Agent-Based Modelling in NetLogo

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Resources

- NetLogo runs on most platforms (Windows, Linux, Mac). It can be downloaded from: https://ccl.northwestern.edu/netlogo
- I ran a lecture course last year which looked at several ABM in the scientific literature: http://davidhales.com/msiis

Schelling's segregation model

- Thomas Schelling (1971) "Dynamic Models of Segregation"
- Could communities become segregated by race, sex, social class, profession etc.
  - if no explicit barriers prevent integration
  - if individuals are tolerant of others
- Explores effects of individual movement (micro interaction) decisions on segregation (emergent macro) outcomes

Schelling’s segregation model

- In his paper Schelling describes several variants of his model:
  - 1D version (agents ordered on a line)
  - 2D versions (agents placed on a checkerboard)
  - Generalised group (agents entering or leaving a large group)
- We will focus only on the 2D version here
- Schelling did not use a computer but a checkerboard with coins and did it by hand
- He called it a game of “solitaire”

Schelling's segregation model

- Schelling makes it clear he is talking about segregation *in general* based on any recognisable attribute and interaction structure
- However he often makes a racial / residential neighbourhood *interpretation*
- This may have something to do with the political and social background of late sixties USA
- *Aside: In is interesting to note the political background in which social models come about*

Schelling’s 2D segregation model

- Bounded grid of cells (checkerboard)
- Each cell may contain an agent or be empty
- Each agent is one of two colours (say, black or white)
- Neighbourhood of each cell are surrounding 8 cells (the Moore neighbourhood)
- An agent is
  - “satisfied” if at least T% of its neighbours the same colour
  - If <T% of neighbours same colour then it is not satisfied
- Unsatisfied agents try to move to nearby empty locations that satisfy them. Satisfied agents stay where they are

Schelling’s 2D segregation model

- Schelling notes that about 25-30% empty cells allows for enough space for movement
- Places equal white/black number of agents randomly on a 13 x 16 grid
- By hand he moves the agents until they are all satisfied and an equilibrium is reached
- His movement involves picking up unsatisfied agents and placing them in the nearest empty cell that makes them satisfied
- He shows diagrams of some example start and end configurations and discusses them

Schelling's 2D segregation model

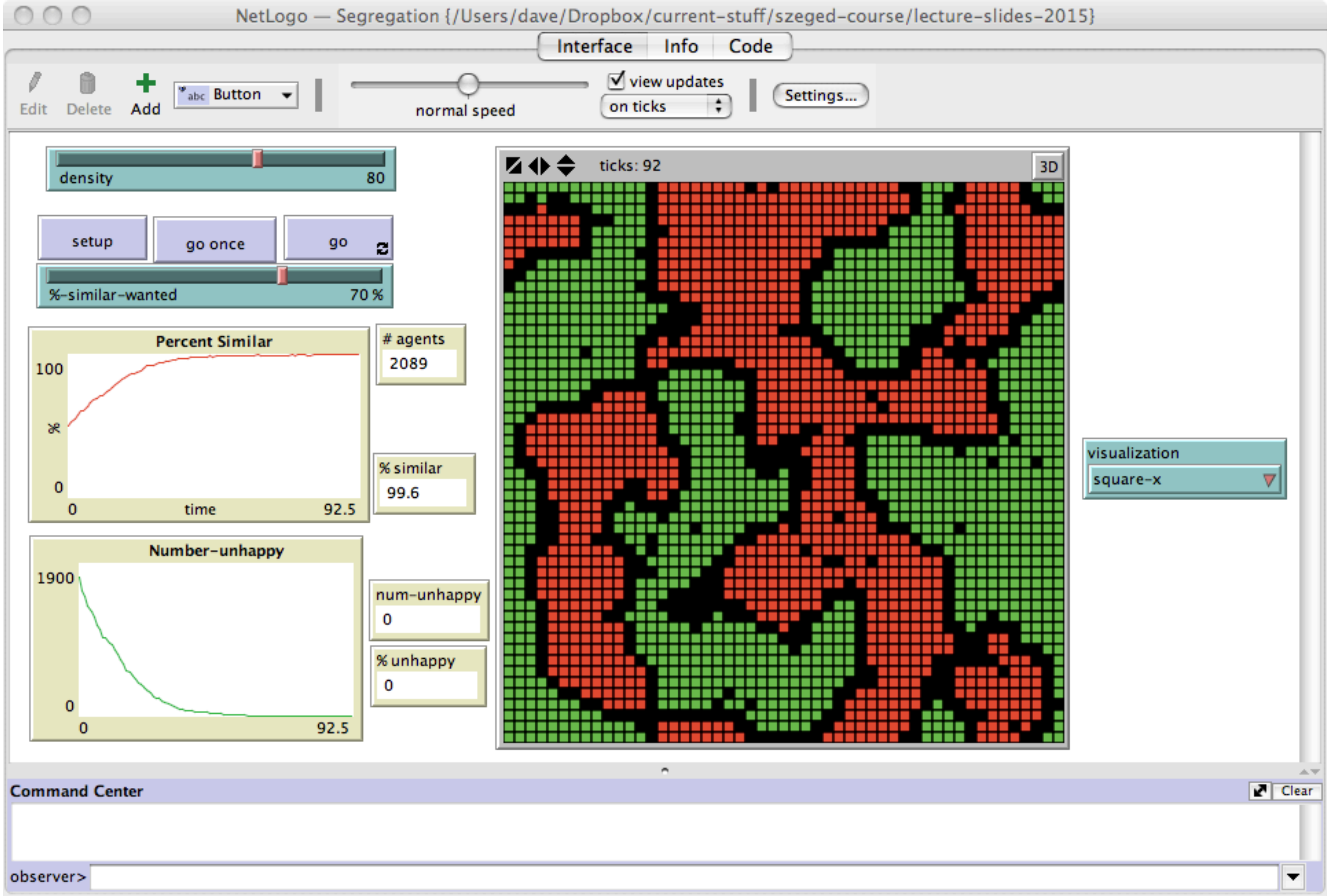
- He finds that with T between 35% to 50% an equilibrium is reached producing high segregation
- With T <= 30% much less segregation is found
- He measures segregation by calculating ave% of agents neighbours that are same colour
- He states he can not do enough simulations by hand to generalise but uses experiments to inform hypotheses

