Modelling the dynamics of police demand and resourcing over space and time.

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Abstract

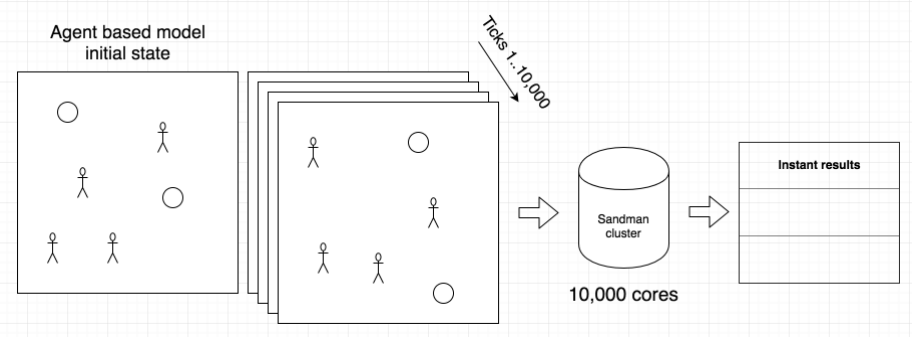
Understanding when and where resources should be distributed in response to dynamic spatio-temporal processes is a complex task. One example of this problem is understanding how to best deploy police resources in response to calls for service. Police agencies have finite numbers of resources that must be allocated to events occurring in a particular locality in real-time. These events can be diverse in nature, require varying levels of resources and represent different levels of importance to the responder. Moreover, they are often interdependent, both at the event level and in terms of opportunity costs when responding to one event is prioritised over another. Understanding this problem is particularly important in the 21st century where police are being asked to deal with increasingly diverse problems, often with relatively restricted resources. This complexity dictates that traditional analytical approaches often struggle to provide adequate solutions to resourcing and demand problems.

In this research, we aim to develop approaches that facilitate a deeper understanding of how resources can be distributed optimally over space and time to reduce the amount of crime. Individual-based modelling enables us to model individuals including the interactions between these individuals and the environment. By modelling these entities, we can better understand how certain phenomena may occur over space and time, allowing us to produce planning solutions to optimise the movement of individuals and test different forms of communications between these individuals.

There has been some promising work within this area that has exploited the potential of individual-based models for simulating the main processes and drivers within these systems. For example, Malleson et al. (2010) constructed an agent-based model of burglar behaviour, the main aim being to predict and therefore implement effective interventions to lower burglary rates. Gerritsen (2015) discusses the potential for agent-based models in the criminology domain, focusing on various crimes and how these crimes can be modelled. Finally, Groff et al (2018) critiques the advancements of agent-based models in crime science. The research citied, does focus on micro examples of a much wider context. Malleson et al. (2010) analyses the behaviour of burglary but not all forms of crime (which we aim to address). It is crucial that environmental factors are considered to ensure the model

is validated, the research done by Birks, Daniel & Davies, Toby (2017) concentrates on street networks in agent-based modelling. We will be using individual-based modelling to simulate the complex spatio-temporal problems and how to optimise positive interaction, an issue which occurs across various services like the fire service, ambulance service and the police service (which we will be focusing on).

Figure 2 Parallel computation of simulation in dynamic environment using Sandman



The value iteration algorithm is not designed for dynamic environments, however, in our domain we were able to adapt it to take into consideration each frame and movement in the simulation and re-calculate the equilibrium policy (best policy). A London-based company, Sandtable, has provided access to their cloud-based platform, Sandman, for running large-scale simulations. Sandman allows us to execute 10,000s of parallel simulations across large amounts of cloud compute resources returning results in timely manner.

What are we going to do?

- Calibrate and validate an agent-based model of police resource allocation
- Build a computational laboratory to allow us to prototype police resource allocation strategies using that model
- Use the laboratory to simulate a number of key policing – call-for-service scenarios
- Utilise the Sandman platform to conduct experiments to identify and evaluate how resources can be distributed over space and time in the most optimal way.

References

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