ACS332 Agent-based modelling and multi-agent systems

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Assignment 2018/19

ACS322 includes a single assignment that is broken down into three components to be completed over the course of the semester. This document provides submission instructions, a detailed assignment briefing, and the marking criteria.

Assignment weighting:	40% of the module (i.e. 4 credits)
Assignment released:	24 September 2018 (Monday, Week 1)
Assignment due:	Component 1: 8 October (Monday, Week 3) Component 2: 29 October (Monday, Week 6) Component 3: 10 December (Monday, Week 12)
Format:	Two short reports of 4 pages maximum each, and a further report of 20 pages maximum (in size 11 font and 2.5cm margins all around). The report must be submitted both electronically via MOLE and in hardcopy to ACSE Reception.
Assignment codes:	Component 1: ACS332-001 Component 2: ACS332-002 Component 3: ACS332-003

Penalties for late submission

Late submissions will incur the usual penalties of a 5% reduction in the mark for every working day (or part thereof) that the assignment is late and a mark of zero for submission more than 5 working days late. For more information see http://www.shef.ac.uk/ssid/exams/policies

Feedback

Written feedback will be provided in hardcopy format for all three components. Feedback on conceptual design and detailed design components is formative and aims to help you improve your model – and your description of your model – for the final report. Feedback for these components will be provided within 5 working days of submission. Feedback for the final report will be provided within 10 working days, in line with Departmental expectations.

Unfair means

This is an individual assignment. You should not discuss the assignment with other students or work together with other students in its completion. The assignment must be wholly your own work. References must be provided to any other work that is used as part of the assignment. Any suspicion of the use of unfair means will be investigated and may lead to penalties. For more information see http://www.shef.ac.uk/ssid/exams/plagiarism

Extenuating circumstances

If you have any medical or special circumstances that you believe may affect your performance on the assignment then you should raise these with the Module Leader at the earliest opportunity. You will also need to submit an extenuating circumstances form. For more information see http://www.shef.ac.uk/ssid/forms/circs

Assignment briefing
In November 2017, Sheffield City Region launched a consultation on its Transport Strategy for the period 2018 to 2040. One of the key aims of the strategy is to achieve a "modal shift" in citizen's commuting journeys from cars to more active forms of transport (cycling and walking). In 2011, 2% of commuting journeys were by bicycle. By 2040, the aim is to increase this proportion to 11%.

Sheffield City Council (SCC) is one of the local government authorities that comprise Sheffield City Region. SCC would like to know how new investments in cycling infrastructure can help increase the number of Sheffield citizens who choose to cycle to work each day. There are a number of new investments they could consider:

- Construct cycle routes that are separate to the road infrastructure
- Increase the amount of road space dedicated to cyclists
- Invest in subsidised pay-per-use docked electric bicycles that require less cycling effort on Sheffield's hills.

SCC know that there is some existing evidence on the effectiveness of these different options. However this evidence was gathered in other places that have a different character to Sheffield (e.g. less hilly places like Copenhagen). SCC would like some estimates that are personal to Sheffield. To obtain these, they would like to build an agent-based model of Sheffield's population and use it to simulate citizens' transport choices over the next 20 years.

In this assignment, you will design, build and test this agent-based model. You will use an agile project management approach to iteratively construct your model, prioritising new features for your model within the resources you have available.

The assignment is split into three components:

Component 1: Draft conceptual design (5% of the module marks)
In this phase, you will develop a first draft of the overall concept for your model. At this stage you should set out a number of aspects:

1. Your overall understanding of the system you are trying to model (including a critical review of any evidence you have found)
2. A prioritised set of features that your model might include, including reasoning for your prioritisation
3. An overview of your overall concept for the agent-based model, including major aspects of model structure (e.g. agent decision-making and interaction processes).

This document is just a first draft for which you will receive some feedback. You will continue to iteratively evolve your conceptual design during the course of the module. You are expected to spend 5 hours of your own time in preparing the draft.

Component 2: Draft detailed design (5% of the module marks)
In this phase, you will develop a first draft of the detailed design for your model, in which you turn your conceptualised model into something that can be implemented on a computer. At this stage, it is important to include the following elements:

1. A schematic of the conceptual design (revised where necessary)
2. A UML class diagram that shows the properties of your agents and the methods for action and interaction, and how these relate to the classes of the Repast HPC architecture for agent-based modelling

3. An overview of your Repast HPC model, considering how many agents will be used to represent the population of Sheffield, the step size used in the simulation, and the duration of the simulation.