Schelling's 2D segregation model

- Schelling observes:
  - Even comparatively "tolerant" agents (say T=35%) can produce high segregation
  - This means that if agents don't want to be in a significant minority => high segregation
  - Playing around with coins on a checkerboard produced counter-intuitive insights
  - Others can reproduce his results (in about 10 minutes with paper and coins)

NetLogo segregation model

- File>models library/social science/segregation
- 2 input parameters: density, %similar-wanted (T)
- Three output windows:
  - percent similar time series (segregation measure)
  - number unhappy (not satisfied) time series
  - 2D grid showing red & green agents
- To run first click “setup” button then “go” button
- Simulation stops when all agents satisfied or go button is pressed again



NetLogo — Segregation {/Users/dave/Dropbox/current-stuff/szeged-course/lecture-slides-2015}

density 80

%-similar-wanted 70 %

agents 2089

% similar 99.6

num-unhappy 0

% unhappy 0

ticks: 92

visualization square-x

Command Center

observer>

Playing with the model

- Playing with the model:
  - The T value (%-similar-wanted) slider can be moved during a simulation run
  - However to change density of agents the setup button needs to be pressed to re-initialise the population
  - Commenting out the stop condition in the code means the simulation keeps running making it easier to play with T value while running

Rough observations from playing

- With density value at 80%:
  - T < 20% tends to produce %similar < 60%
  - T > 30% tends to produce %similar > 70%
  - T > 80% things never seem to stabilise
  - T < 70% things seem to stabilise quickly
- To get an idea of how T affects %similar (segregation) and how long it takes we need to do a systematic set of simulation runs.
- Note: a NetLogo tool called BehavorSpace can do this automatically (we will look at in future labs)

NetLogo implementation

- 51 x 51 grid (wrapped) = 2601 cells (called patches)
- Agents (called turtles) placed on random patches. Divided between colours randomly, placed randomly
- For each cycle:
  - If all turtles are happy then stop simulation
  - Else move all unhappy turtles
- Movement rule (a random walk):
  - Repeat
    - Point turtle in random direction
    - Move forward a random distance
  - Until empty cell found

