Bayesian Belief Networks - Part 2

Tony Starfield

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A few years ago, the Fish and Wildlife service were given the task of looking at the future status of polar bears. The question basically was, "Should polar bears, in the light of climate change, be put on the Threatened or Endangered Species list?" And various offices in the USGS were asked to address different parts of this problem. And one office, in particular, was given perhaps the most difficult problem of trying to predict the future status of polar bears worldwide.

Now, if you think about what their task was, they had time constraints, as we always have in the real world, and they had information constraints, information gaps, if you like. It would probably have been a major research project to try and get into the situation to be able to do a meta-population model of all polar bears worldwide.

So they tried to come up with the best that they could do. And, in particular, the polar bear expert in this office thought long and hard about how he would think through the problem of what might happen to the polar bears in the future, worldwide. And he eventually came up with a very thoughtful influence diagram, listing what he thought were the major influences and drawing the connections between them.

And, at that point, he thought that that was probably the best that he could do. And the diagram was impressive, and it was interesting to look at. But as a tool for making a case, as a tool for influencing the debate about the future of polar bears, one way or the other, it was dead, dead in the sense that it wasn't animated. It couldn't really convince anybody about the argument.

But when the polar bear expert teamed up with an expert in Bayesian Belief Networks, this dead diagram came to life. And what was done in that case--and there's a reference you can read to see exactly how it was done--was to fill in the parameters of the model, the probabilities, on the basis of this one expert's knowledge.

And what came out of it all was a very convincing argument that the future for polar bears was grim. And I'm sure that this argument had an important role in determining the listing of polar bears.

At this stage, you might say, "Yeah, but what about it being just one expert's opinion?" Well, it turned out that one of the great advantages of putting numbers into a model, of populating the parameters of a Bayesian Belief Network, is that you can do a thorough sensitivity analysis.

And so there was a very careful development of worst-case and best-case scenarios. And, perhaps rather surprisingly, it turned out that, even in the best-case scenario, the future for polar bears was grim. So here's an example of, again, taking a conceptual model and turning it into a model that breathes life by enabling you to manipulate it and argue about different cases.

Okay. So the point I'm trying to make here with that example is that Bayesian Belief Networks are just another tool in your toolkit. And along with qualitative models, and along with frame-based models, it is a tool that takes problems where people seem to be comfortable developing conceptual models and turning those conceptual models into animated models, which can actually be used to argue about management options or classification options.

Which tool to use when? When do you want to use a Bayesian Belief Network? When might you actually prefer to develop a spreadsheet model or a qualitative model?

Well, to answer that question, I think one has to realize that there are two main purposes to developing the models. The one is to get your own mind, or small group's mind, around a problem. And the other is to communicate it. And a model that is strong for thinking through the problem might not be as effective as another type of model for communicating the results to stakeholders or decision makers or whoever one wants to communicate them to--the public.

And so, sometimes, it makes a lot of sense to take the same problem and look at it in different ways. For example, one might have a situation where you actually develop a spreadsheet population model. And then for exactly the same problem, you get some of the experts in that particular species to develop a Bayesian Belief Network model.

If it turns out that the two models tell similar stories, then you can decide which of those communicate your results best to the people that you need to communicate to. If the two models produce very different stories, then you're in a situation where you can really probe and figure out what the difference in approach is, what the difference in thinking is between the two groups of people that developed the two models.

And this idea of developing more than one model using different techniques for the same problem is something that ties in beautifully with rapid prototyping because it could well be that

in the early stages of thinking through a problem, you are going to invest your time much more fruitfully in developing two alternative rapid prototypes using different techniques than in taking one technique and pushing it further, say, to the second or third prototype. And that, to me, is yet another reason for prototyping on problems.

So I hope what you're getting out of this is a way of thinking about modeling where small isn't just beautiful, but small is really useful because it gives you enough time and enough money and enough energy to look at a problem using different modeling techniques and compare the results and figure out what really works. If, at that stage you still need a second prototype, you can perhaps run with one of the techniques.

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