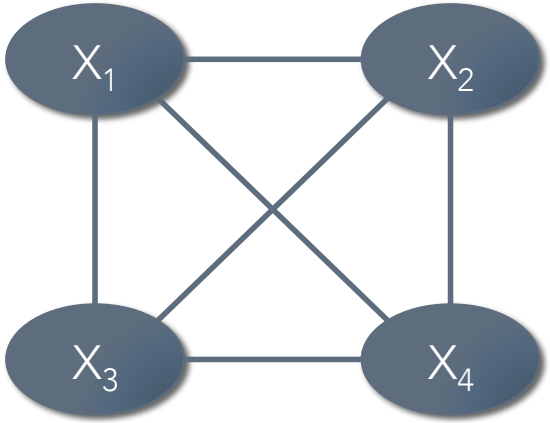
UNIVERSITY OF CALIFORNIA
SANTA CRUZ

OPEN PROBLEM:
JOINT PROBABILISTIC INFERENCE OF CAUSAL STRUCTURE

Dhanya Sridhar and Lise Getoor
UC Santa Cruz

Causation: Foundation to Application Workshop
June 29, 2016

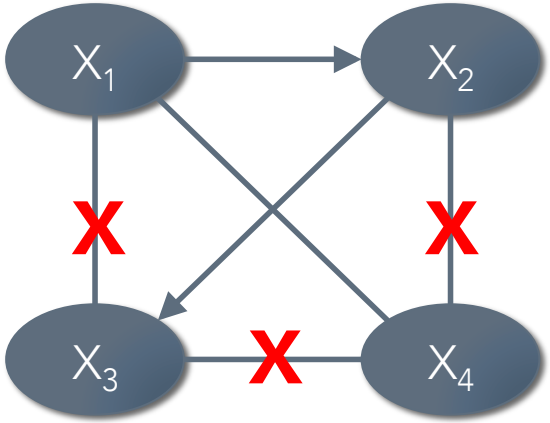
Causal Structure Discovery: Traditional to Hybrid Approaches



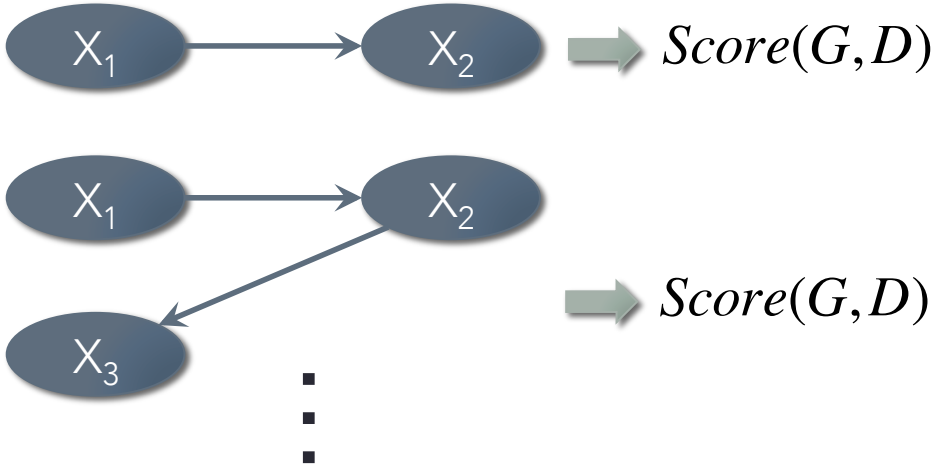
Constraint Based

Search and Score Based

Causal Structure Discovery: Traditional to Hybrid Approaches



Constraint Based



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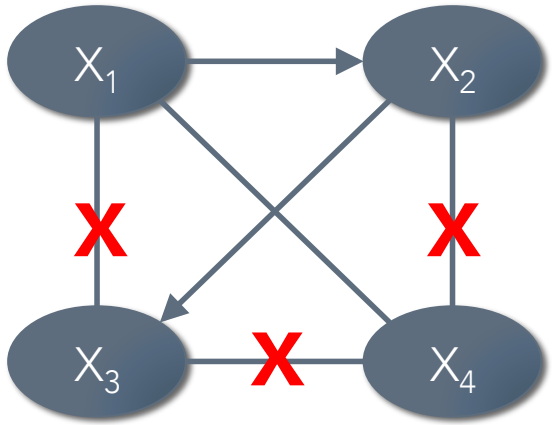