Again, you are expected to spend 5 hours of your own time in preparing the draft.

Component 3: Final modelling report (30% of the module marks)
During the module, you will iteratively develop your model. In addition to the time in the labs, you are expected to spend 30 hours of your own time working on model development and reporting.

By the end of the module, you are required to submit a final written report of your work, along with a zip folder of your C++ source code. The written report should contain the following sections:

1. Introduction
2. Final version of the conceptual design
3. Final version of the detailed design
4. Scenarios and results
5. Discussion
6. Conclusion
7. References

The most important sections of the report are Sections 4 and 5. In the former, you should describe a set of scenarios that your model will be running (hopefully based on different options around cycle investment, including a scenario where there is no investment); in the latter you should discuss the strengths and limitations of your model, including how you would parameterise it with realistic data and validate it for the setting of Sheffield (if you haven't managed to do this already).

Help
During the module you will have a series of labs where the Module Leader and Graduate Teaching Assistants will be available to guide you in using Repast HPC to develop your agent-based model. Components 1 and 2 of the assessment are also intended to help you improve your conceptual understanding of the problem and how it can be tackled using agent-based methods.

Marking criteria
The marking criteria below provide guidance on the relationship between the quality of submission and the marks awarded. Note that the quality statements are *indicative* only – the actual mark awarded will be a holistic judgment of the *overall* quality of submitted work.

Component 1: Draft conceptual design

Mark awarded	Expected attributes of the conceptual design
4-5	A coherent conceptual design, explained using both text and diagrams. Includes a brief discussion of the existing evidence on commuting modal choice (including of existing models) and an explanation of how this evidence is reflected – or not – within the conceptual design. Only minor modifications required for the final report.
2-3	Some issues with the coherence of the design or the quality of explanation. Some discussion of existing evidence, but missing key works or with inadequate explanation of the relevance to the conceptual design. Major modifications required for the final report.
0-1	Largely incoherent or missing conceptual design.

Component 2: Draft detailed design

Mark awarded	Expected attributes of the detailed design
4-5	A clearly communicated design, expressed using appropriate UML diagrams (e.g. class diagrams). The design is able to functionally realise the current draft of the conceptual design. Consideration of Repast implementation details (number of agents, and simulation time step size and duration).
2-3	The ability of the design to realise the conceptual model appears questionable. Incorrect or missing UML diagrams. Failure to fully consider the main aspects of the Repast model implementation.
0-1	Largely incoherent or missing detailed design.

Component 3: Final modelling report

Mark awarded	**Expected attributes of the final report**
21-30	• A conceptual design that is coherent and reflects what is known about transport modal shift. • A detailed design that is faithful to its conceptual underpinnings and is documented using correctly-specified UML diagrams. • A demonstrated implementation in C++ using the Repast HPC platform that is able to generate results • Evidence for successful verification testing of the computer model • Thorough discussion of model calibration and validation, together with some identification of likely useful data sources for model parameterisation • Thorough discussion of implications for decision-makers in Sheffield City Council • Well-presented report, with appropriate use of labelled figures, few spelling or grammatical errors, and appropriate use of references.
18-20	• A conceptual design that is, for the most part, coherent and reflects some of what is known about transport modal shift. • A detailed design that is faithful to its conceptual underpinnings and is documented using correctly-specified UML diagrams. • A demonstrated implementation in C++ using the Repast HPC platform that is able to generate results • Some evidence of verification testing of the computer model • Discussion of model calibration and validation, but may not have identified likely useful data sources for model parameterisation • An attempt to discuss implications for decision-makers in Sheffield City Council • Well-presented report, with appropriate use of labelled figures, few spelling or grammatical errors, and appropriate use of references.
15-17	• A conceptual design that is, for the most part, coherent and reflects some of what is known about transport modal shift. • A detailed design that is, more the most part, faithful to its conceptual underpinnings and is documented using UML diagrams (with occasional errors). • A demonstrated implementation in C++ using the Repast HPC platform that is able to generate results • No evidence of verification testing of the computer model • Some discussion of model calibration and validation, but no identification of likely data sources for the model • No discussion of implications for decision-makers in Sheffield City Council • Minor issues in presentation, with occasionally mislabelled figures, and some spelling or grammatical errors.

