

Welcome to this session: Counterfactual Analysis

The session will start shortly...

Questions? Drop them in the chat.
We'll have dedicated moderators
answering questions.





What is Safeguarding?

Safeguarding refers to actions and measures aimed at protecting the human rights of adults, particularly vulnerable individuals, from abuse, neglect, and harm.



To report a safeguarding concern reach out to us via email:
safeguarding@hyperiondev.com


Live Lecture Housekeeping:

- The use of disrespectful language is prohibited in the questions, this is a supportive, learning environment for all - please engage accordingly.
- No question is daft or silly - ask them!
- For all non-academic questions, please submit a query:
www.hyperiondev.com/support
- To report a safeguarding concern reach out to us via email:
safeguarding@hyperiondev.com
- If you are hearing impaired, please kindly use your computer's function through Google chrome to enable captions.



Learning Outcomes

- ❖ **Define and Explain** Counterfactual Reasoning
- ❖ **Apply Counterfactual Algorithms** to Real-World Scenarios
- ❖ **Evaluate the Impact of Counterfactual Analysis** on Policy and Business Decisions
- ❖ **Identify and Address Ethical Concerns** in Counterfactual Modeling
- ❖ **Formulate and Communicate Counterfactual Insights** Effectively



What is the primary purpose of counterfactual analysis?

- A. To describe the current state of events based on observational data.
- B. To estimate the probability of an event occurring in the future.
- C. To explore "what if" scenarios by considering hypothetical alternatives to past events.
- D. To determine the correlation between two variables without considering causality.



Which of the following is NOT a key requirement for a valid counterfactual scenario?

- A. Proximity – The counterfactual world should be close to reality.
- B. Plausibility – The scenario must be logically possible.
- C. Complexity – The counterfactual must include as many changes as possible.
- D. Minimality – Only necessary changes should be introduced to generate the counterfactual.

Lecture Overview

- Introduction
- Algorithms & Techniques
- Real-World Applications
- Ethical Considerations





Introduction to Counterfactual Analysis

Definition

- Counterfactual analysis is the study of **hypothetical alternatives to past events**,
- Asking "What would have happened if things had been different?"
- It is fundamental in **causal inference**, allowing us to **estimate causal effects** by **comparing observed outcomes with imagined counterfactual scenarios**.

Why do they matter?

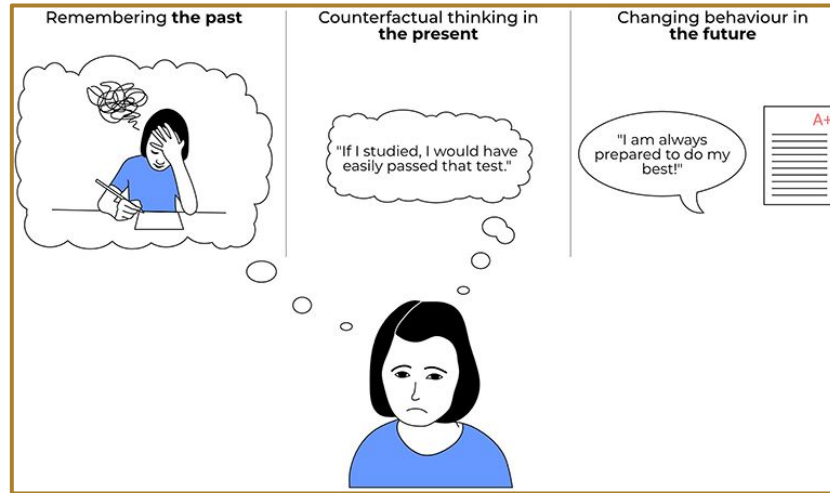
- **Decision-Making:**
 - Helps policymakers, businesses, and scientists understand the impact of their decisions.
- **Causal Reasoning:**
 - Differentiates correlation from causation by isolating the effect of a specific variable.
- **Prediction & Optimisation:**
 - Allows models to anticipate changes before applying interventions.

Counterfactual Statements

- A **counterfactual statement** typically takes the form:
 - "If X had happened, Y would (or would not) have happened."
- For example:
 - "If Germany had won World War II, the global political landscape would be different today."
 - "If a student had studied harder, they would have passed the exam."

Counterfactual Statements

- These statements describe alternative realities and are used in multiple fields to test hypotheses, simulate possible outcomes, and improve decision-making.





Counterfactual Thinking vs Causal Inference

- Causal inference:

- Estimates the causal effect of a treatment or action
- Uses observational data, experiments, and statistical methods
- "Did a policy increase employment?"

