# Predictive Neural Network Modelling of Spatio-Temporal Point Process Data with Self-Excitation Behaviour, with Applications to Crime Data Modelling

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**Abstract**

Many human behaviours, such as social media activity, house sales, even criminal and terrorist activity, exhibit spatio-temporal clustering phenomena, and understanding the nature of this clustering behaviour can provide important sociological insights. Spatio-temporal clustering of crimes and terror attacks can be due to global underlying factors, such as increased social unrest, or they can also exhibit so-called “self-excitation” behaviour, where one criminal act implies that another is more likely. In this work the CANSSI Distinguished Postdoctoral Fellow (CDPF) will investigate self-exciting patterns of criminal-event occurrences in a spatio-temporal context and use neural networks to characterize such behaviour, especially the explicit spatial extent of the self-excitation.

**Interdisciplinary/Applied Experience**

The CDPF will study and develop statistical methods that are relevant to the given data. The CDPF will ensure data quality and discuss the results with subject matter experts to ensure alignment between our goals and the needs of the communities prior to dissemination of the work.

We will collaborate closely with Dr. Tarah Hodgkinson, who is an Associate Professor in the Department of Criminology at the Brantford campus of Wilfrid

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Laurier University (WLU) with research on community safety, the effects of crime in equity-deserving communities, and spatial criminology. The CDPF will regularly travel to meet with them and their research group.

Given the geographical locations of the supervisors and collaborators, the CDPF will spend more time at WLU in Waterloo, Ontario, and will have extended visits with Dr. Ward and their research group at Simon Fraser University in Burnaby, British Columbia, with an expected split of 60/40.

**Teaching/Training/Education**

**Teaching**: The CDPF will teach one three-credit course at WLU during the first year. The CDPF will also mentor students in the supervisors' research groups as well as students participating in case-based competitions.

**Training**: The CDPF will use industry-standard data science tools/methods and cluster computing platforms. They will gain experience in manuscript preparation, grant writing, and presenting their research at their supervisor's research group and at statistical conferences.

**Education**: The CDPF will have funding support to attend conferences and give presentations whenever relevant, and to attend workshops relevant to both their research and their teaching, such as the instructional skills workshop offered regularly by SFU.

**Mentoring**

Dr. Becker will provide guidance on statistical machine learning methods. Dr. Ward will provide guidance on network point and Hawkes processes. Dr. Wang will provide guidance on self-exciting point processes. Collaborator Dr. Tarah Hodgkinson, an expert in crime prevention and reduction, will provide the data and guidance on the applied aspects. Collaborator Dr. Joan Hu, an expert in statistical methodology for event history analysis, will provide further guidance on theoretical aspects of point process modelling.

When the CDPF is at WLU, Drs. Becker and Wang will meet with the CDPF bi-weekly, with monthly remote meetings with Dr. Ward. The mentor (Dr. Wang) will be closely involved in supervision throughout. The CDPF will be encouraged to steer the goals as they learn more about the subject matter and the nature of the data. The visits to SFU will occur early in the research so that the CDPF is exposed to Dr. Ward's perspectives on network data modelling and Hawkes processes, and later in the research to ensure that the spatio-temporal approaches being investigated are appropriate and rigorous.

WLU and SFU will provide office space and organize seminars with invited speakers from academia and industry, giving the CDPF opportunities to engage with participants and learn about current research in statistics and data science. Both universities' career centres offer training in CV writing, job searches, and interview skills. The CDPF will also be expected to attend CANSSI training and workshops.

**Schedule**

**Year 1**: The CDPF will be at WLU in Waterloo, with a visit to Burnaby in the first summer.

**Research:** Review literature related to the project, including Hawkes processes, spatio-temporal machine learning for point processes (with possible review paper), and sociological theories of crime. Fit preliminary models. Meet with collaborators to ensure alignment with goals.

**Teaching:** Prepare and deliver one course, participate in pedagogical workshops/training modules.

**Development:** EDI training, career planning training, mental health training, seminars offered by the Office of Research Services at WLU. Attend statistics conferences.

**Year 2**: At least one term at SFU.

**Research:** Refine models according to the data. Write results in a technical paper and disseminate a non-technical paper to subject matter experts.

**Teaching:** Mentor graduate students working on related research projects.

**Development:** Career development and job search support, present research at statistics conferences.

**List of Desired Qualifications**

- A PhD in Statistics, Data Science, Mathematics, or related field
- Expertise in neural networks or related specialization within statistics/data science
- Familiarity with point processes, stochastic processes, advanced probability theory, or related specialization within statistics
- Strong programming skills in Python, R, and/or Julia
- Good verbal and written communication skills
- A proven publication history (or the potential for one)