In class exercises: Bayes Nets

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25 October 2023

Markov blankets

Given a set of random variables $\mathcal{S}$, the **Markov blanket** of one of the random variables $X \in \mathcal{S}$ is the set of other random variables $\mathcal{S}_1$ such that X is conditionally independent of all the other variables given the Markov blanket $\mathcal{S}_1$. In a Bayes net, the Markov blanket of a node consists of its parents, children, and children's parents, as illustrated in Figure 1.

Question: why do the children's parents need to be included to guarantee conditional independence?

Optional challenge: Prove that this specification of the Markov blanket guarantees conditional independence.

Multiple independent measurements and Bayes Nets

(This is adapted from a problem from Russell and Norvig (2003).)

Two linguists L_1 and L_2 are working on an endangered language, using the same fieldwork protocol P but each working with a different native speaker S_1 and S_2. The language is not used by many members of the community, and the native speakers are elderly, so no one native speaker may necessarily fully remember all of the facts about the language correctly on a given day. The goal is to reconstruct the inventory of the pronoun system for the language. The two reconstructed inventories are I_1 and I_2.

Task: draw a Bayes net for this problem, and critique the research strategy. Could it be improved? How?

The perceptual magnet: speech in noise

The "perceptual magnet" data described in today's lecture are from Iverson and Kuhl (1995). Here is a description of the procedure, taken from Feldman et al. (2009):

> Iverson and Kuhl's (1995) multidimensional scaling experiment was conducted with thirteen vowel stimuli along a single continuum in F1–F2 space ranging from /i/ to /e/...the stimuli were designed to be equally spaced when measured along the mel scale, which equates distances on the basis off difference limens (S. S. Stevens et al., 1937). Subjects performed an AX discrimination task in which they pressed and held a button to begin a trial, releasing the button as quickly as possible if they believed the two stimuli to be different or holding the button for the remainder of the trial (2000 ms) if they heard no difference between the two stimuli. Subjects heard 156 "different" trials, consisting of all possible ordered pairs of nonidentical stimuli, and 52 "same" trials, four of each of the 13 stimuli.

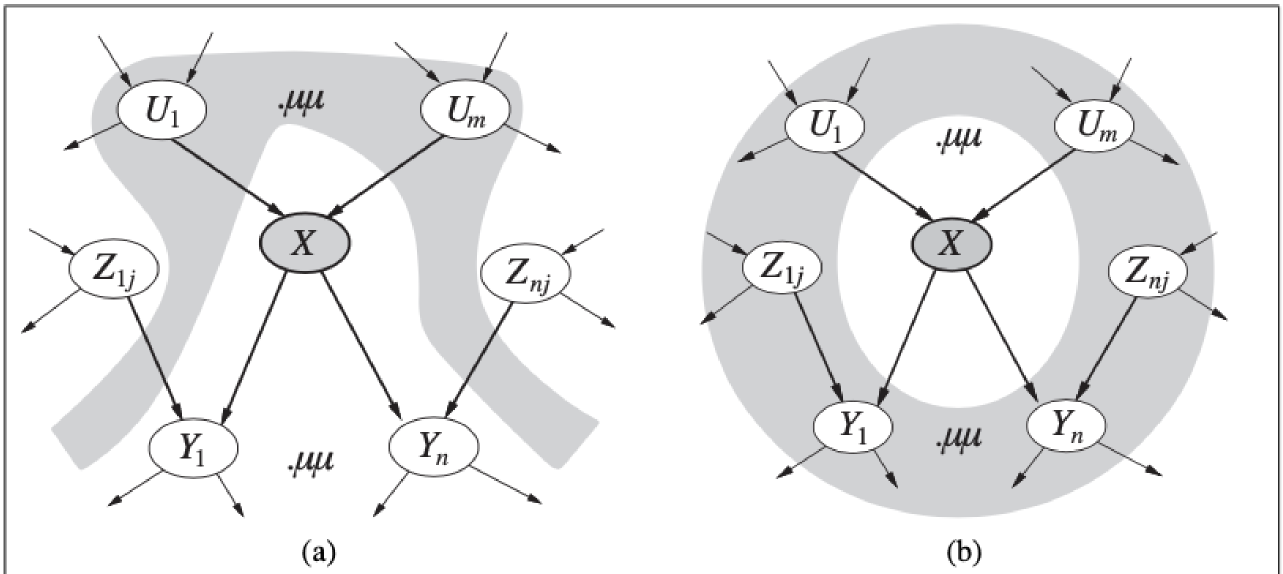

Figure 14.4 (a) A node X is conditionally independent of its non-descendants (e.g., the Z_{ij}s) given its parents (the U_is shown in the gray area). (b) A node X is conditionally independent of all other nodes in the network given its Markov blanket (the gray area).

Figure 1: The Markov blanket of a node in a Bayes net (illustration from Russell and Norvig (2003)).

Suppose we altered the experimental materials by adding white noise to them, so that they are more difficult to hear. What do you predict the effect would be on participant behavior, and on perceptual warping? Why?

The perceptual magnet: multiple tokens

Suppose we altered the procedure of a perceptual magnet experimental trial as follows: each of the two stimuli is presented *twice*: stimulus 1 first plays twice, then stimulus 2 plays twice. The participant is informed that these stimuli will be played in this order.

What do you predict the effect would be on participant behavior, and on perceptual warping? Why?

References

Feldman, N. H., Griffiths, T. L., & Morgan, J. L. (2009). The influence of categories on perception: Explaining the perceptual magnet effect as optimal statistical inference. *Psychological Review*, *116*(4), 752–782.

Iverson, P., & Kuhl, P. K. (1995). Mapping the perceptual magnet effect for speech using signal detection theory and multidimensional scaling. *The Journal of the Acoustical Society of America*, *97*(1), 553–562.

Russell, S., & Norvig, P. (2003). *Artificial intelligence: A modern approach* (Second Edition). Prentice Hall.