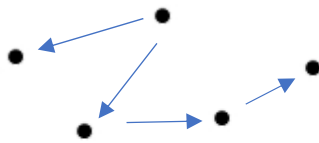


Bayesian nets  
Meeting notes 10/10/2022

Dennis, Zhongming, and Patrick were physically present. Amber was linked by Zoom, and Sophia was under the weather.

A. We started with the big idea—what we're shooting for.

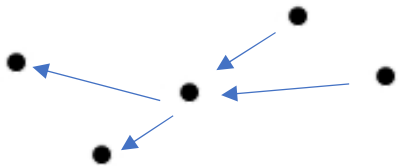
Suppose there is a network that is 'the world': what actually causes what, for example.



nodes are events with certain probabilities. Arrows are conditional probabilities, interpreted as 'causes' (or causes with a certain probability).

We will create this simple 'world' by programming it as a causal Bayesian net.

Now suppose another network that is our 'theory of the world':



Here nodes are propositions (statements) with certain credences (degrees of belief). Arrows between them are conditional probabilities, but here those represent conceptual support: Were my belief in this to increase, my belief in this other thing would too. If this were disconfirmed, my belief in this other thing would diminish.

We program this 'theory of the world' as another Bayesian net.

B. Ideally, we want our theory of the world to match the way the world really is. What we'd like our model to do:

Send evidence from the real world,  
And use that evidence to update and change our theory of the world.

We don't yet know what form that evidence would take, and we don't yet know how to make

a network that ‘hill-climbs’: that tries change in structure (changing conditional probabilities, credences at nodes, adding nodes, changing links) and goes for them if they do better in dealing with the evidence.

C. That’s what we talked about as the big idea. We’ll be doing this entirely theoretically or abstractly (no applications yet, or leave those to others if we succeed), and with very small networks, like 5 nodes or so.

Some interesting questions along the way:

Suppose we start with two radically different theories, but they get the same evidence. Are they bound to converge on their picture of the world?

Or are two radically different theories possible that are each ‘empirically adequate’ to the data? If so, under what conditions?

Are there theories that will never get the picture right because they don’t have the right nodes—they just aren’t dealing with the right categories? One example: The world works in terms of nodes a, b, and c, but our theory just lacks a representation of node b, or treats a and b as if they were a single node...

D. Next steps for next week:

Let this cook in all of our brains, for questions, ideas, all the potential problems...

I gave out copies of Judea Pearl’s *The Book of Why* to read chapter 3. This is a nice simple introduction to Bayesian nets in general.

I asked everybody to look at available Bayesian net software, in order to decide (a) is there something here that we can pick up and use, or (b) should we try to program simple networks and updating ourselves? C++ and Python seemed to be strengths in the group, with R and Matlab on hand for analysis.

**Pyagrum:**

<https://pyagrum.readthedocs.io/en/1.3.1/>

The following is a nice intro, to pyagrum and Bayesian networks in general. Note ‘soft evidence,’ which is probably what we’ll use:

<https://pyagrum.readthedocs.io/en/1.3.1/notebooks/01-Tutorial.html>

Pyagrum is what we used before, which we managed to force to do what we wanted. But we had to go through hoops to do ‘iterated evidence’—a piece of evidence changes the network, then another changes it further—and we could never get it to display conditional probabilities are at a given point.

Other possibilities:

**Bayesfusion** – also free, I think.

[www.bayesfusion.com](http://www.bayesfusion.com)

and with another nice intro:

<https://www.bayesfusion.com/bayesian-networks/>

**Bayesialab** – a couple hundred dollars, but we can afford it.

<https://www.bayesialab.com/home/en-us/>

or **make our own**. With small networks I'm not sure this is out of reach. A main obstacle—'belief propagation'—change one node, which changes another which changes another... Pyagram does this with 'lazy propagation,' but that's invisible under the hood.

E. For next week:

Read Pearl's chapter 3

Check out program possibilities, and go through their nice intros.

We plan on meeting on Wednesday the 19<sup>th</sup>, 11:00 – 12:00. After that Patrick has to be away for a couple weeks to give a paper in Santa Fe, which will be fun for him, and then we'll get back hammer and tongs in November.