- Counterfactual:

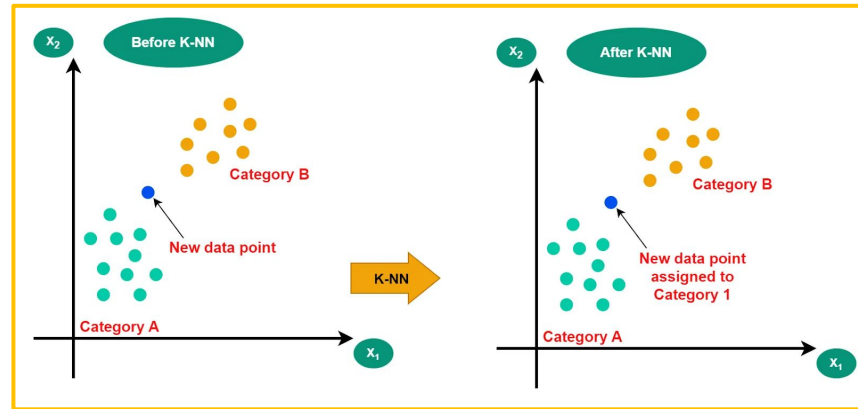
- Constructs an alternative world to explore "what if" scenarios
- Uses logic, simulation, and machine learning to model alternate outcomes
- "If the policy had been stricter, how much unemployment would have occurred?"



Counterfactual Algorithms: How Do We Generate "What If" Scenarios?

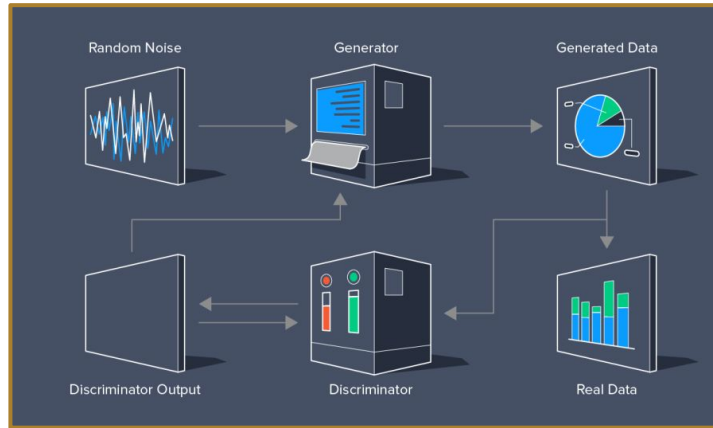
Nearest Neighbor Matching (Instance-Based)

- Finds the most similar real-world case that did not experience the event.
- **Example:** Predicting whether a customer would have purchased a product if they had seen a different ad by comparing them to similar customers.



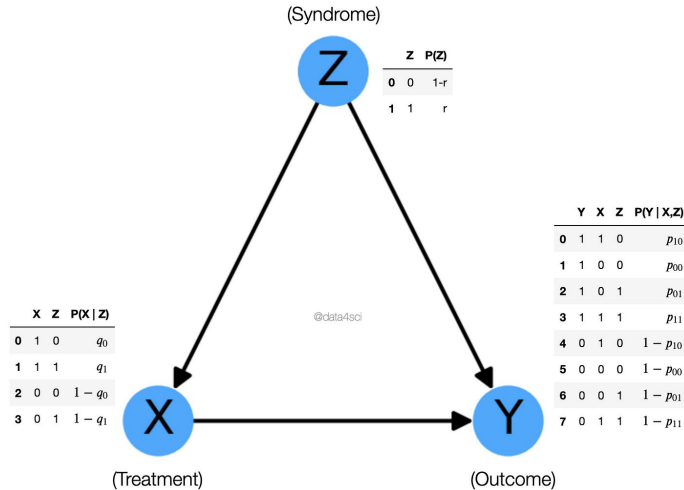
Generative Models (AI & Machine Learning)

- GANs (Generative Adversarial Networks) and VAEs (Variational Autoencoders) generate synthetic counterfactuals.
- **Example:** AI reconstructs what a tumor would have looked like if a patient had undergone a different treatment.



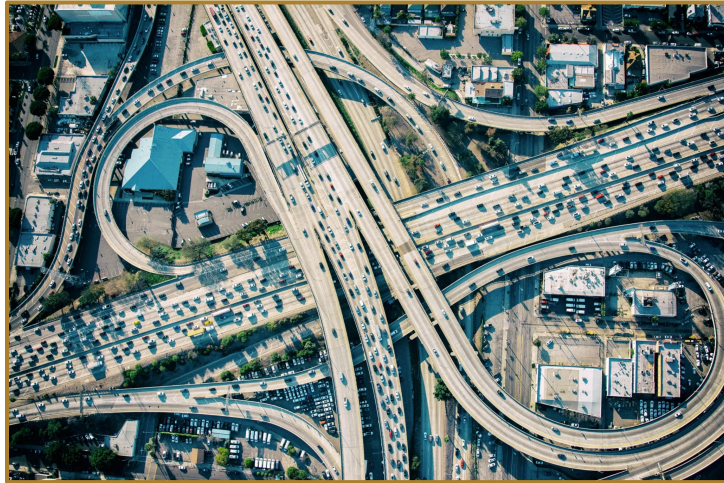
Structural Causal Models (SCMs)

- Uses directed graphs to model causal relationships and counterfactuals.
- **Example:** If smoking had been banned in the 1950s, what would lung cancer rates be today?



