Evidence-based decision-making turns knowledge into power

Many professionals rely on their personal experience and knowledge when making critical decisions, yet the underlying assumptions on which these decisions are reached is not always clear. The Bayes-Knowledge project is developing new methods to support evidence-based decision-making, as Professor Norman Fenton explains

A professional called upon to make an important decision in their field will typically draw on their own knowledge and experience, as well as the data available, before reaching a conclusion. Mathematical modelling techniques can give professionals across a wide variety of disciplines stronger foundations on which to make critical decisions, a topic that lies at the core of Professor Norman Fenton's research in the Bayes Knowledge project. "We are building Bayesian networks which allow for the inclusion of expert judgment in identifying variables, for which data may not be available," he outlines. A Bayesian network can be used to model probabilistic relationships; a classic example is the relationship between symptoms and disease. "With the Bayesian network approach, you can infer from symptoms back to cause, or you can predict the symptoms from the causes. You can work both ways, which is what makes it different to the statistical models normally used in medical diagnosis for example," explains Professor Fenton.

Bayesian networks

The project uses this approach to improve evidence-based decision-making, developing novel strategies and so giving professionals a firmer basis on which to reach decisions, even where no data is available. In the absence of data, people often make decisions based on their past experience of similar situations or their gut instinct; Professor Fenton says the project brings the assumptions behind this kind of reasoning into the open. "We're forcing people to ask; 'what are the assumptions I'm making here? What are the causes and effects? What's the justification for believing that if something is likely to happen, then some other thing is likely to happen?'" he outlines. This information can then be used to help improve mathematical models. "Our view is that exposing all the underlying assumptions in your decision-making process helps in improving a mathematical model," continues Professor Fenton.

This is a core part of the project's overall agenda, with researchers bringing together data, expert opinion and risk and uncertainty information to further refine and optimise Bayesian network models. A key aspect of the project's approach is that there is scope to include expert judgment in identifying the important variables in a given situation. "Where there might be limited data, or even no data, we look to augment that with expert judgment," explains Professor Fenton. A good example is modelling the likely progression of a patient with a specific set of symptoms. "A patient may display certain symptoms, and a Doctor will use that to diagnose them and predict their likely health outcomes. They aim to forecast their health prospects, given the presence of these different symptoms," says Professor Fenton. "They'll have data on this, which will inform statistical models describing the survival prospects of a patient displaying these specific symptoms, helping Doctors assess whether they require urgent treatment."

A standard statistical model might not include data on the impact of a particular intervention however, so now Professor Fenton and his colleagues in the project are exploring a new approach. "With our model, we can look at the relevant causal structure of a problem, and realise where certain interventions may have an impact. Even if

