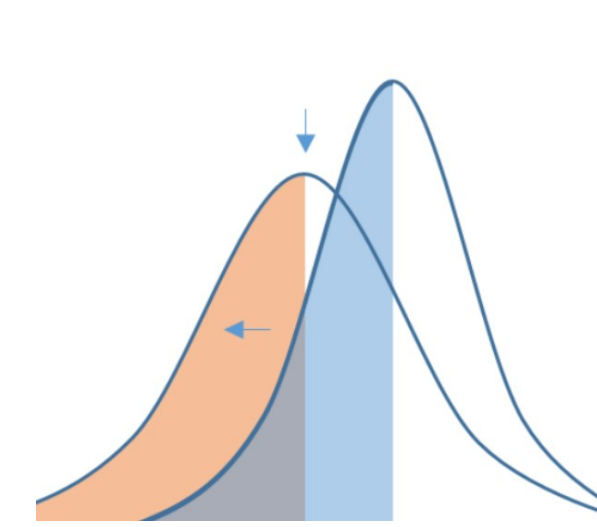
Causal Discovery is **task agnostic** no variables like prediction & target.

Signal-Noise Ratio



Causal features are recorded with a **low SNR**, might not be useful for prediction

Shift Strength



A **small domain shift** might not be enough to expose a spurious predictor.

Conclusion and Take-Aways

In DG problem **Causality CANNOT be reduced to feature selection** principles.
Deeper insights into the **Roles of Confounding**, the **Nature of Anticipated Shifts** are needed.



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