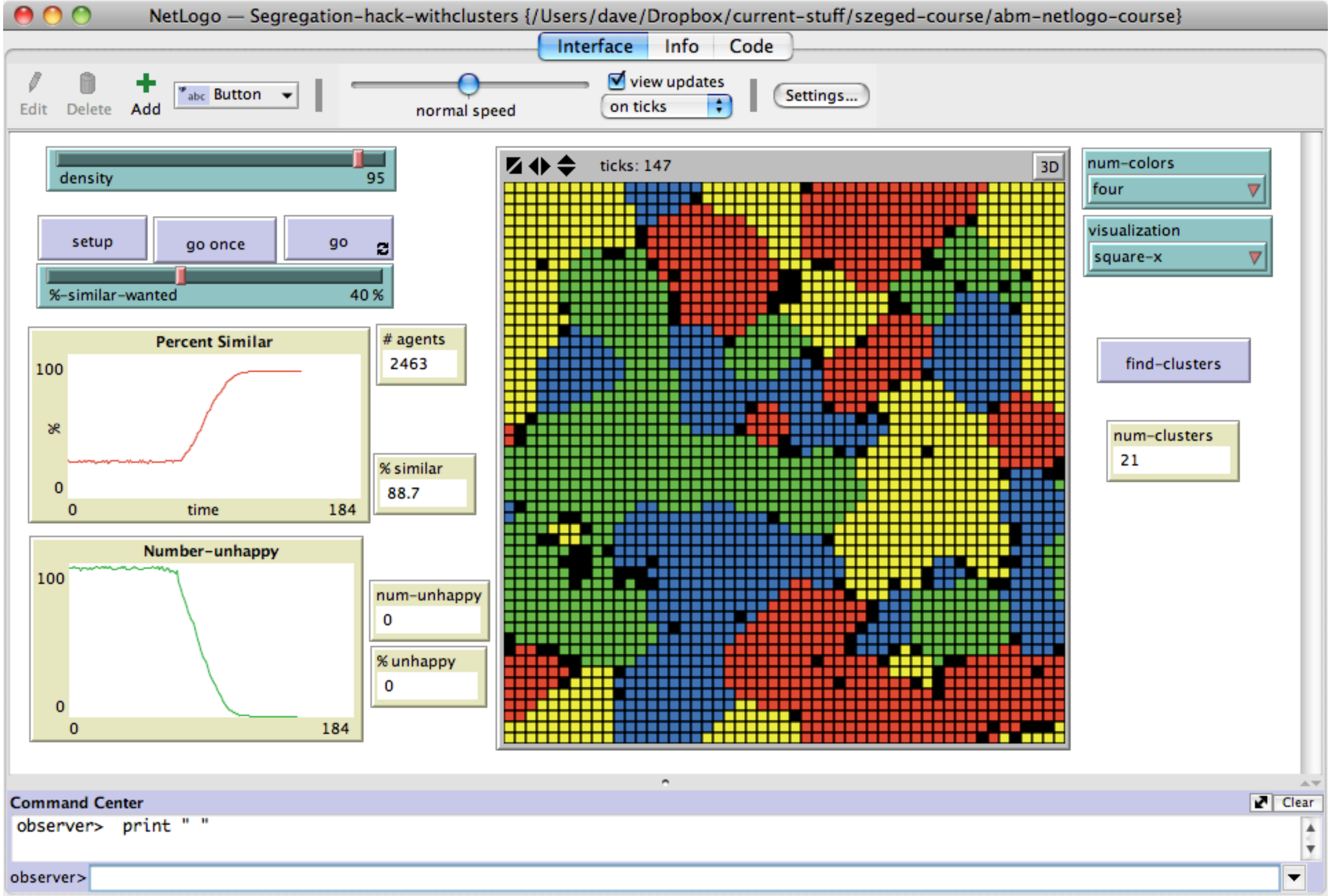
Code

- See exercise sheet for description of code

Tasks

- Modify model so agents take one of four colours (red, green, blue or yellow)
- Add a “Chooser” dropdown to the Interface (like the visualization one) that lets user select between two or four colours.
- Modify the find-new-spot procedure so instead of recursively moving it moves directly to a random empty patch. Hint: this can be done in one line by asking patches
- Create button called “find-clusters” that when clicked counts number of connected clusters of the same colour. Display the result in a monitor. Hint: this can be done with a recursive procedure

model after tasks



NetLogo — Segregation-hack-withclusters {/Users/dave/Dropbox/current-stuff/szeged-course/abm-netlogo-course}