Counterfactual Simulations

- Uses Monte Carlo simulations or agent-based modeling.
- **Example:** Predicting how traffic congestion would have changed if a new highway had been built.



Evaluating Counterfactual Validity

- How do we ensure counterfactuals are meaningful?
 - Proximity – The counterfactual world should be close to reality.
 - Plausibility – The scenario should be possible within known constraints.
 - Minimality – Only the necessary changes should be made to create the counterfactual.





BREAK





Real-World Applications of Counterfactual Analysis

Legal Reasoning: Establishing Liability


Courts use counterfactuals to determine whether someone is responsible for damages.

Example: If the doctor had diagnosed the disease earlier, would the patient have survived?



Simulating economic and social policies.

The chart displays the daily count of confirmed COVID-19 cases for 18 countries. China's data is visible from January 12 to February 5, showing a peak of approximately 5.8 cases. The Philippines' data starts around February 23 and peaks at 6 cases on March 15. Most other countries show lower case counts, generally below 2, with some fluctuations throughout the period.

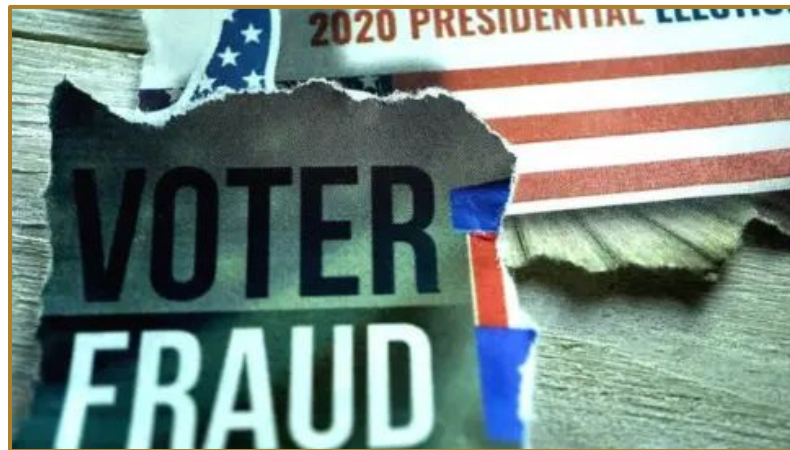


Ethical Considerations in Counterfactual Reasoning

Misuse of Counterfactuals

Manipulating historical facts for political propaganda.

Example: Fake claims that elections were rigged based on unverifiable counterfactuals.



Counterfactual Fairness in AI

Ensuring AI-generated counterfactuals do not reinforce discrimination.

Example: AI models should not suggest "If you were a man, you would have gotten the job."



Privacy Risks

Counterfactual simulations may require personal data, leading to privacy concerns.

Example: Predicting whether a person would have committed a crime based on their digital footprint.

DIGITAL FOOTPRINTS

What do yours say?

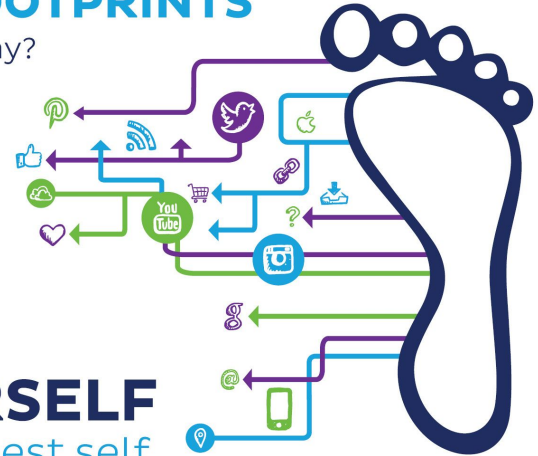
BE CAREFUL ABOUT:

- What you share.
- Where you share.
- With whom you share.

BE SMART ABOUT:

- Sites you visit.
- Emails you open.
- Links you click.

BE YOURSELF
but be your best self.



The Power and Limitations of Counterfactual Thinking

- **What Counterfactuals Do Well**

- Help in decision-making, AI fairness, law, medicine, and economics.
- Allow us to explore alternative worlds without real-world risks.
- Improve AI explainability and causal reasoning.

- **What They Struggle With**

- Counterfactuals are hypothetical, so they require strong assumptions.
- Not all counterfactuals are verifiable—we can never know for sure what would have happened.
- Ethical challenges arise when counterfactuals are misused for manipulation.

Which of the following is an example of counterfactual reasoning?

- A. "If a person smokes, they are more likely to develop lung cancer."
- B. "If John had left his house earlier, he would not have missed his flight."
- C. "Higher education levels correlate with higher income."
- D. "Countries with stronger economies tend to have better healthcare systems."



In AI and machine learning, counterfactual analysis is commonly used for which of the following?

- A. Identifying random patterns in large datasets.
- B. Generating alternative outcomes to explain algorithmic decisions.
- C. Replacing traditional statistical models with neural networks.
- D. Creating entirely new datasets without considering real-world data.

Q & A SECTION

**Please use this time to ask
any questions relating to the
topic, should you have any.**

Thank you
for attending



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