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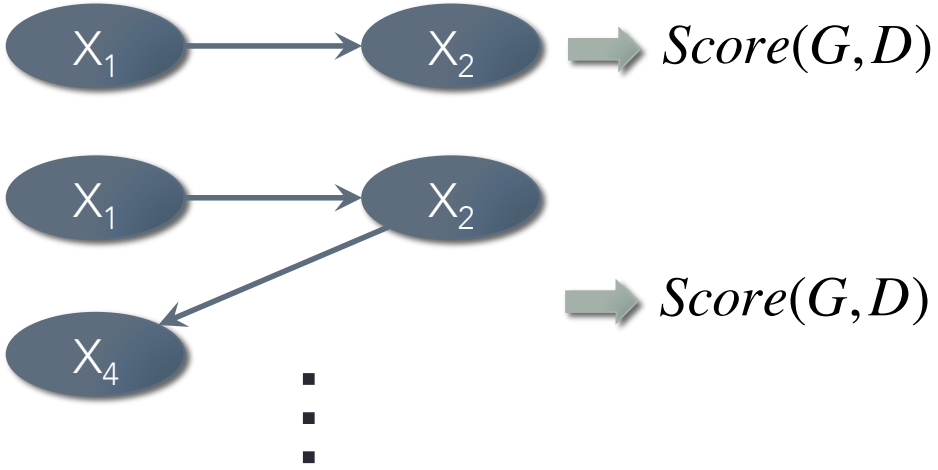

Search and Score Based

Hybrid Approaches

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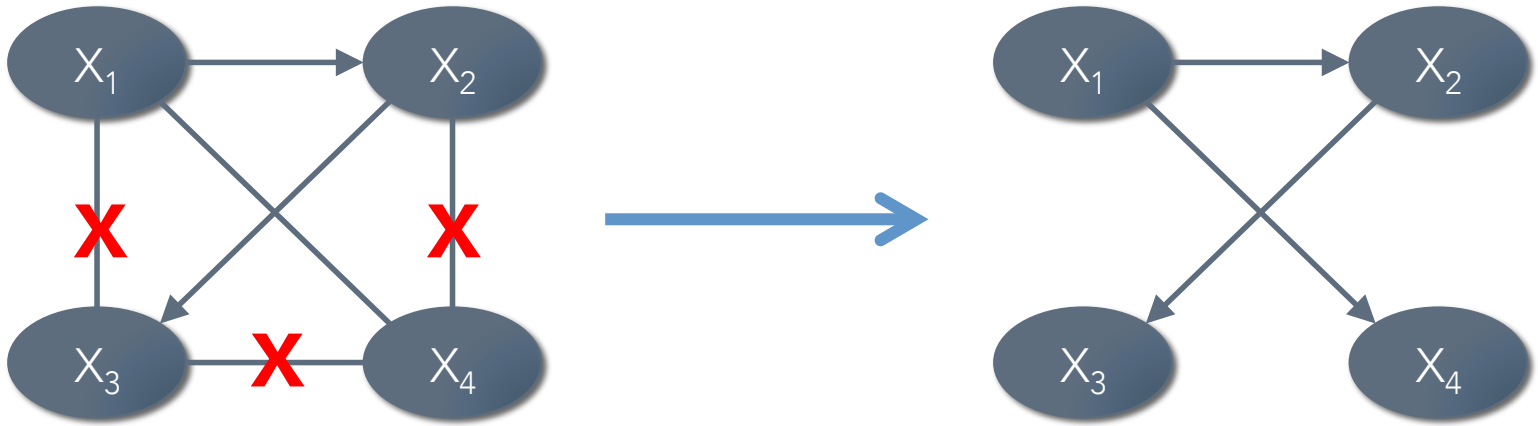
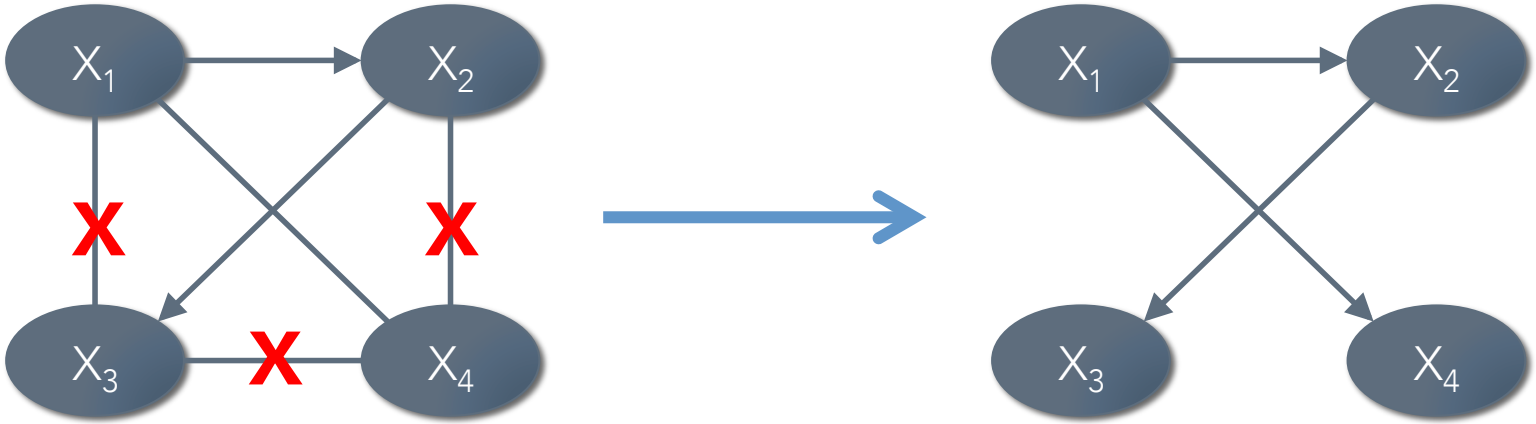