☑ view updates

on ticks

density 95

%-similar-wanted 40 %

ticks: 147

agents 2463

% similar 88.7

num-unhappy 0

% unhappy 0

num-colors four

visualization square-x

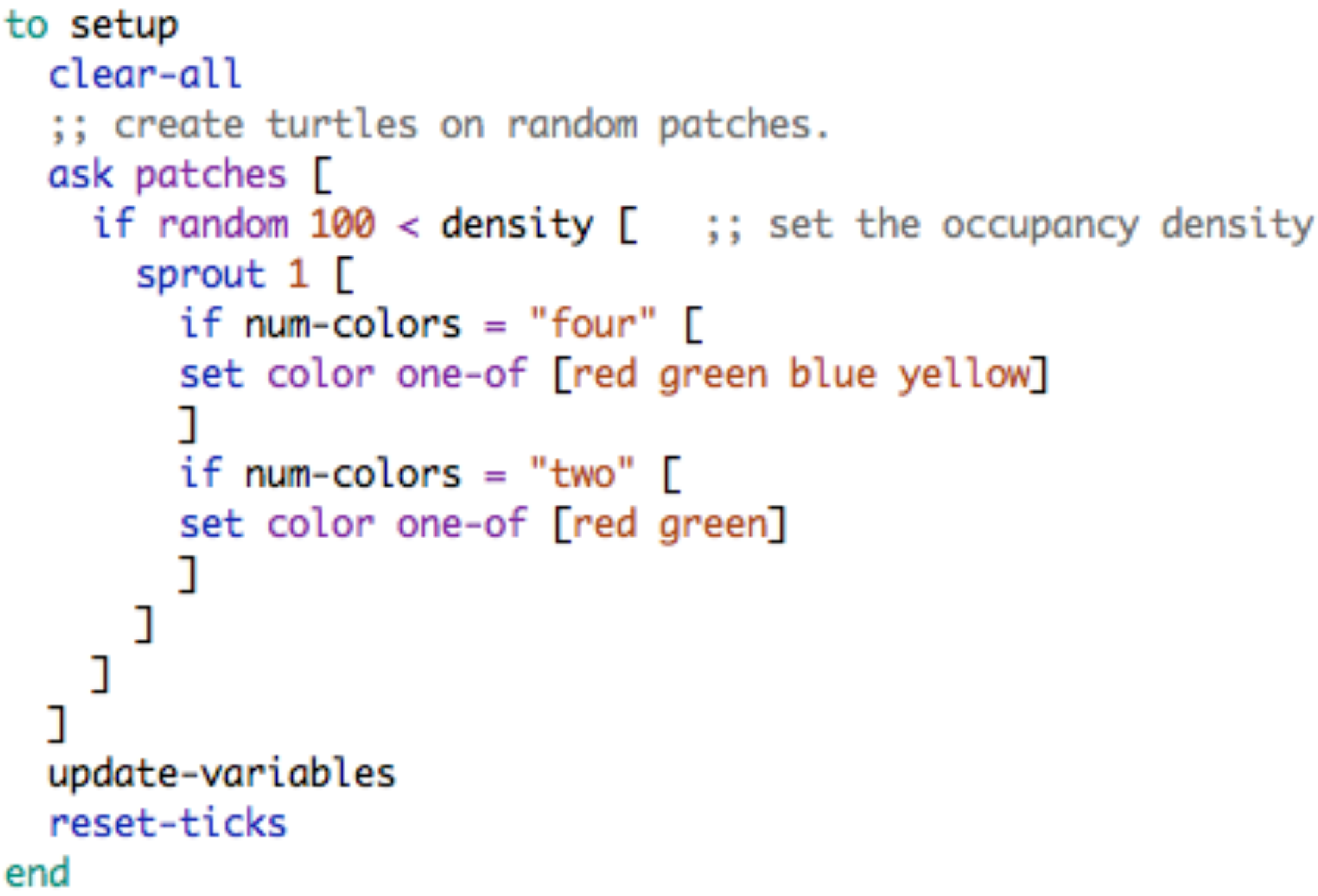
num-clusters 21

Command Center

```
observer> print " "
```

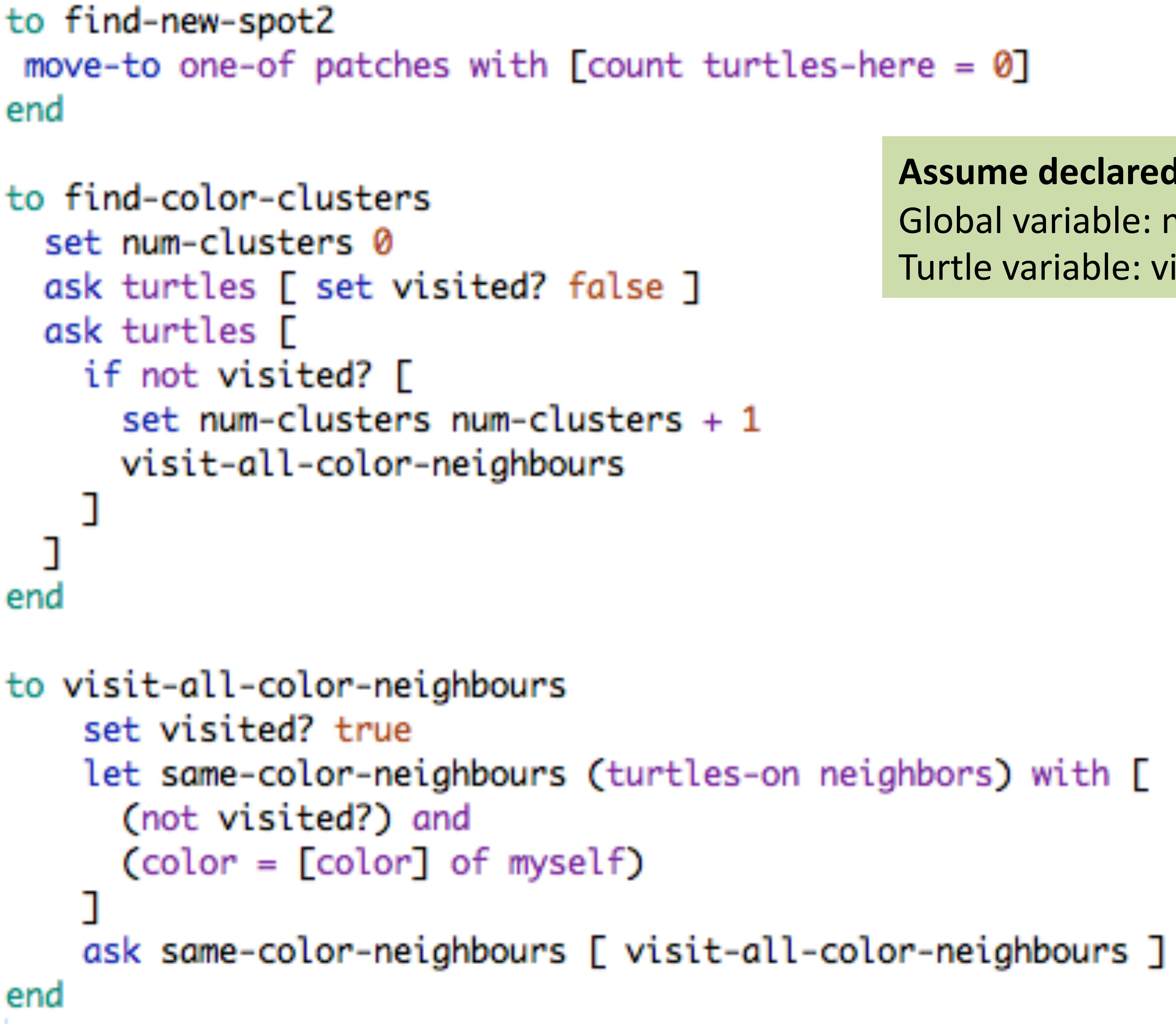
observer>

new code



```
to setup
  clear-all
  ;; create turtles on random patches.
  ask patches [
    if random 100 < density [   ;; set the occupancy density
      sprout 1 [
        if num-colors = "four" [
        set color one-of [red green blue yellow]
        ]
        if num-colors = "two" [
        set color one-of [red green]
        ]
      ]
    ]
  ]
  update-variables
  reset-ticks
end
```

new code



```
to find-new-spot2
 move-to one-of patches with [count turtles-here = 0]
end

to find-color-clusters
  set num-clusters 0
  ask turtles [ set visited? false ]
  ask turtles [
    if not visited? [
      set num-clusters num-clusters + 1
      visit-all-color-neighbours
    ]
  ]
end

to visit-all-color-neighbours
    set visited? true
    let same-color-neighbours (turtles-on neighbors) with [
      (not visited?) and
      (color = [color] of myself)
    ]
    ask same-color-neighbours [ visit-all-color-neighbours ]
end
```

Assume declared:
Global variable: num-clusters
Turtle variable: visited?

Thomas Schelling

- American political economist
- “Nobel prize” in economics (2005)
- Involved in post WWII Marshall Plan
- Major book: The Strategy of Conflict (1960)
- Cold war strategist, US govt. RAND
- *Not a* “game theorist”, much more than that
- Helped inspire director Stanley Kubrick (who did movie 2001) to do movie “Dr Strangelove” (1964) This can be viewed as a satire on game theory – worth watching
- Rumours say that the character Dr Strangelove in the movie was partially inspired by John von Neumann
- Invented term “collateral damage” (1961) ?

Video interview: https://youtu.be/fujQaAgqgxQ