

Introduction to Structural Causal Models

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- Foundations of SCMs
 - Assumptions
 - Comparing Causal Tools
- Pearl's Causal Hierarchy
 - Prediction
 - Intervention
 - Counterfactuals
- Graphical Models
- Causality and Time

Assumptions SCM

- Mechanisms independent/autonomous
- Set of equations (assignments $':='$)
- Observational Data
- Endogenous and Exogenous Variables
- Latent noise variables
- Noise terms independent

Graphical Example

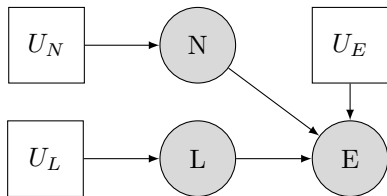


Figure 1: Structural Causal Model

- $\{U_N\}$ - Numeric Ability
- $\{U_L\}$ - Literary Ability
- $\{U_C\}$ - Quality of the Student
- $\{A\}$ - Math Test
- $\{E\}$ - English-Test
- $\{C\}$ - GPA

Mathematical Example

$$\begin{aligned}N &:= f_N(U_N) \\ L &:= f_L(U_L) \\ E &:= f_E(N, L, U_E)\end{aligned}$$

$\{U_N\}$ - Numeric Ability

$\{U_L\}$ - Literary Ability

$\{U_E\}$ - Quality of the Student

$\{N\}$ - Math Test

$\{L\}$ - English-Test

$\{E\}$ - GPA

Pearl's Causal Hierarchy

Table 1: Pearls Hierarchy of Causation (2009)

Method	Action	Example	Usage
Association $P(a b)$	Co-occurrence	What happened. . .	(Un-)Supervised ML, BN, Reg.
Intervention $P(a do(b), c)$	Do- manipulation	What happens if . . .	CBN,MDP,RL
Counterfactual $P(a_b a', b')$	Hypotheticals	What would have happened if. . .	SCM ,PO

Questions for Discussion

Do you have any concepts that are still unclear to you?