Constraint Based

$Score(G, D)$

Causal Structure Discovery: Traditional to Hybrid Approaches



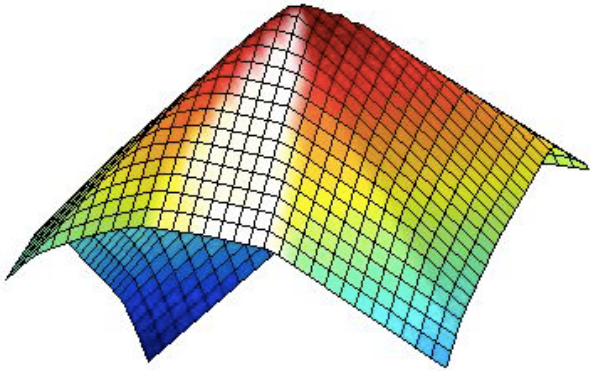
Constraint Based

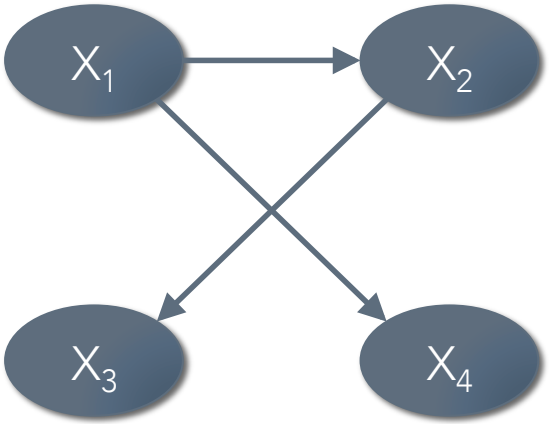
$Score(G, D)$

Hybrid Approaches:

- PC-based DAG Search – Dash and Drudzel, UAI 99
- Min-max Hill Climbing – Tsamardinos et al., JMLR 06