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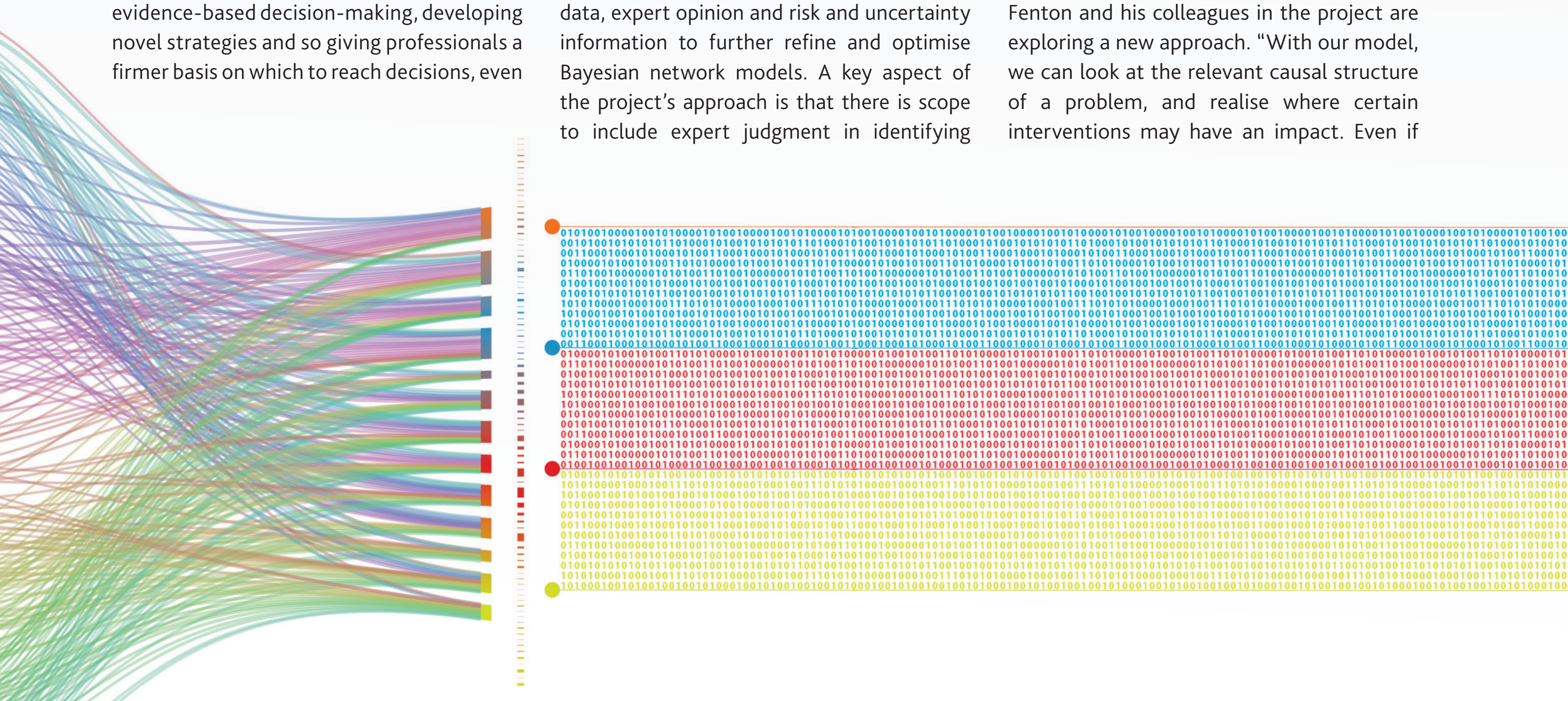


you haven't got specific data on those points, you can use expert judgment about what will happen in cases where you do intervene, given the condition of the patient," he outlines. A medical expert can provide insights into what type of intervention is feasible under which circumstances for example, information which can then be incorporated in a Bayesian network model. "It's about eliciting genuine expert causal knowledge. An expert will know for example that certain things will happen before others, and the impact of certain interventions, while you've also got time constraints to consider," says Professor Fenton.

