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http://r-bayesian-networks.org/

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BAYESIAN NETWORKS MEET OBSERVATIONAL DATA

ADVANCED METHODS WITH BN MODELING

Outline of the talk

- Mixed models – correction for grouped data
- Heuristic search
- MCMC over structures

- *Other advanced methods/features:*
  - *Scoring system*
  - *Tunable parameter prior*
  - *Structural prior*
  - *Data separation*
  - *Covariate adjustment*
  - *Likelihood contribution*

CORRECTION FOR CLUSTERING

Correction for grouped data

- The way the data were collected has a clear **grouping aspect**
- Then potential for **non-independence** between data points
- Lead to analyses which are **over-optimistic**
- As the **true level of variation** in the data is **under-estimated**
- Could impact study result … or not!
- **Good practice to check!**

In practice:

- Random effect
- **GLM** -> **GLMM** for each node
- Fit the DAG and check the posterior distribution (**widening**)
- If needed one can **incorporate random effect** in the **scoring** scheme

Pitfalls:

- Hugh computational complexity!

ADVANCED METHODS WITH BN MODELING

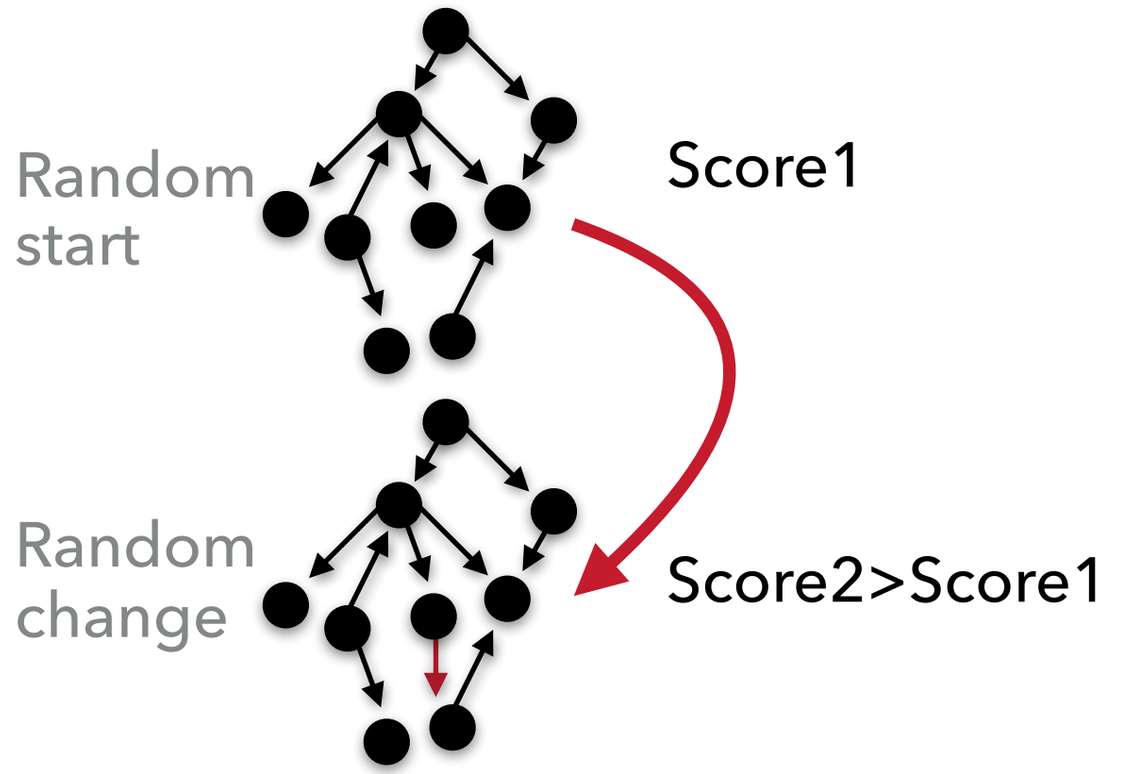
Find maximum a posteriori score

- ✓ Exact search
- ▸ Heuristic search
- ▸ MCMC over structures

HEURISTIC SEARCH

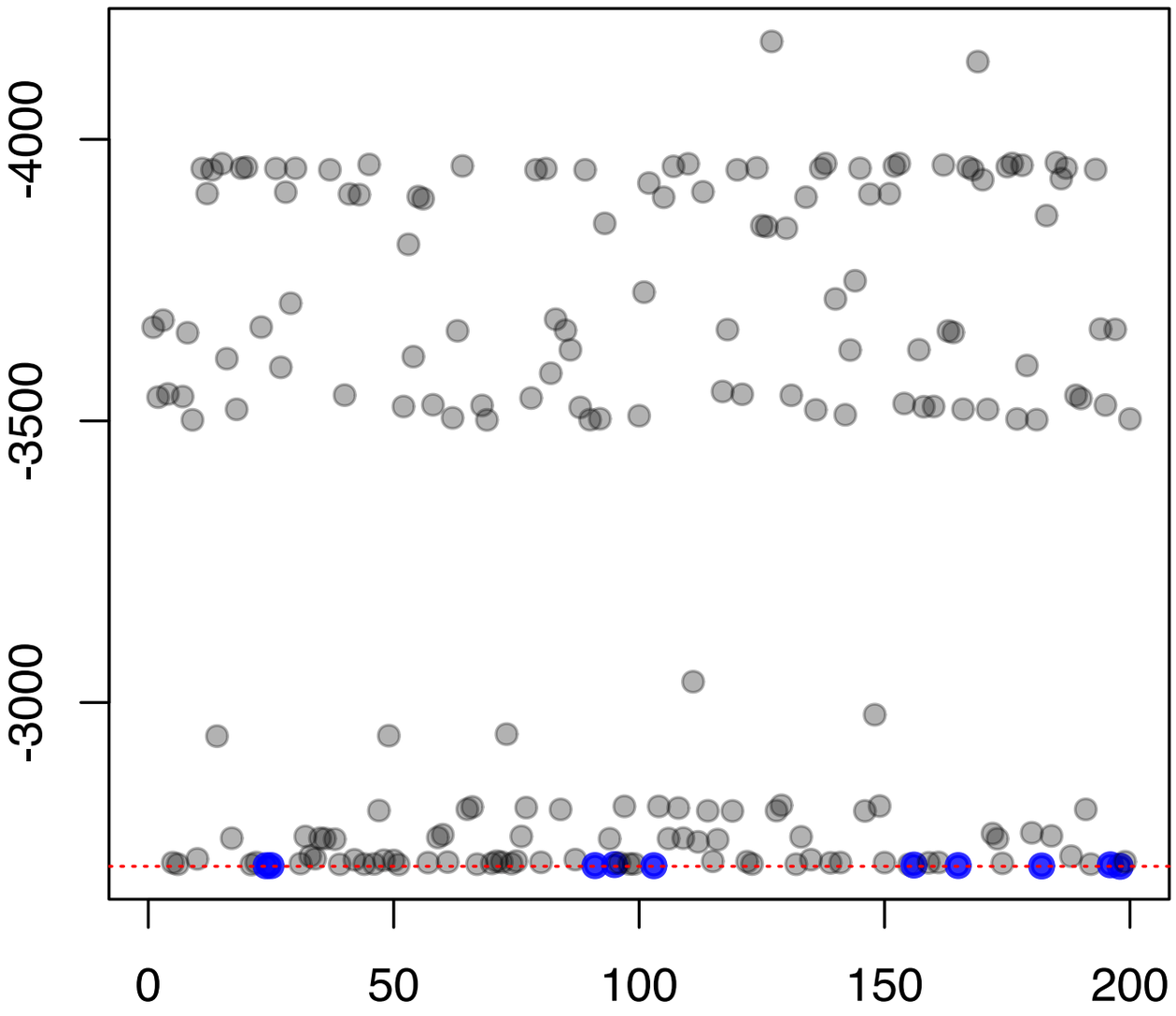
Heuristic search: Greedy Hill-Climbing

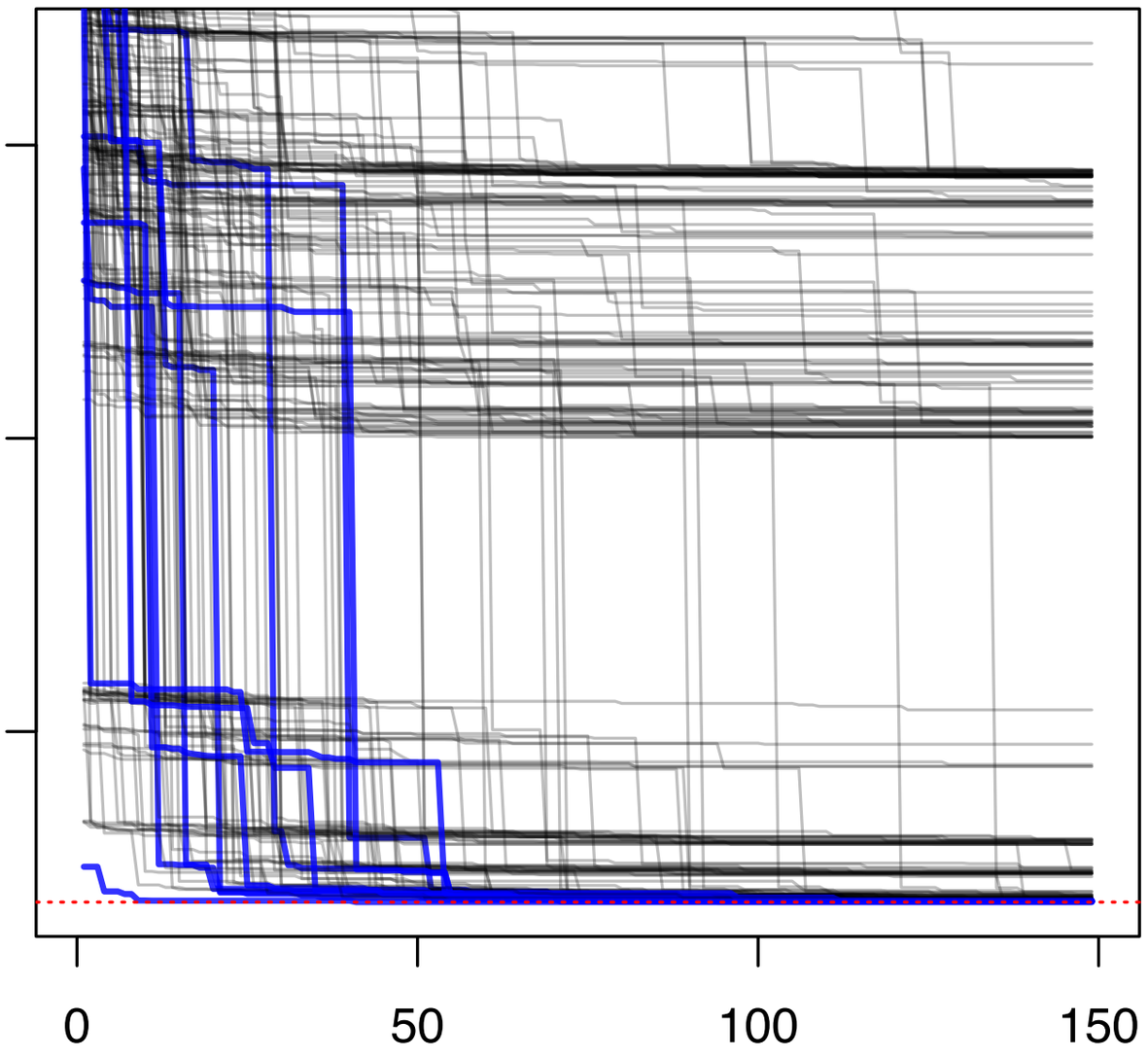
- Simplest heuristic local search
  - Start with a given network
    - empty network
    - best tree
    - a random network
  - At each iteration
    - Evaluate all possible changes
      - Apply change that leads to best improvement in score
      - Reiterate
  - Stop when no modification improves score
- *Pitfalls*:
  - Local Maxima
  - Plateaus
- *Solution*:
  - Tabu
  - Random restart
  - Simulated annealing



HEURISTIC SEARCH

```
num.searches <- 200
max.steps <- 150
heur.res <- quiet(search.heuristic(score.cache = mycache,
                                   score = "mlik",
                                   data.dists = dist,
                                   max.parents = 4,
                                   start.dag = "random",
                                   num.searches = num.searches,
                                   max.steps = max.steps,
                                   seed = 3213,
                                   verbose = TRUE,
                                   algo = "hc"))
```

