Data-parallel Structural Optimisation in Agent-based Modelling

A thesis presented in partial fulfilment of the
requirements for the degree of

Doctor of Philosophy
in
Computer Science

at Massey University, Albany,
New Zealand.

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May 2014

Abstract

AGENT-BASED MODELLING (ABM) IS PARTICULARLY SUITABLE for aiding analysis and producing insight in a range of domains where systems have constituent entities which are autonomous, interactive and situated. Decentralised control and irregular communication patterns among these make such models difficult to simulate and even more so to understand. However, the value in this methodology lies in its ability to formulate systems naturally, not only generating the desired macroscopic phenomena, but doing so in an elegant manner. With these advantages, ABM has been enjoying widespread and sustained increasing use.

It is then reasonable to seek advances in the field of ABM which would improve productivity, comparability, and ease of implementation. Much work has been done towards these, notably in terms of design methodology, reporting, languages and optimisation. Three issues which remain despite these efforts concern the efficient construction, performance and calibration of agent-based models.

Constructing a model involves selecting agents, their attributes, behaviours, interaction rules, and environment, but it also demands a certain level of programming ability. This learning curve stymies research effort from disciplines unrelated to computer science. It is also not clear that one methodology and software package is suitable for all circumstances. Domain-specific languages (DSLs) make development much simpler for their application area.

Agent-based model simulation sometimes suffer tremendously from performance issues. Models of situations such as algal cultivation, international markets and pedestrians in dense urban areas invariably suffer from poor scaling. This puts large system sizes and temporally distant states out of reach. The advent of scientific programming on graphical processing units (GPUs) now provides inexpensive high performance, giving hope in this area.

It is also important to calibrate such models. More interestingly, the problem of calibrating model *structure* is given particular emphasis. This ambitious task is difficult for a number of reasons, and is investigated with considerable thought in this work.

In summary, the research shows that appropriate use of *data-parallelism* by *multi-stage programming* in a simple *domain-specific language* affords *high performance*, *extensibility* and *ease of use* which is capable of effective automatic model structure optimisation.

Key words: Agent-based Modelling, Domain-specific Languages, GPUs, Optimisation.

Acknowledgements

To the memory of David Frederik Husselmann Sr., 1929-2003.

The invaluable guidance of several people have made this project possible. Firstly, I would like to express my gratitude to my supervisors, Prof. Ken Hawick and A/Prof. Chris Scogings, without whom this dissertation would certainly not have been possible.

I am also greatly indebted to the members of the Complex Systems and Simulations Group at Massey University, especially Dr. Daniel Playne and Dr. Arno Leist for continuing advice and valuable suggestions for improvements to the manuscript.

I have been very privileged to have been able, in November of 2013, to marry my now-wife, Leah. To her I express my appreciation for her neverending support, especially during times of profound difficulty and late work nights.

My family has been very supportive, and I would like to thank my parents particularly, Erika and David, for a place to live and study. Without their support, I certainly could not have studied full time, and would not be in a position to progress my career for several years. My brothers, sisters-in-law and grandmother were also highly supportive during this time.

Finally, I would like to acknowledge the financial support I received from the Massey University Vice-Chancellor's Doctoral Scholarship.

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