A Gentle Introduction into Structural Causal Models

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Abstract

This paper provides a gentle introduction into causal inference, focusing on structural causal models and respective causal graphs. The first section provides introduces probabilities and will focus on clarifying the difference between observations and causal concepts. The second section discusses the hierachy of causation. The third section dicusses causal graphs.

Topic 1: Structural Causal Models (SCMs) Structural Causal Models are a general framework to describe data generating mechanisms. The values of variables are described as functions of exogeneous and endogeneous variables. These mechanisms can also be described with directed graphs. Typically one requires for the endogenous variables to fulfill causal sufficiency and the corresponding graph to be acyclic. Also, one requires mechanisms to be independent. The student should convey and explain the notation on a number of examples and explain the motivation and role of the aforementioned assumptions.

1 Introduction

Table 1: Pearl - Hierachy of Causation

Method	Action	Example
Prediction	Observation/Co-occurrence	What happened...
Intervention	Do-manipulation	What happens if ...
Counterfactual	Hypothetical Realities	What would have happened if...

1.1 SEM and Structural Causal Model

1.2 Prediction

1.3 Intervention

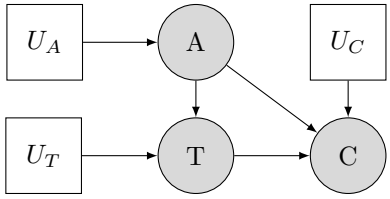

Figure 1: Structural Causal Model

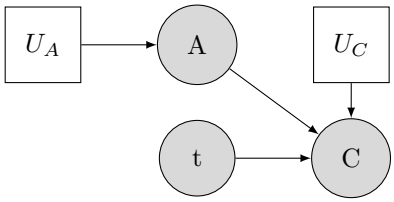

Figure 2: Atomic Intervention

1.4 Counterfactuals

Process is described as follows:

(a) Abduction: Cast probability $P(u)$ as conditional probability $P(u|\epsilon)$

(b) Action: Exchange $(X = x)$

(c) Prediction: Compute $(Y = y)$

1.5 Bayesian Models vs. SCM

1.6 Probabilistic Models vs SCMs

Method	CBN	SCM
Prediction	· Unstable	· Stable
	· Volatile to parameter changes	· More Natural Specification
	· Re-Estimate entire model	· Only estimate Δ CM

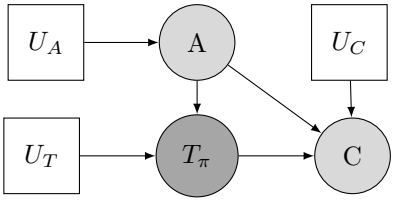

Figure 3: Policy Intervention

Method	CBN	SCM
Intervention	· Costly for Non-Markovian Models	· Pot. Cyclic Representation
	· Unstable(Nature CP)	· Stable(Nature Eq.)
	· Only generic estimates(Δ CP)	· Context specific(Invariance of Eq.)
Counterfactuals	· **Impossible**	· Possible
	· no information on latent factors(ϵ)	· Inclusion of latent factors