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## Theoretical Advancements in Hawkes Processes and Their Practical Applications

**Abstract.** Hawkes self-exciting point processes have been widely used in fields such as seismology, finance and social media analysis. Despite decades of research focusing on these processes, several key aspects remain under-explored. These include broadly applicable methods for model evaluation and selection, intuitive nonparametric inference approaches akin to kernel density estimation for probability density functions, and strategies to enhance the performance of generative point process models in predictive tasks.

First, we extend the time-rescaling theorem, which is traditionally limited to non-terminating processes with complete observations, to accommodate terminating processes and incomplete observations as well. This extension allows for more robust model validation across diverse contexts, especially for Hawkes processes intended to model real-world, event dynamics.

Second, we propose a nonparametric, kernel-based intensity estimation algorithm tailored to Hawkes processes. The algorithm iteratively updates declustering probabilities and estimates the intensity function of such processes with rigorously derived kernel weights and established asymptotic properties. Its simplicity and flexibility make it a valuable tool for many real-world scenarios.

Third, we study the first- and second-order moments of counting processes associated to Hawkes processes and provide a closed-form expression for conditional mean counts. This facilitates a predictive learning of future event counts that yields models that are superior, when compared to predictions based on Hawkes processes fitted via maximum likelihood estimation.

Through these contributions, this dissertation advances the theoretical understanding of Hawkes processes and expands applicability of such processes to a broader range of real-world problems.

## Education

M.Sc. in Electrical Engineering, Florida Institute of Technology, USA, 2014.

B.Sc. in Electrical Engineering, Dalian Minzu University, People's Republic of China, 2012.

## Selected Peer-Reviewed Publications

- **Xi Zhang**, Akshay Aravamudan and Georgios C. Anagnostopoulos. A Non-parametric Kernel-based Intensity Estimation Algorithm for Hawkes Processes. Submitted for consideration by the 28<sup>th</sup> International Conference on Artificial Intelligence and Statistics (AISTATS 2025). Acceptance rate (estimated): ~30%. Under review.
- **Xi Zhang**, Akshay Aravamudan and Georgios C. Anagnostopoulos. A Generalized Time Rescaling Theorem for Temporal Point Processes. Submitted for consideration by Neural Computation. Impact Factor: 3.28. Under review.
- Zimeena Rasheed, Akshay Aravamudan, **Xi Zhang**, Georgios C. Anagnostopoulos, and Efthymios I. Nikolopoulos. Combining global precipitation data and machine learning to predict flood peaks in ungauged areas with similar climate. *Advances in Water Resources*, page 104781, 2024. Impact Factor: 4.26. [\[DOI\]](#)
- Akshay Aravamudan, **Xi Zhang**, and Georgios C. Anagnostopoulos. Anytime user engagement prediction in information cascades for arbitrary observation periods. In *Proceedings of the 37<sup>th</sup> AAAI Conference on Artificial Intelligence (AAAI 2023)*, volume 37 of *Proceedings of Machine Learning Research*, pages 4999–5009. PKP Publishing Services, Jun. 2023. Acceptance rate: 19.6%. [\[DOI\]](#)
- **Xi Zhang**, Akshay Aravamudan and Georgios C. Anagnostopoulos. Anytime information cascade popularity prediction via self-exciting processes. In *Proceedings of the 39<sup>th</sup> International Conference on Machine Learning (ICML 2022)*, volume 162 of *Proceedings of Machine Learning Research*, pages 26028–26047. PKP Publishing Services, Jul. 2022. Acceptance rate: 21.9%. [\[URL\]](#)
- Akshay Aravamudan, **Xi Zhang**, Jihye Song, Stephen M. Fiore, and Georgios C. Anagnostopoulos. Influence dynamics among narratives. In Robert Thomson, Muhammad Nihal Hussain, Christopher Dancy, and Aryn Pyke, editors, *Social, Cultural, and Behavioral Modeling*, pages 204–213, Cham, 2021. Springer International Publishing. Acceptance rate: 57%. [\[DOI\]](#)

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### **Dissertation Defense**

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Tuesday, November 19, 2024 @ 2pm

Conference Room 340

Gordon L. Nelson Health Building

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