

Presenter: Professor Maria Garcia de la Banda - 2017

Title: Optimisation technology (15:03)

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00:09	Thanks-you very much. Hello everyone. My name is Maria Garcia de la Banda and I'm a professor at Monash University in the Faculty of Information Technology. Great to see that everyone managed to find a seat and in doing so you just solved a combinatorial optimization problem, and what is that? Well it's a problem when you need to make a choice. In this case pick a seat among a lot of different possibilities. All the seats in this lecture theatre. Now possibly when you enter how do you do that?
00:41	Well the first thing that you probably did was eliminate any seat that was already occupied. That's what we call a constraint. Only empty seats can be part of the solution. But even then I'm sure there were a lot of different places available, different seats that were empty. So how is it you ended up where you are? You probably put your preferences or the organisers preferences on top of those constraints or perhaps you came in a group and therefore you were not just looking for any empty seat but an empty seat that had enough empty seats around to sit together.
01:18	Or perhaps you like to be up close and personal and you ended up, up the front where you could hear and listen properly. Or perhaps you don't like disturbing people or you like to stretch your legs and you ended up on an aisle where you can come in and out easily. This combinatorial optimisation problem where you need to make a choice, pick a seat, satisfy certain constraints, only empty seats and optimise a particular objective function, your preferences, is something that occurs every day in our lives.
01:54	Inside and outside work. It's pervasive. We are pretty good at solving many of them but there are some that we cannot solve. Navigation tools are something that I'm sure that you are extremely familiar with. What's the problem here? I want to drive from point A to point B. The constraints are quite simple. We need to be on a road. Hopefully in the right direction. Start at point A and go all the way to point B. Those are the constraints but even with those constraints there are a lot of different possibilities available still.
02:27	Google here is providing several but in fact you can go from Acland St to Monash University via Sydney. That's a possibility so what do you do on top of all of those constraints? You put preferences. Now some navigators allow you to say, 'give me the shortest path' or 'give me the fastest path', or 'give me the path that is the cheapest'. I don't want to pay any tolls. Or 'give me the greenest path' that uses the least amount of fuel consumption. That's great. These tools as I am sure that you have experienced are fantastic and have improved enormously people's lives. They definitely have improved mine.
03:08	I have zero orientation sense and I get lost all the time but using this I now can go to any city in the world and I'm reasonably confident that I can get where I want to be without getting lost a hundred times or having to ask some people. So that is fantastic but as I'm sure you also have experienced they don't always provide you with the best solution. Right. So if you know the neighbourhood you can probably find something that is a bit better but the difference between an optimal solution and the solution that they provide is not that different.
03:40	The slower path might make you wait for ... I don't know a few seconds or a minute and that is not going to kill you unless of course you are at the back of an ambulance in a critical condition. But in general there fine and you know you can cope with it and it's perfectly good. So one could say that having automatic tools that solve this combinatorial optimisation problem is fantastic even if the solution they provide is not an optimal one. It's you know, OK.

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04:08	And I would say yes and no. Yes having automatic tools that solve these problems is fantastic but not all combinatorial problems are solved automatically and even if they are solved automatically the impact of having a 'not so good' or a not a high quality solution can be quite amazing. Think for example you are in the enviable position of planning a holiday. You are actually planning a holiday to Seville and lots of things to organise. You need to first figure out how are you going to get there?
04:41	So I want all the possible combinations, boats, planes, etc. What do you want? You want to be there reasonably fast, reasonably direct and not spend a fortune. Right? Still lots of different companies and flights. Can you go via Singapore or Hong Kong? Lots of different possibilities. Once you get here you definitely want somewhere to stay. Something that is reasonably comfortable, close to the action and not too expensive.
05:11	Again, Hotel, Hostel, Air BNB, serviced apartment, there are a lot of different possibilities. And how do you get from the airport to this place? You can use in Spain, a train, a bus, a metro. You can rent a car and then use it afterwards. How to solve this is something we do quite often but there is no automatic solution for that and yet solving it is quite easy. Right? We do it every time. You could just go to Google and pick the first thing. The first flight, the first accommodation, the first transport from the plane to this place.
05:49	Not a problem but chases are that the quality of that solution is going to have an impact in your pocket. You will probably end up paying 100's or 1000's of dollars more. You might spend a lot of time lost in some airport waiting for something or you might have a lot of sleepless nights when the apartment or the place that you hired was not all that good. So sometimes having a not so good, a poor quality solution can have a massive impact. And yet the fact that there is no automatic way of solving this as yet, well who cares. The world has more important things than you know helping people with their holidays.
06:31	That's true, but there's many, as I said at the beginning, these problems occur in many different areas of life. Not just for individuals but for organisations, for Governments all over the world and sometimes the impact of these poor solutions is just really really high. Think about you are, for example an airline. A big airline company like QANTAS and you need to schedule all your planes and all your staff divided into crews for those planes in such a way that they cover all the agreed routes and satisfy all of the constraints of human resources, fuel etc. and reducing costs and reducing delays etc.
07:18	The difference between a high quality solution and a poor quality solution might mean that QANTAS as to buy three more planes and hire 200 more people which is pretty significant. That is millions of dollars and a lot of regulations to satisfy and yet you think that it is only money. It's a company. It's only money they can pay it. Well yes but sometimes the impact is more personal.
07:46	Imagine then that you are a cancer institute like Peter MacCallum and you have to figure out how many radiation points to put on a tumour so it covers as much as possible of the tumour while minimising the effect or the impact on the healthy cells around [the tumour] and not just how many points but where exactly those points in the tumour are going to be and how much radiation you are going to provide for those points.
08:16	The difference between a bad solution and a high quality solution might end up saving the lives of people or improving the quality of life until they die significantly and that is very worth [the effort]. So considering that they are everywhere and that they appear in every single area and they are so important and have massive impact you would expect optimisation technology to be the talk of the town right? Everyone knows about it. Everyone is using it. Everyone knows about how to contact the people who are going to make life much better and yet it is not.