Causal Structure Discovery: Traditional to Hybrid Approaches





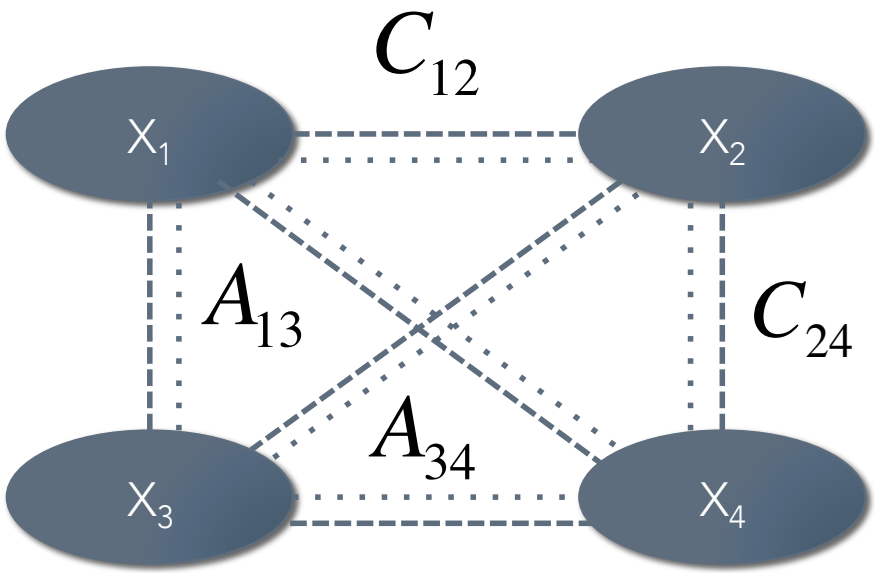
$Score(G, D)$

L1 Regularized Variable Selection and DAG Search – Schmidt et al., AAAI 07

Joint Inference for Structure Discovery

Joint Inference of Variables:

Causal Edge C_{ij}
Adjacency Edges A_{ij}



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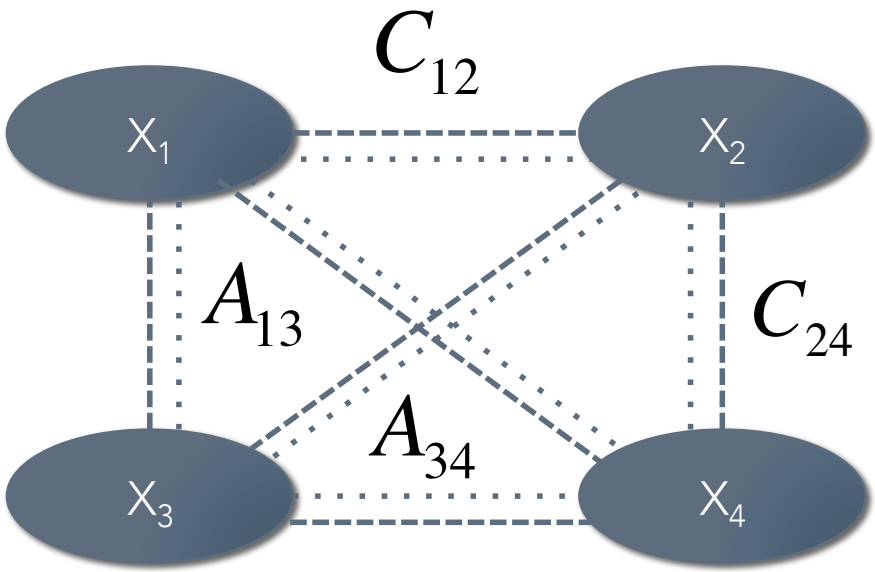

Joint Inference Approaches:

- Linear Programming Relaxations, Jaakkola et al., AISTATS 10

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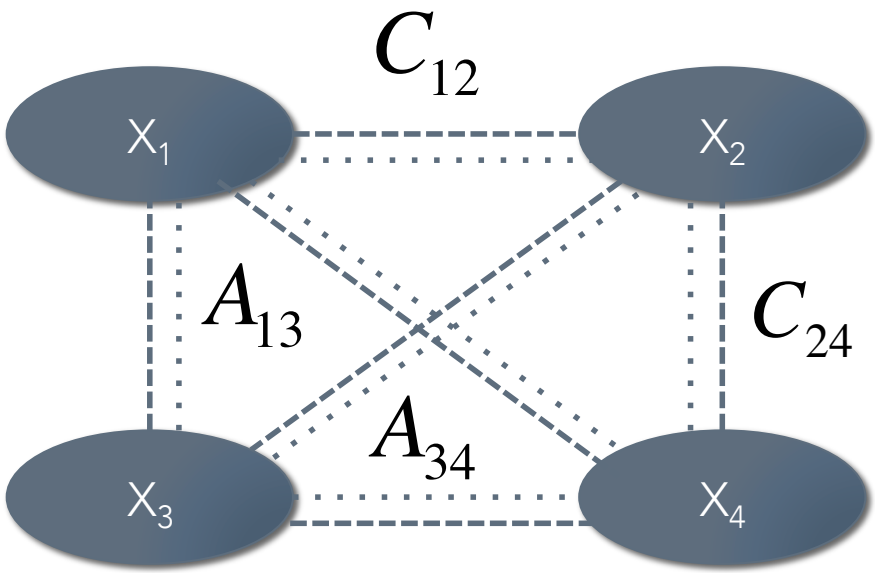
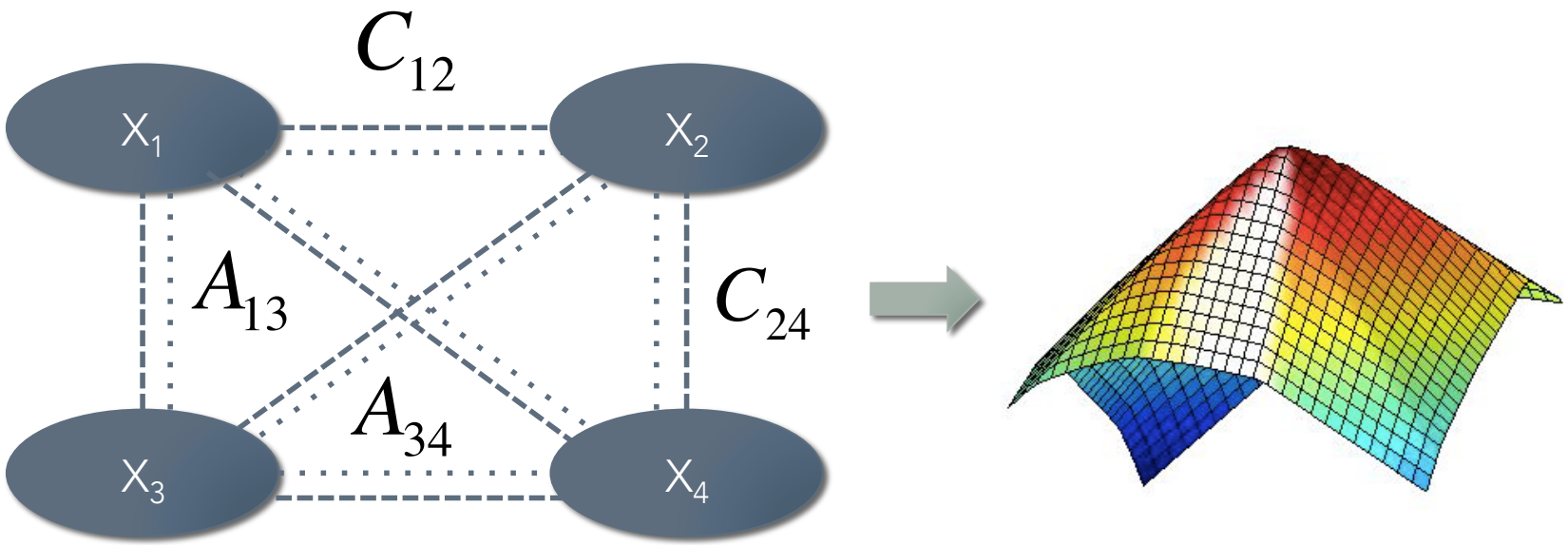


Joint Inference Approaches:

- Linear Programming Relaxations, Jaakkola et al., AISTATS 10
- MAX-SAT, Hyttinen et al., UAI 13

Probabilistic Joint Model of Causal Structure



Extending joint approaches:
probabilistic model over causal structures

Desiderata for Probabilistic Inference of Causal Structure

1. Using d-separation and acyclicity constraints
2. Fitting data
3. Trading off between multiple evidence sources
4. Flexibly incorporating priors and domain knowledge to guide optimization

Discussion Questions

- Q1: Do we need joint inference methods?
  - How do we efficiently enforce global constraints?
- Q2: What constraints and domain knowledge are most important to encode in a probabilistic model over causal structures?
- Q3: How can we extend joint probabilistic causal discovery for latent variables and confounders?