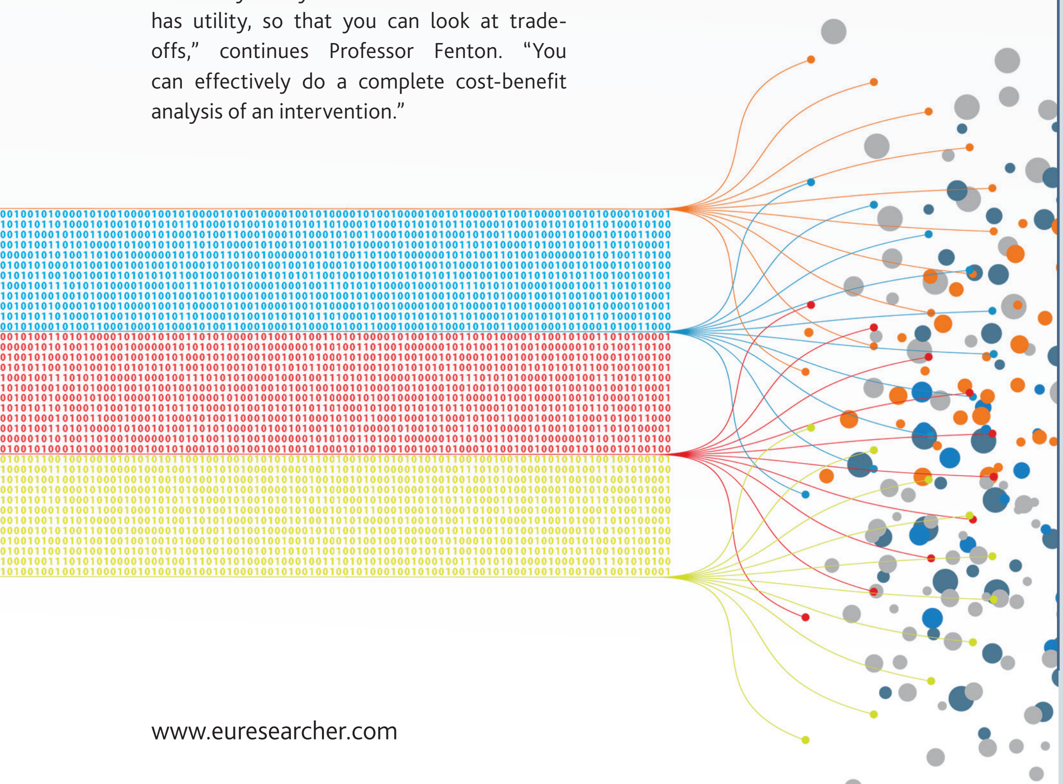
Health economics

This research holds important implications for the healthcare sector, where staff are regularly called upon to make decisions which will not only affect the health of the patient, but will also have social and economic consequences further down the line. A more rigorous method of developing models will give staff more solid foundations on which to take these kinds of decisions. "By incorporating these causal Bayesian networks you get better decision support. It gives you better predictive capabilities and allows you to analyse a particular situation at greater depth," explains Professor Fenton. With the costs of healthcare a major concern across several European countries, Bayesian network models could play an important role in assessing the impact of specific interventions.

"We've achieved much better incorporation of so-called utility decision models, where effectively every intervention and decision has utility, so that you can look at trade-offs," continues Professor Fenton. "You can effectively do a complete cost-benefit analysis of an intervention."

The healthcare sector is a major area of interest in terms of the application of this research, yet Professor Fenton is keen to stress that the methods developed in the project are also being used in other areas. Alongside medicine, the project's methods have been tested on case studies in law, forensics and transport. "We had a six-month programme in the Isaac Newton institute in Cambridge investigating Bayesian approaches to the law," outlines Professor Fenton. These Bayesian network models are also used quite extensively in certain areas, such as in auditing the operational risk of major companies, while Professor Fenton believes there are also further potential applications in government, finance, and other areas of commerce. "Lots of people are interested in doing work using our research in cyber-security. That's an area where I expect to see growth," he says. "We've also just started a major EPSRC project called PAMBEYSIAN, which is about putting these Bayesian network-based models into small medical devices in the home."

This is part of wider efforts to reduce the burden of care on the NHS by moving the management of chronic conditions into the home. The challenge here will be to create a decision support system that ordinary people, the vast majority of whom will not be medically trained, can easily interact with. "It's about dealing with all of that complexity and providing the simplest possible inputs and the simplest possible outputs, so that people know when they need to take their medicine, to increase the dose, or to contact their doctor," explains Professor Fenton.



BAYES-KNOWLEDGE

Effective Bayesian Modelling with Knowledge before Data

Project Objectives

The Bayes-Knowledge research team uses Bayesian Networks to assess risk and aid decision-making in a wide range of applications. Bayesian networks are built on a structure of causes and effects, into which information of many types may be integrated.

Bayes-Knowledge methods bring together data, expert opinion, risk and uncertainty into a formal statistical framework, allowing decision-makers to see their choices clearly.

They may be used in the same way as classical methods, where data is the primary source of information. However, Bayesian Networks can also handle those scenarios where data are sparse, or unreliable, by allowing other sources of information to be tapped.

The research team develops novel strategies for Bayesian Networks, using new algorithms to extend and refine the use of Bayesian Networks in decision-making.

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Professor Norman Fenton

Norman Fenton is Professor of Risk Information Management at Queen Mary London University. He works on quantitative risk assessment, which typically involves analysing and predicting the probabilities of unknown events using Bayesian statistical methods. This type of reasoning enables improved assessment by taking account of both statistical data and expert judgment.

BAYES KNOWLEDGE