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08:53	It is what I call the great unknown. Most people now days have heard about data science and data science encompasses many things including optimisation but the focus right now appears to be mostly on machine learning, on data mining, on data analytics and things like that. Optimisation is not even part of the picture. Definitely not part of this picture. It doesn't even appear there. And yet there is a huge amount of industry, of Government organisations that are making do with really poor solutions and who could do much better if they had optimisation technology.
09:30	So ... what's going on? You might think, well the technology is not there yet? Perhaps it is not good enough? But it is. Mathematicians and Computer scientists have been working for a very long time to make this technology really, really good. Yes it is true that you might not be able to find optimal solutions for all problems. These problems are incredibly complex and they grow exponentially. They might start with 100's, very quickly they go into the millions and very quickly the choices, the amount of possibilities are bigger than the number of stars in the universe.
10:03	So yes ... computational power is an issue but the technology is definitely there for finding much better solutions to everyday problems. So why is it we are still with the great unknown? Well I think that it is mainly because of two things. The first one is expertise. The amount of expertise it takes for a person to go from the problem description to a solution using optimisation technology with a high quality solution is actually a lot.
10:35	In fact you probably need at least one PhD to be able to put together modelling languages, the algorithms and all the software tools that are going to give you the high quality solution and that is really a little bit too much expertise. The solution is to have more research, more people, more students coming into this incredibly important area and making sure that computer science makes the advances they need to connect the mathematical theory with the practical tools so people without so much expertise can look at the problem and can generate a solution that would be of high quality.
11:11	That is number one. The number two issue is what I call 'The great unknown', is to stop optimisation being the great unknown and making sure it is in the spot light. Right there. The second problem is that most organisations as I said have not even heard about it. So we need to connect organisations with optimisation. We need to shine really bright lights on optimisation to make sure all these companies and all these governments know that optimisation technology is there and is ready to make the problems better. To give them much higher quality solutions than they have.
11:50	One of the most satisfying things that I have done in my research career happened last year when I was on a sabbatical [I was so lucky] in Spain with my partner who happens to also be a Professor in computer Science. We have fantastic dinner conversations and he was contacted by the United Nations High Commissioner for Refugees. In particular by the income management and fund analysis section who have the enviable position of having to distribute all of the donated money to the different refugee needs which as I'm sure you know are many.
12:25	Often very urgent and always very critical. So you would think that given that the aim is to spend all the money that is donated that that's pretty easy right? You just get all the money and you start spending on all those very terribly important things until you run out of it. Unfortunately not the case. Not so easy. Why? Because the money that is donated usually has strings attached, meaning that the money is donated for a region or a country or perhaps a particular crisis and you cannot transfer money from bucket of donations to another bucket of donations willy-nilly.
13:01	You have very, very particular rules of if I've donated for this then what can I move it to afterwards. So you might end up with something like \$25 million surplus in Syria while you still have \$50 million that you need but you cannot find in say South Sudan. That's a situation that you don't want to be in. The United nations does have a solution that helps them solve this problem. It doesn't used optimisation technology or rather didn't use optimisation technology. Last year this solution would have left \$500 million euros unspent.

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13:44	There donated but not being able to get to them. We spent a month with emails trying to understand the problem. Trying to understand exactly what it is they needed and work that could have been reduced if you compress it up to about a week. In a week of work using our optimisation technology which is based on the MiniZinc language that we have developed here at Monash University and Melbourne University and Data61 [Data61 Decision Sciences] in collaboration, we managed to reduce \$500 million to \$100 million and that meant that \$400 million euro were able to be spent on all the needs of all these amazing people that were suffering so much.
14:26	And for me that was the best reward my career could have had. Much better than a grant or a paper or anything else accepted and that is why we need more researchers in this very important field. More organisation need to know that they just need to contact optimisation experts and
14:52	they will have amazing results. Thanks for listening.