Analyzing and Understanding ABMs

EES 4760/5760

Agent-Based and Individual-Based Computational Modeling

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Class #24: Wednesday, November 12 2025

Organization

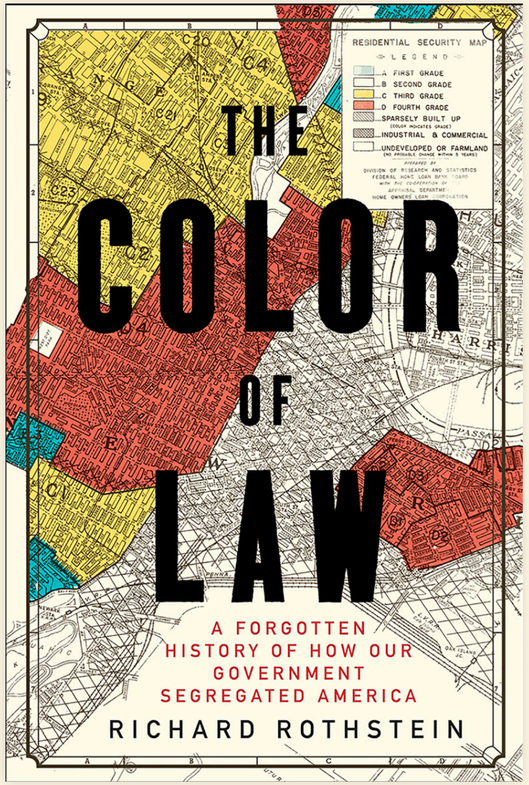
Downloads

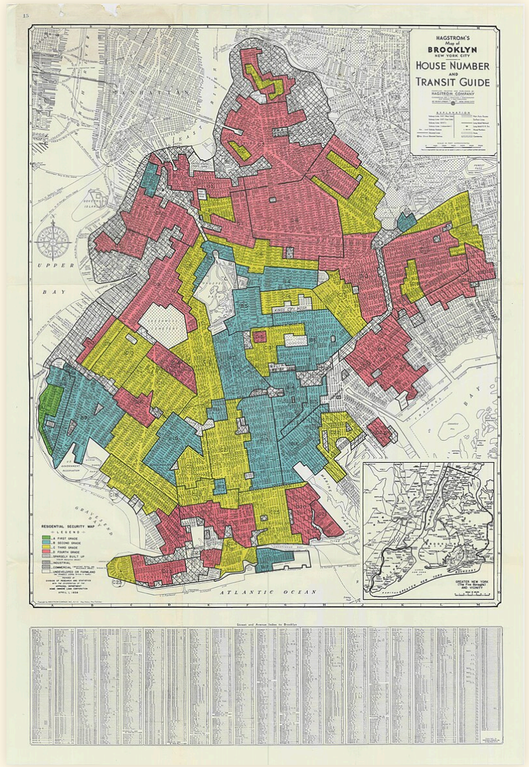
- NetLogo version of Schelling's segregation model:
  - Download page (23. Analyzing and Understanding Models) or
  - https://ees4760.jgilligan.org/models/class_24/class_24_models.zip
  - https://ees4760.jgilligan.org/models/class_24/segregation.nlogo

Schelling Model

Background on Racial Segregation in US Housing

- Possible causes of racial segregation:
  1. *Organized action:* Starting in the early 20th century, federal, state, & local laws & regulations enforced segregation
     - Neighborhoods were designated “white”, “black”, etc. and only people of a certain race were allowed to buy property there
     - Banks were forbidden to make loans to people of the “wrong” race.
       - The Home-Owners’ Loan Corporation (HOLC), maintained maps that were used to discrimninate.
     - Private property developers, landlords, and homeowners’ associations used contract law to enforce discrimination.
       - “Covenants” attached to the deed, prohibiting the owner from selling to anyone of a different race.

