Agent-based Models in Archaeology: Are there Limits?

Forum ReSoc: Discussing present Archaeology

Maja Gori $^{1,3}$  Frederik Schaff $^{2,3}$

$^1$Ruhr-University Bochum, Institute of Archaeological Sciences

$^2$Ruhr-University Bochum, Institute of Macroeconomics

$^3$Deutsches Bergbau-Museum Bochum, Project ReSoc – Resources in Society, Leibniz Postgraduate School

21st March 2019,
Ruhr-Universität Bochum, Haus der Archäologien
ReSoc: Resources in Society - Leibniz Postgraduate School

Project start: June, 2017

ReSoc Members (Left to right, in the back: Arne Windler, Peter Thomas, Yiu-Kang "Gary" Hsu, Marc Pearce (Nottingham), Michael Roos, Frederik Schaff, Petra Eisenach. In front: Frank Hillebrandt, Susan Pollock, Constance von Rüden, Thomas Stöllner, Maja Gori; without photo: Sabine Klein, Roland Hardenberg)
The Roman forum and the comitium after 44BC

From the book The Roman Forum: a topographical study By Francis Morgan Nichols 1877, wikipedia (PD)
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Edmund Chattoe-Brown
(University of Leicester)

Iza Romanowska
(Barcelona Supercomputing Center)

Marc Vander Linden
(University of Cambridge)

Michael Roos
(Ruhr-University Bochum)
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Program

14.00 Welcome & Introduction

14:30 Edmund Chattoe-Brown, *Toughening the Methodology of Agent Based Modelling by Working Across Disciplines*

15:15 Marc Vander Linden, *The Fallacy of Holism: Views on Practising ABM in Archaeology*

- 5 minutes break -

16:05 Panel Discussion: ABM Archaeology: Are there Limits?

16:35 Open Discussion with the audience

afterwards Reception
From a Static Archaeological Record to the Reconstruction of Past Behaviour

Archaeology in the field and in the (computational) lab.
Trends in Archaeological Simulation after Lake (2014)
Agent-based Modelling

Agents

Agent Smith (The Matrix) by Hersson Piratoba, flic.kr/p/hJV4qf, CC BY-NC-ND 2.0
Agent-based Modelling

Actions

Machine Learning & Artificial Intelligence by Mike MacKenzie, flic.kr/p/27pq9bw, CC BY 2.0
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Networks

Principal Ocean Cables in 1917 by Eric Fischer ("Cable," The World Book, 1920), flic.kr/p/bs3Vms, CC BY 2.0
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Interaction

Flock of geese by scyrene, flic.kr/p/dgLHqc ,CC BY-NC-ND 2.0
Agent-based Modelling

- Way of thinking -

What elements are relevant?
- Agents - people, resources, animals, ...

What do they do?
- Actions - having goals, causing effects

How are they related?
- Networks - people, ecology, places, ...

What is the consequence of relations?
- Interaction - being effected

Outcome: Formalised theory - An agent-based model
Agent-based Modelling

- Agent-based Model, formalised theory

- How-possibly explanation(s) -

What happens? - Emergence

- Computation - forward propagation
- Result: A simulated history (deductive)

Why happens? - Understanding

- Detective work - analyse the single run
- Result: A causal explanation (deductive)

When happens? - Quantifying

- Computational Experiment - multiple runs
- Statistical Analysis - find regularities
- Result: Abstract model (inductive)

Outcome: Potential explanation & quantified likelihood
ABM in Archaeology

Two non-representative examples

Artificial Anasazi (data driven)

Stone Raw Material Procurement (theory testing)
Problem Description

Case 1: Artificial Anasazi (data driven)

Long House Valley, looking to the South (Axtell et al., 2002)
Problem Description

Case 1: Artificial Anasazi (data driven)

(Ecological) data used in the Anasazi Project (Swedlund et al., 2015)
Data to model

**Case 1: Artificial Anasazi (data driven)**

- **Palmer Drought Severity Indices** (red: draught)
- **Crop Yield Rates** (darker: more yield)
- **Hydrology** (blue: floodplain area)
- **Water sources**

Data usage in the Artificial Anasazi model (using Janssen, 2009)
Conclusions drawn

Case 1: Artificial Anasazi (data driven)

