Agent-Based Model Implementation Lecture 3

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Spatially Explicit ABM/GIS integration in NetLogo

- ABM with spatial data
- GIS data as environment
- GIS data as agents

GIS extension

Adding GIS extension for building spatially explicit ABM using Geographic Information System (GIS) data.

Extensions [gis]

GIS extension adds GIS (Geographic Information Systems) support to NetLogo.

It provides the ability to load GIS data and access information from GIS data.

GIS extension

Types of GIS data

Vector GIS data (shapefiles)

Points such as cities

Lines such as streams or streets

Polygons such as property parcels

Raster GIS data (ASCII grid file, TIFF, grid)

Elevation, slope, aspect, land use imagery

GIS example data

C -> Program files -> NetLogo -> app -> models -> code examples -> extension examples -> gis

-> save gis folder in your personal folder

Uploading GIS data

Shape file example

```
Extensions [gis]

to load
  ca
  let view gis:load-dataset "data/countries.shp"
  gis:set-world-envelope gis:envelope-of view
  foreach gis:feature-list-of view
 [
   gis:set-drawing-color white
   gis:draw view 1
  ]
end
```

Uploading GIS data

Raster file example

```
extensions [ gis ]

globals [ elevation ]

to load
  ca
  set elevation gis:load-dataset "data/local-elevation.asc"
  gis:set-world-envelope gis:envelope-of elevation
  gis:paint elevation 0
end
```

Accessing values from GIS data

- How to read, modify and use values from GIS data.
- Making agents from GIS data.

Example in NetLogo

The GIS Examples

The General example

How to load and access the data n NetLogo

The Gradient Example

How to access the value from GIS data

Types of socio-environmental model within NetLogo framework

- Spatially explicit ABM (discussed previously)
- System dynamic models

Types of socio-environmental model within NetLogo framework (Wilensky, 1999)

Basic Concepts

A System Dynamics diagram is made of four kinds of elements:

Stock is a collection of stuff, an aggregate.

Flow brings things into, or out of a Stock.

Variable is a value used in the diagram.

Link makes a value from one part of the diagram available to another.

Example

ODD PROTOCOL

Overview (O) Design (D) and Details (D).

Grimm and Railsback (2012) described the ODD protocol for describing and formulating ABM for publication purpose.

Overview (an extract from Grimm & Railsback, 2012)

Purpose

What is the purpose of the model?

Entities, State Variables and Scale

What kind of entities are in the model?

By what state variables, or attributes, are these entities characterized?

What are the temporal and spatial resolutions and extents of the model?

Process overview and scheduling

Which entities do what, in what order?

When are state variables updated?

How is time modelled as discrete steps or as a continuum over which both continuous processes and discrete events can occur?

Design Concepts (an extract from Grimm & Railsback, 2012)

Emergence

What key outputs of the model are modelled as emerging from the adaptive behavior of its agents?

Are there other outputs that are more tightly imposed by model rules and hence less dependent on what individuals decide to do?

Adaptation

What rules do agents have for changing behaviour in response to changes in themselves or their environment?

Do these traits explicitly aim at increasing some measure of individual objectives or success?

Or do they instead cause individuals to reproduce observed behaviours that are implicitly assumed to convey success?

Design Concepts (an extract from Grimm & Railsback, 2012)

Objectives

If adaptive behavior is represented as explicitly seeking some objective, what is the objective and how is it measured?

Examples of “objectives” are “fitness” for organisms, “utility” for economic reward in social models, or simply “success”.

Learning

Do individuals change their adaptive behavior over time as a consequence of their experience? How?

Design Concepts (an extract from Grimm & Railsback, 2012)

Prediction

To make decisions, model agents often need to predict future consequences of their alternatives.

What internal models are used by the agents to estimate future conditions or consequences of their decisions?

What “tacit” or hidden predictions are implied in these internal models?

Sensing

What information (state variables of other model entities and themselves) can agents sense and consider in their adaptive decisions?

Are the mechanisms by which agents obtain information modelled explicitly, or are agents simply assumed to “know” these variables?

Design Concepts (an extract from Grimm & Railsback, 2012)

Interaction

What kinds of interactions among agents are in the model?

Are there direct interactions, or are the interactions indirect, e.g. via competition for a mediating resource? How do agents interact with their environment?

Stochasticity

What processes are modelled by assuming that they are random or partly random?

Why is stochasticity used – to represent variability in a simple way, or to cause events or behaviors to occur with a specified frequency?

Design Concepts (an extract from Grimm & Railsback, 2012)

Collectives

Are there aggregations of agents that affect, and are affected by, the agents?

Examples include social groups, fish schools and bird flocks, human networks and organizations, or cells constituting an organ. Are collectives represented as emergent properties of the agents or as a separate kind of entity with its own state variables and traits?

Observation

What data and patterns must be observed from the ABM for testing, understanding, and analyzing it, and how are they collected?

Details (an extract from Grimm & Railsback, 2012)

Initialization

What is the initial state of the model, i.e. at time $t = 0$?

Input data

What input does the model use from external sources such as data files or other models to represent processes that change over time?

Sub models

What, in detail, are the sub models that represent the processes listed in “Process overview and scheduling”? What are the model parameters, their dimensions, and reference values? How were sub models designed or chosen, tested, and parameterized?

Suggested readings

A J Heppenstall, A T Crooks, L M See, M Batty. 2012. Agent-based Models of Geographical Systems. Springer, Dordrecht.

References

Grimm V, Railsback S F, 2012, “Designing, formulating, and communicating agent-based models”, in Agent-based Models of Geographical Systems Eds A J Heppenstall, A T Crooks, L M See, M Batty (Springer, Dordrecht) pp 361–377

Wilensky, U. (1999). NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.