Agent-Based Modeling Toolkits: A Practical Introduction

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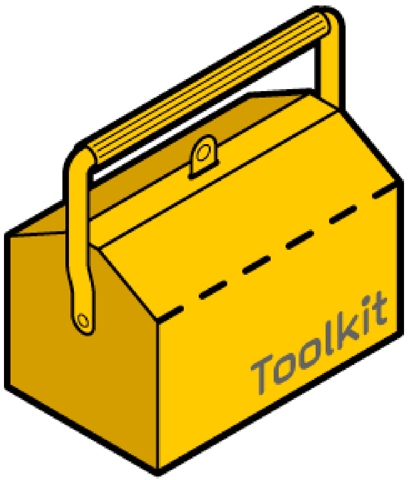
Overview

- Introduction and Survey of Major ABM Platforms
- Presentation of a Residential Preference ABM
- Introduction to the StupidModels (SimpleModels)
- Development of Models in NetLogo
- Development of Models in Repast
- Summary



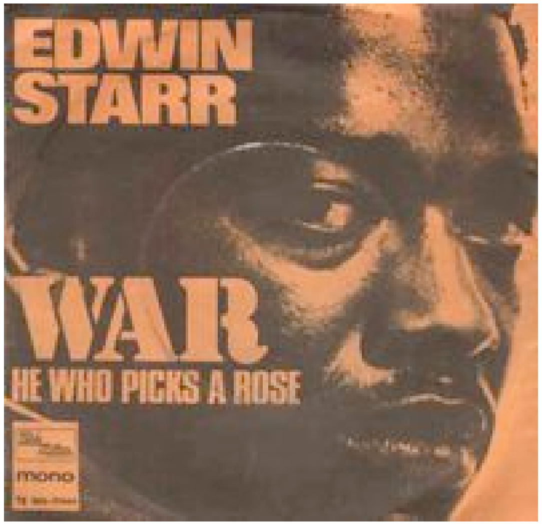
How to write ABMs?

1. Utilize ABM Platforms
   - Wholly contained ABM development platforms
   - AgentSheets, MobiDyc, NetLogo
2. Build upon ABM Libraries ("Framework and Library")
   - Gives you the tools to build complex models in a general language
   - Repast, Swarm, Ascape
3. "Roll your own"
   - Allows full control but you have to do everything from scratch
   - C, Java, Perl, VisualBasic, Mathematica

What is an ABM Toolkit?

(Huh-yeah…What is it good for?…apologies to Edwin Starr)

- Agent-Based Modeling Toolkits assist model developers
- Gives you quick access to the basic components of an ABM
  - World (Environment)
    - The space where the agents act
  - Agents
    - Basic entities
  - Scheduler
    - Keeps track of what agents are doing what / when
    - Maintains records
  - Controller
    - Used to operate the model and allow interactive control
  - Parameters
    - Specifies characteristics the model and agents



Major ABM Platforms
(in use)

- Swarm (Minar, Burkhart, Langton, and Askenazi; 1996)
  - First platform designed with the purpose of ABM, created at SFI
  - Written primarily in Objective-C though a Java interface exists
- NetLogo (Wilensky; 1999)
  - Developed at Tufts and now Northwestern University
  - A variant on the Logo language
- Repast (Sallach, Collier, Howe, and North; 2000)
  - Robust platform, developed at Argonne National Labs and University of Chicago
  - Written in many languages, but most widely used is RepastJ (Java)
- MASON (Luke, Balan, and Panait; 2003)
  - Newest platform and Extremely efficient
  - Written in Java at George Mason University

Project Sluce

- 4 year study funded by the NSF (PI: Dan Brown, U of Michigan)
- Study the consequences of suburban sprawl and its ecological impact
- Utilized a combination of three types of modeling
  - Survey Data
  - GIS
  - Agent-Based Modeling

