Developing efficient spatio-temporal infectious disease models

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The COVID-19 pandemic has shown us the important role infectious disease modelling can have in informing policy response in real time. Unsurprisingly, most of the methods used were purely temporal because these are quicker and easier to develop and run, with only 6% of the published research including any spatial component. With increasing globalisation and climate induced changes in where disease transmission is occurring, capturing space in disease transmission models is more important now than ever. This addition of a spatial aspect would enable us to learn more about how endemic diseases, such as malaria, spread alongside helping us prepare for the next pandemic.

This project will focus on using probabilistic programming languages (PPLs) such as Stan and NumPyro to develop efficient spatio-temporal disease forecasts that can be used in real time to inform policy. It will build on previous work using renewal [1, 2, 3] and Hawkes Process [4] models for COVID-19 and malaria but add a spatial element so that more accurate forecasts can be generated. There will be strong links with a PhD student at Imperial College London working with Dr Will Pearse who will be using similar methods to improve the predictability of ecological models and another student at the University of Oxford with Dr Seth Flaxman looking at new deep generative neural network models to accelerate Bayesian spatiotemporal inference. In addition, you will be a member of the Machine Learning and Global Health Network, which is a network of researchers across 9 institutions worldwide that focuses on using statistics and machine learning to solve problems related to global health.

Finally, this PhD position comes with the unique opportunity to help shape a UK Spatial, Climate, and Health PPL Community that will drive the direction of applied research in these areas. The community will share training material about PPLs and host regular forecasting competitions alongside the degree, which will provide this student with networking opportunities with industry, NGOs and other academics.

References:

[1] Seth Flaxman et al. Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. *Nature*, 584(7820):257–261, 2020.
[2] H. Juliette T. Unwin et al. State-level tracking of COVID-19 in the United States. *Nature Communications*, 11(1):1–9, 2020.
[3] James A. Scott et al. epidemia: Modeling of epidemics using hierarchical bayesian models (https://imperialcollegelondon.github.io/epidemia/), 2020.
[4] H. J. T. Unwin et al. Using Hawkes Processes to model imported and local malaria cases in near-elimination settings, PLoS computational biology, 17, (4), e1008830, 2021.