Simulated vs. historical population size and location (Axtell et al., 2002)

Our model closely reproduces important spatial and demographic features of the Anasazi in Long House Valley from about A.D. 800 to 1300. To “explain” an observed spatiotemporal history is to specify agents that generate -or grow- this history. By this criterion, our strictly environmental account of the evolution of this society during this period goes a long way toward explaining this history (Axtell et al., 2002, p. 7278).
ABM in Archaeology

Two *non-representative* examples

**Artificial Anasazi (data driven)**

**Stone Raw Material Procurement (theory testing)**
The Claim

Case 2: Stone Raw Material Procurement (theory testing)

The richness of raw materials, transport distances, and character of the transported materials found in archaeological assemblages are often interpreted in terms of adaptive optimization, depth of planning, and risk minimization. In many instances, however, these patterns may be qualitatively indistinguishable from a non-adaptive model of Paleolithic foragers engaged in a random-walk foraging strategy and procuring stone raw materials without any regard for raw material type (Brantingham, 2003, p. 506).
An agent-based neutral model

Case 2: Stone Raw Material Procurement (theory testing)

World
Settings
+size: pair(xn,yn) = 500, 500
The (abstract) size of the space
+d_metric: string = Chebyshev
Distance metric. Chebyshev = "Magic Grid"
+wrap?: bool = true
If true, the Forager can exit the space at the border just to re-enter at the opposite border.
+n_resources: int = 5,000
# unique resources to be distributed randomly in space
+Initialise()
Add resources. Add Forager. Execute once.

Forager
+Position: pair<x,y>
+maxToolkitSize: int = 100
Maximum size of the toolkit.
+Consume()
One item in the toolkit breaks.
+Move()
Move randomly to adjacent position or stay.
+Collect()
If the position entails resources, refill the toolkit.

Resource
+ID: unique int
+Position: pair<x,y>

Tool
+ID: unique int

n_resources
0 ... maxToolkitSize
Random Walk in a Random Environment

Case 2: Stone Raw Material Procurement (theory testing)

5,000 unique resources in a 500x500 landscape own reimplementation
Case 2: Stone Raw Material Procurement (theory testing)

5,000 unique resources in a 500x500 landscape own reimplemention

... and the path travelled at time 248
Random Walk in a Random Environment

Case 2: Stone Raw Material Procurement (theory testing)

5,000 unique resources in a 500x500 landscape

...and the path travelled at time 1,002
Random Walk in a Random Environment

Case 2: Stone Raw Material Procurement (theory testing)

5,000 unique resources in a 500x500 landscape own reimplementation

... and the path travelled at time 5,015
Case 2: Stone Raw Material Procurement (theory testing)

5,000 unique resources in a 500x500 landscape and the path travelled at time 10,006
Random Walk in a Random Environment

Case 2: Stone Raw Material Procurement (theory testing)

5,000 unique resources in a 500x500 landscape own reimplementaion

...and the path travelled at time 22,356
Time-Evolution of the Toolset: Size vs Richness

Case 2: Stone Raw Material Procurement (theory testing)

5,000 unique resources in a 500x500 landscape

...and the evolution of the toolset
Conclusions drawn

Case 2: Stone Raw Material Procurement (theory testing)

Toolkit richness vs size: virtual and empirical correlation (Brantingham, 2003)
Conclusions drawn

Case 2: Stone Raw Material Procurement (theory testing)

The primary implication of the neutral model is that our inferences about adaptive variability based on patterns of raw material richness and transport may be difficult to prove (Brantingham, 2003, p. 506).

For a recent discussion of the model, see Oestmo et al. (2016).
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Image by Wendy Cegielski and Jay Etchings (Arizona State University, Tempe, AZ), taken from Rogers and Cegielski (2017)
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@ReSoc_Bochum #ForumReSoc

Edmund Chattoe-Brown
Computational Sociologist
(University of Leicester)

Marc Vander Linden
Prehistoric Archaeologist
(University of Cambridge)

Iza Romanowska
Computational Archaeologist
(Barcelona Supercomputing Center)

Michael Roos
Complexity Economist
(Ruhr-University Bochum)

Maja Gori
Prehistoric Archaeologist
(Ruhr-University Bochum)

Frederik Schaff
Computational Economist
(Ruhr-University Bochum)