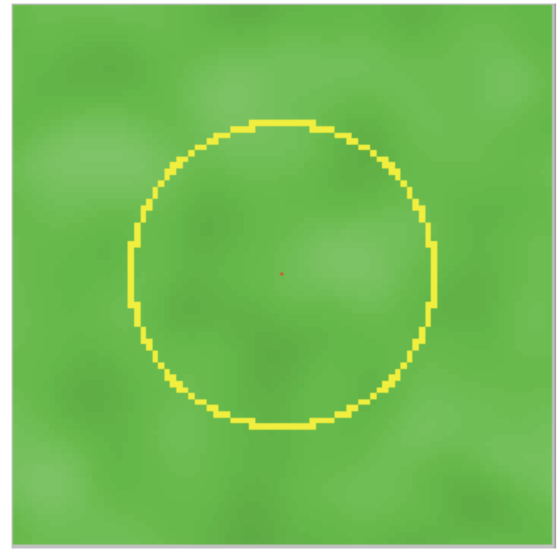
History of Sluce Modeling

- Model originally written in C (Scott Page, circa 2000-2001)
  - Hard to modify, rewritten any time parameters were varied
- Rewritten and Expanded in Swarm (SOME; Rand, circa 2001-2002)
  - Exposed the parameters, began using loose GIS integration

  (Rand, Zellner, Page, Riolo, Brown, and Fernandez, Agent 2002)
- Pedagogical Version Created in NetLogo (SOME; Robinson, 2003)
  - Posted on the website and used in classes
- Re-coded and emphasis shifted in Repast (ARMS-R; Zellner and Rand, 2003)
  - Subdivisions are the focus

  (Zellner, Rand, Brown, Nassauer, Low, An, Riolo, Page, and Robinson, AAG 2004)

SOME in NetLogo



- Two types of agents
  - Residents
  - Service Centers
- Every time step residents evaluate a number of places and decide based on distance to service centers and natural beauty what is the best place for them
- Service centers follow every 100th resident in

ARMS-R in Repast

- Add developers, townships, subdivision types
- Basic resident actions were the same but they were more complex
  - Economic Status, Kids, Environmentally Friendly
- Farmers randomly decide to sell land
- Developers develop the land based on characteristics into different development types
  - Hills, Water, Elevation
  - Remnant, Commercial, Horticultural
- Townships could implement zoning policies
- Decision Trees based on Detroit Area Study (Marans and others)

Cities Project

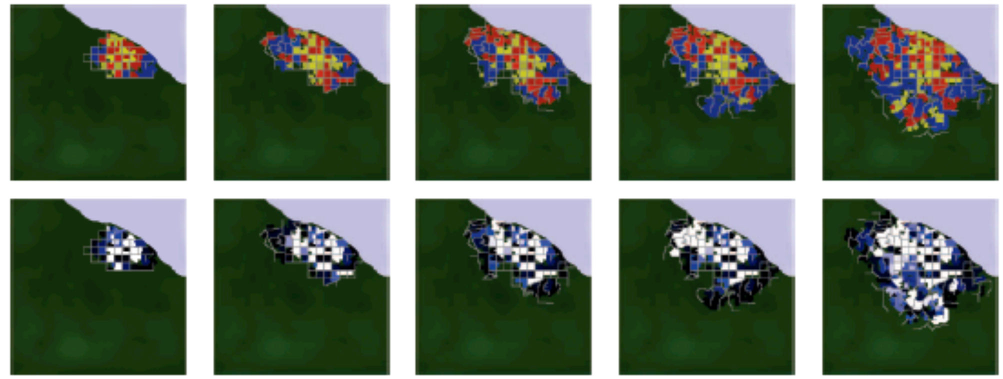


Figure 4: *A sequence of development stages. Top row represents land use, bottom row represents population density.*

