InFoMM
Industrially Focused Mathematical Modelling

UNIVERSITY OF OXFORD

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I graduated from Harvard in 2012, where I majored in mathematics and minored in astrophysics. I spent two years working as an investment analyst in the United States before coming to Oxford to pursue my DPhil as part of InFoMM's first Cohort.

Given that my undergraduate studies were in pure rather than applied maths, I found the taught component of InFoMM to be essential in getting up to speed with topics and techniques in applied mathematics. I enjoyed the courses close to my interests, such as graph theory or probability, but also the courses on numerical techniques that introduced me to new areas such as numerical linear algebra and finite element methods. Many of these courses had group assignments, which included modelling the production of sugar from sugar cane and implementing deep learning techniques for data classification. For me, these collaborations with others in my cohort — and learning how to work in teams of people with different personalities — were a highlight of the first year.

In addition to these mathematical courses, I also attended skills training sessions with others in my cohort. I found the courses on teamwork, project management, and outreach to be especially interesting and relevant both for my DPhil and for my future career.

After the training phase of the CDT came the two 10-week miniprojects. For one of them, I worked with Thales UK in Crawley, investigating how to separate or "deinterleave" signals coming from different radars in an area. This problem is relevant in military settings, where it is crucial for a ship to distinguish civilian radars from enemy sources. I used statistical methods to improve the process of clustering radar pulses in order to deinterleave the signals. The new approach gives higher detection accuracy on simple test problems compared to existing methods. This mini-project work resulted in an internal review of the deinterleaving algorithms used by Thales.

My other mini-project, with dunnhumby in London, led to my ongoing research project on the topic of consumer behaviour. I use anonymised transaction information to construct networks of customers and products, where connections indicate purchases that occurred in the past (see figure 1 overleaf). The goal of the project is to identify groups or "communities"

Roxana presenting her mini-project results

Roxana receiving a prize at the UK Graduate Modelling Camp 2015

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of customers who shop for similar products, and what these shared product groups are. This information can feed into a system of personalised product recommendations, where consumers are recommended items that others similar to them have purchased. It can also suggest new "segmentations" or groupings of customers and products, which are used by stores for business planning. Mathematically, I study bipartite networks. These are networks with two types of nodes such that connections only occur between nodes of different types. Examples include a network of airlines connected to airports they service, researchers connected to papers that they wrote, or indeed customers connected to products that they bought in the past. Mathematical insights from my work will be useful for all these applications. In terms of consumer behaviour, my research so far has revealed two groups of customers with distinctive shopping patterns: a group of price-sensitive customers with preference towards snacks and ready-meals, and a group of people more likely to buy produce, fresh meat, and other ingredients for cooking at home. I presented these findings at the British Applied Mathematics Colloquium in 2016, where I won the “best poster” award.

Company interactions are key to the success of my research project. I give short updates to my industrial supervisors every fortnight, and I visit dunnhumby's London office frequently. I have given two presentations so far to the Data Science

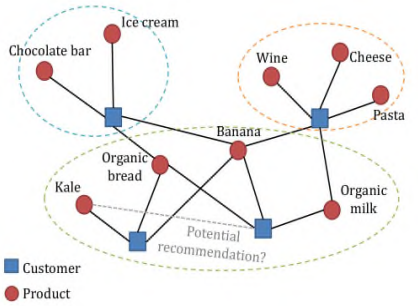
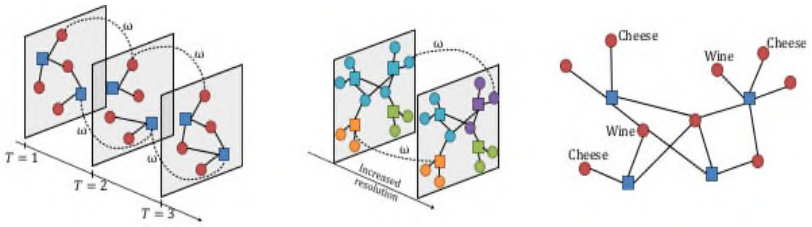


Figure 1



Time dependent networks | Multiscale networks | Annotated networks

Figure 2

team in the company, and will give another one in February. I had discussions with various employees on how to validate the results of my research project, how to use the results of my work to improve existing recommendation systems, and even how dunnhumby can use network science techniques elsewhere in their work.

After my DPhil, I wish to work as a researcher or data scientist within a company. Through InFoMM, I am able to learn about how maths is used in different industries, by meeting representatives from a variety of companies and keeping up with the research work of others in my cohort. My favourite events have been InFoMM Project Presentation Days where InFoMM students give talks on the outcomes of their mini-projects. They are a rare opportunity to see 10-12 talks on different areas of mathematics applied to diverse problems in industry.