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|  | **Prerequisites**  The project requires an interest in the behaviour of social insects and a solid understanding of machine learning and equation discovery.  This project requires a strong mathematical and computational background.  The successful candidate will liaise with the Ant Lab and other MSc and PhD students already working on related projects. |
|  | **Abstract:**  The process of ant colony emigration from one nest site to another is a classic example of a system in nature that demonstrates decentralised decision making. Understanding this process will not only help us gain insight into behaviour of social insects in general, but also provide mathematical foundation to study other networks capable of exhibiting emergent intelligence, such as neurons in a brain or AI swarm intelligence. The Bristol Ant Lab [1] is one of the leading research groups to carry out ground-breaking studies on the behaviour of ant species Temnothorax albipennis. Their work has contributed to the development of several mathematical models that aim to describe and study the process of ant colony emigration.   Some models aim to explain this phenomenon by a set of coupled differential equations which describe the evolution of global number of scouts, assessors and recruiters over time, assuming that ants are indistinguishable. While this methodology provides an unambiguous tractable mathematical solution, it often fails to capture the complexity required to understand the process of emigration. Agent-based spatial and non-spatial models on the other hand are capable of taking into account intricacies of individual interactions between ants, however these models often do not produce a clear-cut result that can easily be studied and applied elsewhere.   The aim of this project is to bridge the gap between existing coupled ODE models (Pratt [2] and Planque models [3]) and agent-based models (Pratt-Sumpter [4], AH-HA [5 and SPACE [6] models) by using a new area of machine learning called "equation discovery". The idea is to infer global population dynamics from agent-based models by using a genetic algorithm or other search methods in order to find a set of ODEs. Recent work by MSc student James Collerton (2015) [7] revealed limitations of current equation discovery system (Nutonian Eureqa [8]) in inferring population ODE models from position data. Although the system can accurately learn individual equations, it scoring metric prevents it from accurately learning a whole system of differential equations to model the data. Thus the aim of this project is to develop a new equation discovery approach which can do this more effectively. Our aim is to use this technique to learn equations from biological data and to help us compare agent-based computational models with population-based ODE models.   References:  [1] – http://www.bristol.ac.uk/biology/research/behaviour/antlab/  [2]– Pratt, S., Mallon, E., Sumpter, D., & Franks, N. (2002). Quorum sensing, recruitment, and collective decision-making during colony emigration by the ant Leptothorax albipennis. Behavioral Ecology and Sociobiology, 52(2)  [3] – Planqué, R., Dechaume-Moncharmont, F.-X., Franks, N. R., Kovacs, T., & Marshall, J. a R. (2007). Why do house-hunting ants recruit in both directions? Die Naturwissenschaften, 94(11), 911–8.  [4] – Pratt, S. C., Sumpter, D. J. T., Mallon, E. B., & Franks, N. R. (2005). An agent-based model of collective nest choice by the ant Temnothorax albipennis. Animal Behaviour, 70(5), 1023–1036. doi:10.1016/j.anbehav.2005.01.022  [5] – Marshall, J. a R., Dornhaus, A., Franks, N. R., & Kovacs, T. (2006). Noise, cost and speed-accuracy trade-offs: decision-making in a decentralized system. Journal of the Royal Society, Interface / the Royal Society, 3(7), 243–54. doi:10.1098/rsif.2005.0075  [6] – Martin Stephen Garrad. “Decentralised Decision Making in Temnothorax albipennis colonies.” Department of Computer Science, University of Bristol, 2014  [7] – James Collerton. “Learning Population Dynamics in Ant Colony Emigrations” Department of Computer Science, University of Bristol, 2015  [8] - http://www.nutonian.com/products/eureqa/ |