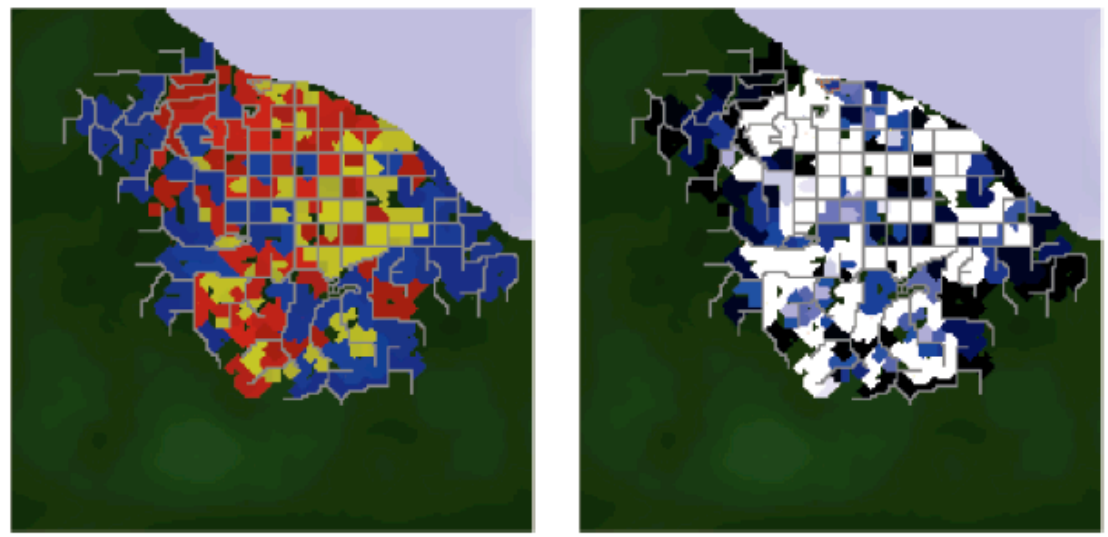


Figure 5: *The left image represents the final simulated land use. Yellow is residential, red is commercial, blue is industrial. The right image represents the final simulated population density. Blue is low density, white is high density.*

(Lechner, Watson, Wilensky, Felsen, & Tisue, 2004)

