Fellow	<Changqing / **Lu**>
Host Organisation	<Centrum Wiskunde & Informatica>
Scientific coordinator	<Marie-Colette / **van Lieshout**>

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

During my fellowship, I conducted several research projects on the development of spatial and spatio-temporal point process models for complex data, continuing and extending my PhD work. I also carried out research on machine learning methods for state estimation in clustered multivariate spatial point processes. Below, I elaborate on these research activities specifically.

The first project focuses on the ignorability of preferential sampling in geostatistical models. In such models, sampling locations are selected to obtain measurements for inferring an underlying spatial process. When these locations are chosen independently from the spatial process, classical methods, for example maximum likelihood estimation, can be used for inference. However, in many real-world applications, sampling locations are highly correlated with the underlying spatial process, which may lead to substantial bias in standard maximum likelihood estimation. To address this, a variety of likelihood-based approaches have been developed that explicitly model the sampling mechanism. While effective in some settings, these methods are often computationally expensive and can be susceptible to model misspecification. We presented a surprising result: some existing non-likelihood-based methods that ignore preferential sampling can still produce unbiased and consistent estimators. We investigated the conditions under which preferential sampling can be ignored and develop estimators for both regression and covariance parameters of the underlying spatial process without specifying the sampling mechanism parametrically. We also conducted simulation studies to demonstrate the advantages of our approach and showed the practical utility by applying it to a tropical forest data set.

The second project concerns Bayesian inference for independent cluster point processes, motivated by the analysis of an arson fire data set. Classical models for independent cluster point processes often assume that the cluster centres, the offspring points, or both, follow Poisson point processes, due to the tractability of their probability density functions. However, these assumptions fail to capture the complexity observed in real-world data. To address this, we studied a general class of independent cluster point process that relaxes the Poisson assumptions for both cluster centres and offspring points. We constructed a model featuring a regular prior for cluster centres, a shifted-Poisson distribution for the number of offspring points per cluster, and a Gaussian offspring scatter distribution for arson fire data. We developed a tailor-made Markov chain Monte Carlo algorithm to sample cluster states for fixed model parameters, along with a Monte Carlo expectation-maximization procedure to estimate the parameters themselves. We proved the convergence of our MCMC sampler and validated its effectiveness through simulation studies and an application to the arson fire data. The resulting Bayesian framework is flexible, accommodating a broad class of point processes for cluster centres and offspring points, provided that their probability densities have an analytical form up to normalization.

We are conducting a research project on the development of tree-based methods for state estimation in clustered point processes, such as log-Gaussian Cox processes and shot-noise Cox processes. For the former, the state is defined as the conditional expectation of the underlying Gaussian random field given the observed point pattern, while for the latter it is defined as the conditional expectation of the offspring intensity. This work extends the methodology in paper 2 in Section II below, which proposed tree-based methods for intensity estimation in point processes. We proposed a unified tree-based estimation framework that accommodates Cox point processes

and is also applicable to conditional intensity estimation for pairwise interaction point processes. Under this framework, explicit model specification becomes unnecessary when analyzing point pattern data in practice. We further extended this methodology to multivariate point processes by incorporating inter-process interaction and dependence structures. Currently, we are conducting simulation studies and real-data applications.

In addition to the main research activities above, I also actively participated in international conferences and seminars, and am paying a research visit with an Inria research team in Lille, France, to explore future collaborations.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

Published:

1. Lieshout, M.N.M. van & Lu, C. (2025). Infill asymptotics for logistic regression estimators for parameters of the intensity function of spatial point processes. Annals of the Institute of Statistical Mathematics, in press.

2. Lu, C., Guan, Y., Lieshout, M.N.M. van & Xu, G. (2025). XGBoostPP: Tree-based estimation of point process intensity functions. Journal of Computational and Graphical Statistics, in press.

Submitted:

1. Lu, C., Xu, G., Yang, J. & Guan, Y. (2025). On ignorability of preferential sampling in geostatistics. (pending)

Working paper:

1. Lieshout, M.N.M. van & Lu, C. (2026+). Bayesian inference for independent cluster processes. (pending)

2. Lu, C., Guan, Y., Lieshout, M.N.M. van & Xu, G. (2026+). Tree-based state estimation for multivariate point processes. (pending)

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

Seminar:

1. Tree-based methods for intensity and state estimation in Cox clustered point processes. Seminar at Lille Research Centre for Computer Science, Signal Processing and Automation (CNRS CRIStAL), Lille, France, 2026.

Workshop:

1. Bayesian inference for independent cluster point processes. Workshop on Spatial Statistics and Image Analysis in Biology, Smogen, Sweden, 2025.

Conference:

1. Bayesian inference for independent cluster point processes. International Chinese Statistical Association China Conference, Zhuhai, China, 2025.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

A research visit is conducted to Inria Lille with the PoPoPoP research team. During the visit, I meet with Prof. dr. David Coupier and Dr. Rémi Bardenet and engage with local researchers, exchanging ideas on the theory and applications of point processes. I also give a presentation on the topic of tree-based methods for intensity and state estimation in Cox clustered point processes.