Mark awarded	Expected attributes of the final report
12-14	• A conceptual design that may lack coherency and fails to make explicit connections to what is know about transport modal shift. • A detailed design that is, more the most part, faithful to its conceptual underpinnings, but may lack correctly-specified UML diagrams. • A demonstrated implementation in C++ using the Repast HPC platform that is able to generate results • No evidence of verification testing of the computer model • Lacks a discussion of model calibration and validation • No discussion of implications for decision-makers in Sheffield City Council • Notable issues in presentation, with mislabelled figures, and some spelling or grammatical errors.
<12	• A conceptual design that lacks coherency and fails to make explicit connections to what is know about transport modal shift. • A detailed design that is questionable in its ability to realise the conceptual design • An implementation in C++ using the Repast HPC platform, but not one that is able to generate results • No evidence of verification testing of the computer model • Lacks a discussion of model calibration and validation • No discussion of implications for decision-makers in Sheffield City Council • Major concerns with the presentation of the report, that substantially hinder its legibility.

Project management

Personal Kanban

Early in the module you will be introduced to an agile project management approach known as Personal Kanban. Agile methods are very suitable for this assignment, since the assignment carries quite a lot of uncertainty that must be resolved and managed over the course of the semester:

- The agent-based modelling challenge has an ambitious scope and you may only be able to implement part of this within the timeframe for the assignment
- Your understanding of agent-based modelling methods is developing during the assignment, and you may encounter new methods that would be beneficial to include
- Your familiarity with Repast HPC will grow and you will understand more clearly which aspects of your model are more straightforward or difficult to implement using the software.

You are recommended to implement Personal Kanban with a sprint duration of 1 week. Note that you will not be assessed directly in terms of your use of this approach.

Source code control

In an iterative project management approach such as Personal Kanban, you will create regular (i.e. weekly) working versions of your software. Each version aims to enhance the features of your model, or fix problems that you have identified. You are recommended to create a private repository for your code (e.g. using Bitbucket https://bitbucket.org) and use git version control software to manage your evolving code base.

Purpose of the labs

The labs in the module are not tightly programmed, but serve to help you in accomplishing the assignment. Note that you will not be able to learn Repast HPC or develop your model using only the time available in the labs. Rather, you should use the lab time to gain support and assistance in developing and verifying the model. An indicative schedule for the labs is shown below:

Lab number	Timing	Typical activities
1	3 October 2018 (Wednesday, Week 2)	Gain familiarity with the Repast HPC software by starting to work through the online *Zombie Model* tutorial: https://repast.github.io/hpc_tutorial/TOC.html
2	17 October 2018 (Wednesday, Week 4)	Finish working through the Repast HPC tutorial and begin experimenting with your own toy models
3	31 October 2018 (Wednesday, Week 6)	Implement your agent design in Repast HPC and perform verification tests for agent behaviour
4	14 November 2018 (Wednesday, Week 8)	Implement a revised agent design and/or network design in Repast HPC, and perform verification tests for agent interaction
5	28 November 2018 (Wednesday, Week 10)	Implement further revisions and perform scenario analysis with the resulting model

Bibliography

Sheffield City Region & ARUP, Sheffield City Region Transport Strategy 2018-2040: Draft for Consultation, 2017.
Contains details on the different transport modes used by Sheffield City Region commuters, an overview of the socio-demographics of the region, and some high-level strategies for encouraging modal shift towards cycling.

Macmillan A, Connor J, Witten K, Kearns R, Rees D, Woodward A. The societal costs and benefits of commuter bicycling: simulating the effects of specific policies using system dynamics modeling. Environmental Health Perspectives 2014;122(4):335-344.
Presents a model (not using agent-based methods) to simulate the effect of a number of cycling policies over the next 40 years in the city of Auckland, New Zealand. Contains rich details on the model structure and how evidence was used to inform model parameters.

Rydin Y, Bleahu A, Davies M, Dávila J, Friel S, et al. Shaping cities for health: complexity and the planning of urban environments in the 21st century. Lancet 2012;379:2079-2108.
Takes a global perspective on city planning strategies, including the role of active transport (walking and cycling). Explores the relationship between the environment and the individual, including the impacts of socio-economic status. Presents a case study in Bogota, Columbia.