Cell-DEVS-Based Modelling
for
Multistate voter models

by

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Assignment 2 - Final Report
SYSC 5104 - Methodologies for Discrete Event Modelling and Simulation

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1 Part 1 - CONCEPTUAL MODEL

1.1 Abstract Model

The Multistate Voter Model is a simple probabilistic cellular automata model. It is a useful model to study trends relating to how sharing beliefs can influence others in societal settings [1].
In this cellular automata model, each cell represents a voter, with a defined set of chosen **preferences**. In the voter model, the cells have a 1-radius von Neumann neighborhood. The total cell space is 10x10 dimensions. The initial preferences of the model is randomly distributed according to a chosen **distribution**. The rules for the next step preference are as follows:

1. For each cycle, a voter's preference can remain unchanged according to some chosen **probability**, (u).

2. Otherwise, with probability (1-u), the voter changes his preference to the preference of one of its neighbors.

3. The probability of choosing an individual neighbor among its neighborhoods is uniform, which is a probability of (1-u)/4.

1.2 Concrete Model

For this assignment, the concrete values we have decided for our implementation is as follows:

- **Preferences:** The set of preferences for a cell (states) will be Blue(**B**), Red(**B**), Neutral(**N**).

- **Probability:** The probability constant u will be 0.5. Meaning 50% of the time, a voter will change their preference to one of their neighbor's.

- **Distribution:** The initial preference distribution will be (B, 45%), (R, 45%), (N, 10%).

Another detail of our implementation is the use of ranges instead of discrete values for preferences. Every time a preference is set, we also add a real value between 0 and 1 to avoid the possibility of matching states. This is to avoid quiescent states halting the simulation unintentionally since voters are supposed to randomly change over time independently of external events.

2 Part 2 - IMPLEMENTATION

2.1 Formal Specifications

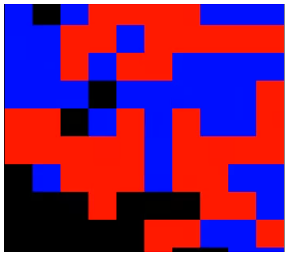
The formal specification for the atomic Cell-DEVS model is defined as follows:
$< X, Y, S, N, d, \tau, \delta_{int}, \delta_{ext}, \lambda, D >$

- $S = \{B, R, N\}$
- $X = \{x | x \in S\}$
- $Y = \{y | y \in S\}$
- $N = S^5 \implies \{(1,0)(0,1)(0,0)(-1,0)(0,-1)\}$(Von Neumann Neighborhood)
- d = 1 (time unit)
- $\tau : N \rightarrow S$ is defined by these rules:
  - With probability u, set preference to trunc(0,0) + uniform(0,0.99)
  - With probability $(1-u)/4$, set preference to trunc(0,1) + uniform(0,0.99)
  - With probability $(1-u)/4$, set preference to trunc(1,0) + uniform(0,0.99)
  - With probability $(1-u)/4$, set preference to trunc(0,-1) + uniform(0,0.99)
  - With probability $(1-u)/4$, set preference to trunc(-1,0) + uniform(0,0.99)
  - trunc: rounds down preference value of given relative cell.
  - uniform: adds uniformly random real number within given range.
- $\delta_{int}, \delta_{ext}, \lambda, D$ defined using Cell-DEVS specifications.

2.2 Test Strategy

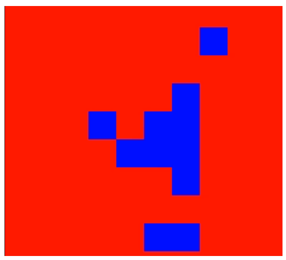
2.2.1 Test 1: Even Distribution

This test case splits the distribution evenly among the main parties (blue, red) but with a small amount of undecided voters (neutral, black). The precise distribution is (B: 0.45, R: 0.45, N:0.1).



The Initial distribution of the Test 1 grid.

The expected outcome is the elimination of the neutral party, and eventually an even chance of blue or red remaining by the end.



The state of the Test 1 grid at the end of simulation.

2.2.2 Test 2: Skewed Distribution

This test case skews the distribution towards (red) but with a small amount of undecided voters (neutral, black). The precise distribution is (B: 0.2, R: 0.7, N:0.1).

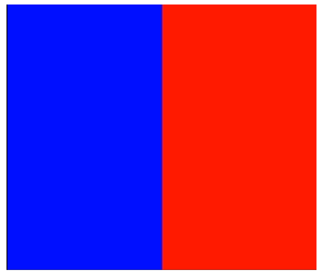
The Initial distribution of the Test 2 grid.

The expected outcome is the elimination of the neutral party, and eventually red should take over. There is still a small chance that blue takes over.

The state of the Test 2 grid at the end of simulation.

2.2.3 Test 3: No Neutral Equal Distribution

This test case eliminates the neutral party, and splits the rest of the voters evenly. The precise distribution is (B: 0.5, R: 0.5, N:0.0).



The Initial distribution of the Test 3 grid.

The expected outcome over time is an even chance of a fully red or blue party.

The state of the Test 3 grid at the end of simulation.

3 References

[1] S. G. Alves, N. M. Oliveira Neto, and M. L. Martins, "Electoral surveys' influence on the voting processes: a cellular automata model," Physica A: Statistical Mechanics and its Applications, vol. 316, no. 1–4, pp. 601–614, Dec. 2002, doi: https://doi.org/10.1016/s0378-4371(02)01208-6.