# Understanding Multi-Modal Data for Social and Human Behaviour

**Newton Gateway to Mathematics**

## BACKGROUND

A vast amount of data on human activity is captured by sensors, cameras, computers, and smart phones. This data is typically high-dimensional, sequential, complex, heterogeneous, and multimodal (for example, comprising images and text) in nature, but of small sample size. New techniques for predicting patterns, and thus extracting meaningful and useful information from this "data deluge" are emerging, providing a huge opportunity for significant societal benefit. One such tool is Rough Path Theory, a sub-branch of stochastic analysis, which can be used to describe complex behaviour concisely.

In November 2018, as part of the four-month Isaac Newton Institute Research Programme on Scaling Limits, Rough Paths, Quantum Field Theory, the Newton Gateway, in partnership with BAE Systems, organised a one-day "Open for Business" knowledge exchange workshop. The aim of the event was to raise awareness of the wide range of potential end-user applications of Rough Path Theory.

## CHALLENGES

In the rapidly moving field of data science, Rough Path Theory can add significant value to existing methods. There is a rich range of real-world streamed data, which, for example, can be recorded at different times and in different amounts. In contrast to conventional methods for describing sequential data (where order matters), it can efficiently describe this data in terms of the sequence of events without introducing a parameterisation, resulting in a massive and controlled dimension reduction. These simplified "top-down" descriptions of the data offer great potential for facilitating the use of data science in understanding social and human data.

Modern life presents many serious data challenges. Specific areas, where Rough Path Theory has been used to summarise large complex data, highlighted in the event talks included:

- Diagnosing mental health conditions, such as bipolar disease, using data from smartphone mood diary apps or audio recordings.
- Predicting early-stage Alzheimer's disease from brain imaging data.
- Recognising Arabic and Chinese handwriting on a mobile device, and translating finger movements into characters.
- Classifying human movement from video data, which is typically of 30-75 dimensions, without using personally identifiable data.
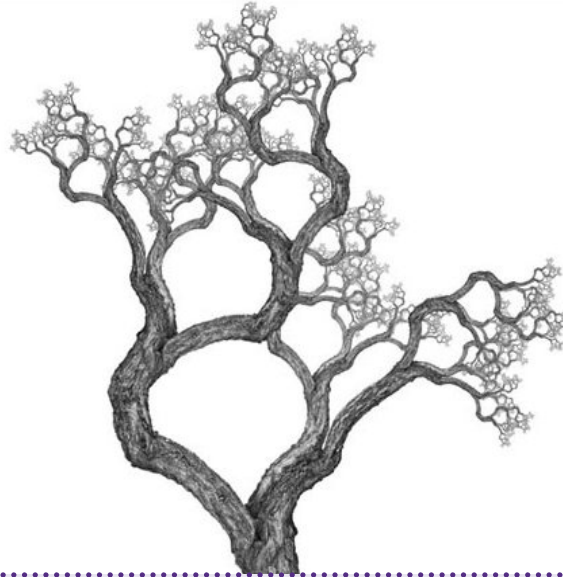
> "The workshop was marvellously useful, and brought us into direct contact with several companies. I have used the website and the recorded talks a number of times to help clinch relationships, bringing organisations on board as project partners for a 5-year £4.1m EPSRC Programme Grant. The truth is that your help was wonderful, the right break at the right time".
>
> **PROFESSOR TERRY LYONS**
> **UNIVERSITY OF OXFORD**

## ACTIVITY

The event brought together nearly 50 researchers, representing 23 different institutions, from mathematics, statistics, computer science, psychiatry, and engineering with a high number of stakeholders from the public and private sectors. These included representatives from a variety of different sectors, including engineering, finance, food, health, pharmaceuticals, and security.

The programme spanned Rough Path Theory and its application to a variety of real-world problems. The first half of the day included presentations from academics from UK and Chinese universities who outlined the state-of-the-art research, and provided success stories of applications of the research. These talks were chosen to assist end-users with visualising and articulating their own data challenges in this area.

Following a lunchtime poster session, the second half of the programme comprised end-user talks from the security, safety, and human health and behaviour areas. Presentations were given by a combination of academics and stakeholders from the private and public sectors. Diverse topics included using video analytics to automatically detect early-warning signs of unsafe worker behaviour and classifying and monitoring dynamic trading strategies. The day concluded with a discussion and wrap-up session, and extended networking.

## IMPACTS

Benefits of the event included participants developing a better understanding of Rough Path Theory and its applications, and how it could potentially be deployed in their area of work. 100% of survey respondents reported that the event had met their expectations, and 75% of participants said they had heard an idea or challenge that was of particular interest to them. The workshop provided an ideal knowledge exchange opportunity for academia, industry, and the public sector to share current practice and successful case studies of Rough Path Theory, with 75% of participants making at least one new contact.

Several ideas for promising topics to explore at future meetings were identified, including how Rough Path methods might cope with fake or poisoned data, and applying the theory to predict competitors' courses of action, quantify portfolio risk, and analyse facial data.

*"The Rough Paths event was a very effective way to understand an emerging technique that could have significant impact on our work. As ever with Newton Gateway events, the organisation was exemplary and there was a good cross-section of the key academics in the field present together with representatives from a wide range of other companies.".*

**DR NICK EASTON,
ENGINEERING DIRECTOR,
BAE SYSTEMS APPLIED INTELLIGENCE**

*"The whole thing was incredibly useful. This has been one of the best events of this type that I have attended."*

**PARTICIPANT FEEDBACK**

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