Cities Project

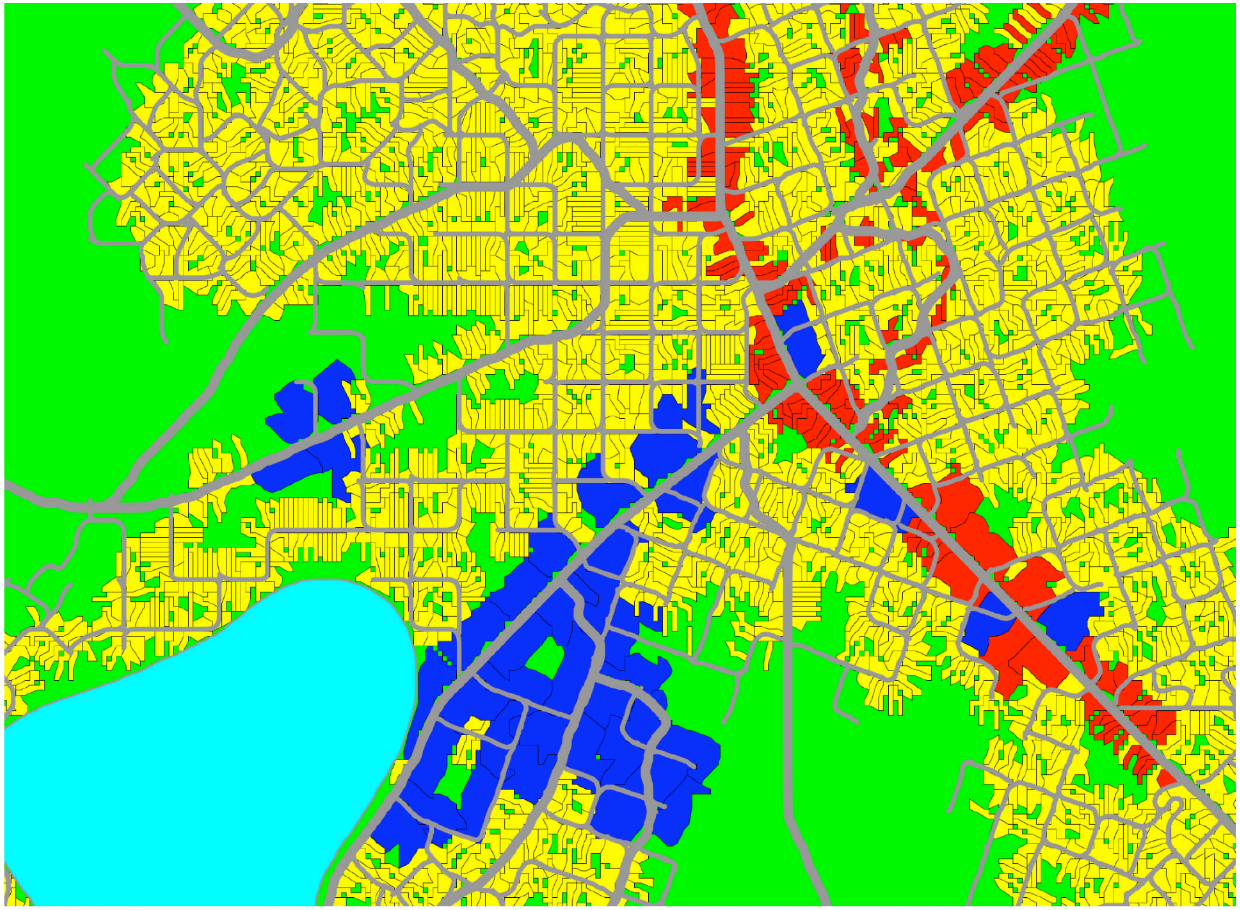


Figure 0: An urban map output from our system and vectorized. Here yellow is residential use, red commercial, and blue industrial. Thick gray lines are primary roads, thin gray lines are tertiary (access) roads. The thinnest lines are parcel boundaries.

(Lechner, Watson, Wilensky, Felsen, & Tisue, 2004)

StupidModels

- The StupidModels were created by the three “Steves” (Railsback, Lytinen and Jackson)
- Two-fold purpose
  - Provide a comparison between different ABM platforms
  - A teaching tool, they begin with the most basic techniques needed for ABM and scaffold
- Results published in SIMULATION (Railsback, Lytinen, and Jackson, 2007)

Introduction to NetLogo

- Demonstration

Model 1

- Create 100 Agents
- Place them randomly in the world
- Each time step have them move to a random nearby location

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Model 2

- Have agents keep track of energy
- Update agent size based on energy

Model 3

- Add resources to patches
- Resources on patches regrow at a fixed rate
- Agents consume resources from patches
- Agents energy is related to resource consumption

Model 4

- Agents consume their own energy when moving
- Agents die if they do not have enough energy

Model 5

- Plot number of agents over time

Model 6

- Run an experiment varying input parameters (e.g. move-cost, resource-regrowth)
- Plot data against outputs (e.g. number of agents, average size)

StupidModels and Repast

- Demonstration
- Code
- How to run
  - Command line
  - ANT
- IDEs
  - Emacs
  - Eclipse

Conclusion

- Many different platforms exist out there and deciding which one to use is often a matter of personal taste and personal ability
- Many issues to consider when building agent-based models
  - Should we make everything an agent?
  - How much flexibility do we want in our model?
  - How do we place more advanced machine learning within our model?
  - How can I replicate someone else’s model?
  - How do I validate and verify a model?
  - How do I utilize empirical data within an ABM?

Any Questions?

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Repast
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