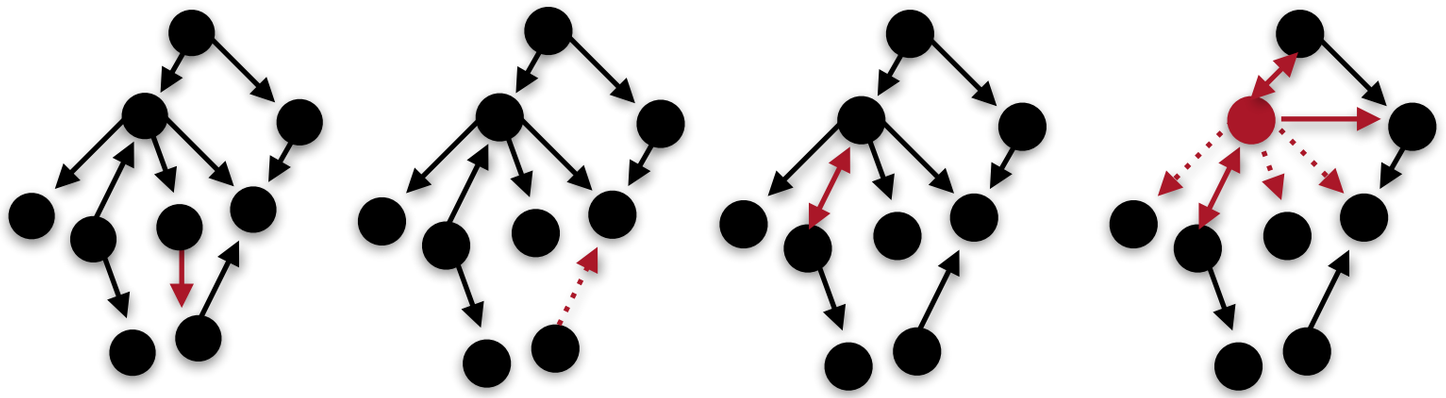




MCMC OVER STRUCTURES

MCMC jumps

=



Moderate downhill steps are usually accepted

Steep downhill steps are almost never accepted

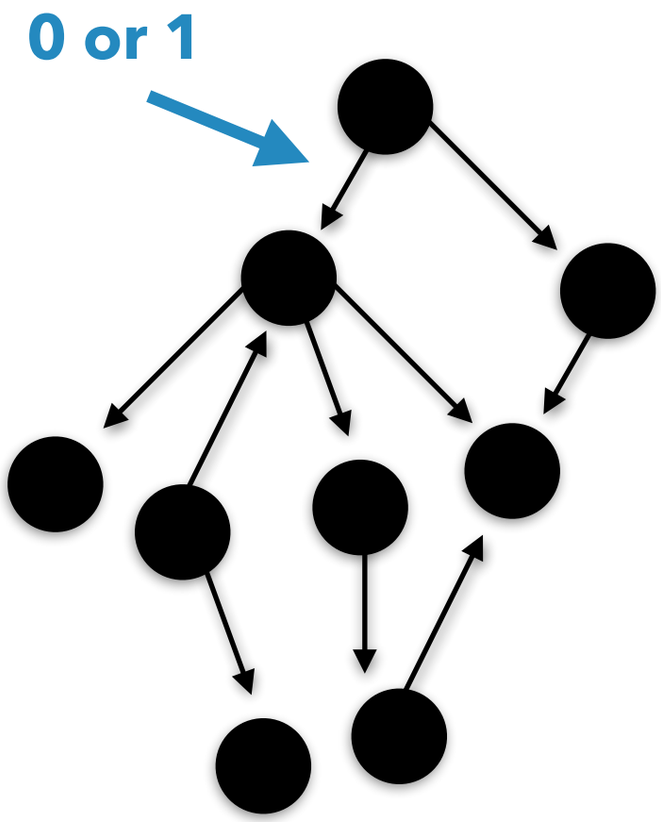
Uphill steps are always accepted

Following these rules, the workers tend to stay near the peak

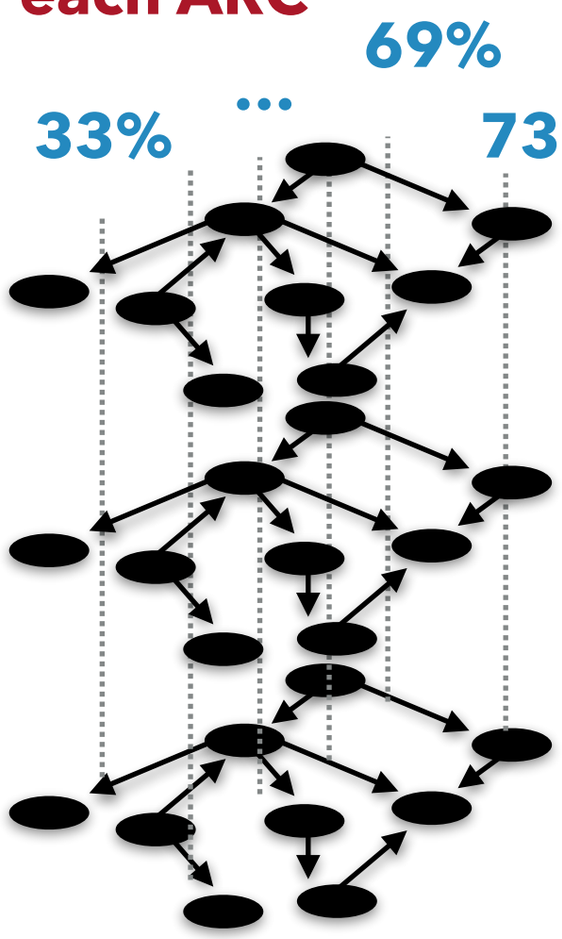
Adapted Lewis (2011)

MCMC OVER STRUCTURES

Best Unique Bayesian Network



Counting prevalence of each ARC



MCMC OVER STRUCTURES

MCMC over structures

- Selecting the most probable structure
- Controlling for overfitting
- Sampling the landscape of high scoring structures
  - In applied perspective avoid reducing the richness of BN modelling to only **one** structure
  - Quantify the marginal impact of relationships by marginalising out over structures

HANDS-ON EXERCICES