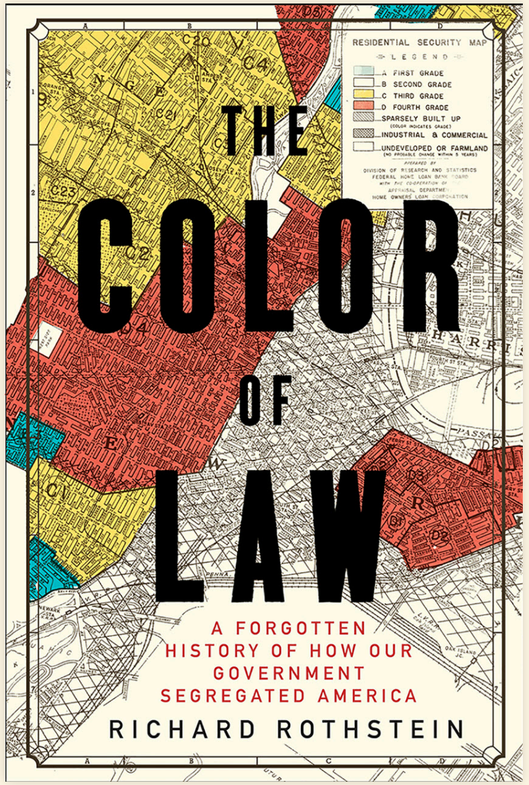


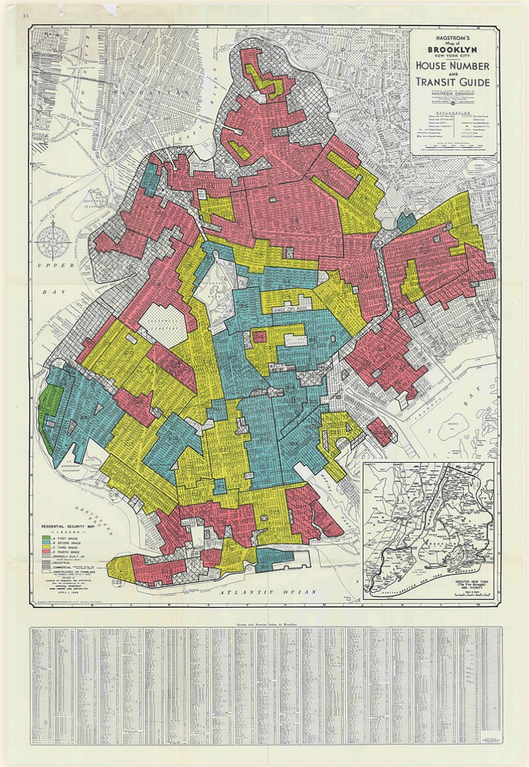


HOLC red-lining map of Brooklyn NY, 1938. Public Domain

Background on Racial Segregation in US Housing

- Possible causes of racial segregation:
  1. *Organized action:* Starting in the early 20th century, federal, state, & local laws & regulations enforced segregation
  2. *Socioeconomic filters:* After Black families are denied opportunities to accumulate wealth through homeownership, lack of money can exclude them from better housing, even after segregation laws are repealed.
  3. *Individual preference:* Even when there is equal opportunity to buy homes, people often want to live near other people like themselves (*homophily*), so segregation patterns can be hard to break.





HOLC red-lining map of Brooklyn NY, 1938. Public Domain

Schelling Model of Housing Segregation

- Maybe the first Agent-Based Model.
  - T.C. Schelling, “Dynamic Models of Segregation”, *Journal of Mathematical Sociology* **1**, 143–186 (1971),
  - *Micromotives and Macrobehavior* (WW Norton, 1978).
- No computers. Schelling worked the model on graph paper with pennies and dimes representing the two kinds of agents.
- Schelling new about the three causes and thought *organized action* and *socioeconomic filters* were the most important causes of segregation …
  - but he thought it was important to study the role of individual preference as an obstacle to integration, even after the other causes were eliminated.

Model Overview

- Turtles represent households.
  - Two colors of turtles: red and blue
  - Turtles have one state-variable: `happy?` (true or false)
- There is a global variable `%-similar-wanted` and a turtle is `happy?` if at least this fraction of its neighbors have the same color as its own.
- At each tick, unhappy turtles move to a random empty patch.
- When all turtles are `happy?`, the model stops.

Experiments

Experiments

Vary `%-similar-wanted` and the `density` of turtles on the patches.

Suggestions:

- Try extreme values of parameters:
  - Set `density` and `%-similar-wanted` to different combinations near maximum, minimum, and in the middle.
  - What do you see?

Extreme Values

- Set `density` to 75% and set `%-similar-wanted` to 95%
- Press `setup` and then press `go`
  - What happens?
- Now, with `go` still pushed, slowly reduce `%-similar-wanted`.
  - Now what happens?

Systematic experiment:

- Using Behaviorspace, create a new experiment to vary `%-similar-wanted`
  - Set `time limit` to 1000
  - Set `density` to 75
  - Measure `percent-similar`
- What do you see?
- Try adjusting both `%-similar-wanted` and `density`

Visualizing Structures

- Add the following to the procedure `to update-turtles`, after `set happy?`

```
ifelse happy? [ set shape "square" ] [ set shape "square-x" ]
```

- Repeat the exercise of:
  - set `density` = 75% and `%-similar-wanted` = 95%,
  - press `setup` and `go`
  - gradually reduce `%-similar-wanted`
- Is it easier to see the emerging patterns now?

Heuristics

Another Heuristic

- When you're at an interesting value for one parameter
  - (e.g., `%-similar-wanted` = 75%),
  - vary other paremters (`density`).
  - Set `density` to 75% and `%-similar-wanted` to 75%.
    - Vary `density`
  - Set `density` to 96% and `%-similar-wanted` to 75%.
    - Vary `%-similar-wanted`
    - Set `%-similar-wanted` to 70%.

Other heuristics:

- Use several *currencies* to evaluate models
  - Statistical analysis of spatial patterns and time-series
  - Analyze agent properties:
    - Are they unimodal or multimodal
      - (e.g., are turtles divided into distinct groups of rich/poor, healthy/sick, etc.,
      - or distributed continuously around one dominant value of state variables?)
  - Stability: Does system return quickly to steady state after it's disturbed?
- Simplify models:
  - Make all patches the same
  - Make all turtles the same
  - Reduce places where you use stochasticity
  - Use fewer turtles and patches
- Explore unrealistic scenarios
- See book for heuristics for statistical analysis of model output...