

Modeling Voter Behaviour and Electoral Dynamics using Cellular Automata

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Basic 1: Voter model with local interaction - Linear voter model

Two Party System: Opinion 0 and opinion 1

Rules:

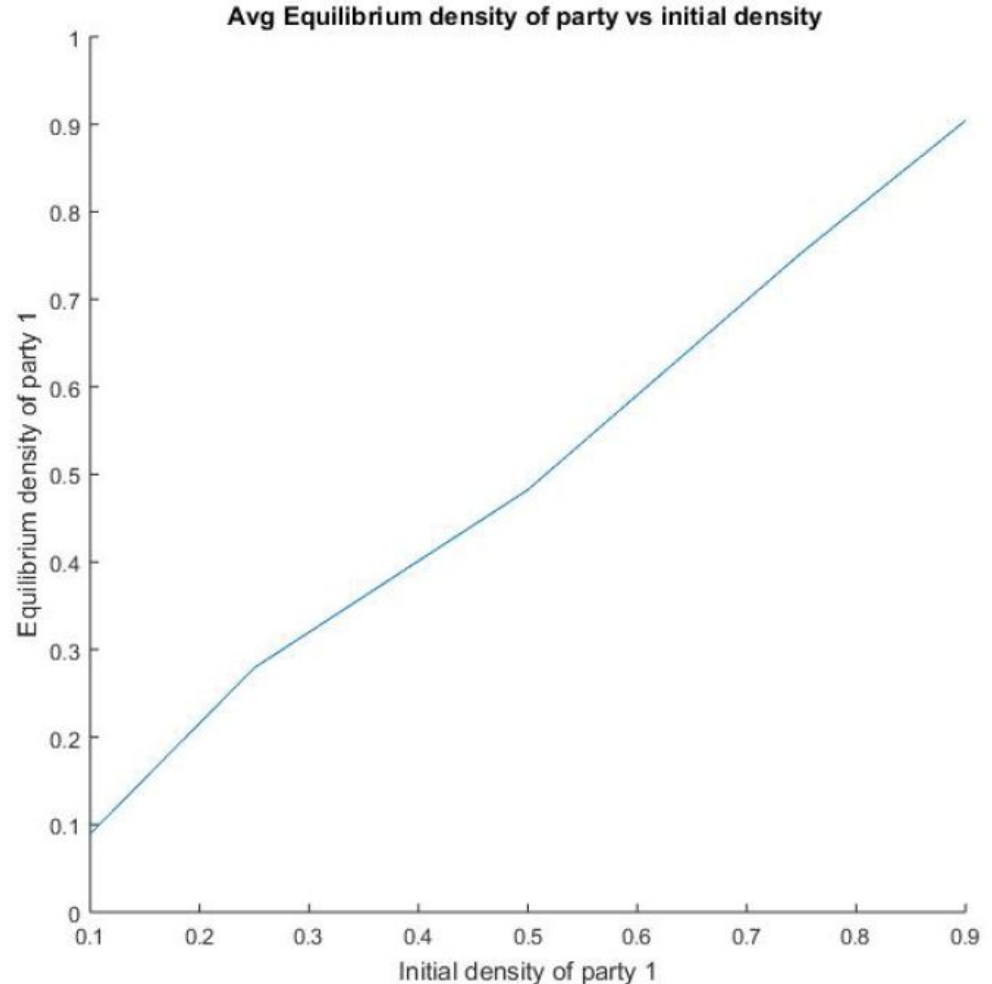
1. For every time step, an agent is selected at random.
2. The agent further selects a random neighbour in his Moore Neighbourhood and takes his opinion.
3. Periodic Boundary Condition



Basic model

Important observations -

1. Relation is linear
2. As if results are predetermined by initial density.
3. Even for initial density 0.9 on an average, the stronger opinion cannot establish complete dominance.
4. Weak are resilient. This is because of the rule which allows the minority to potentially contribute to the cell's opinion.



Basic 2: Nonlinear voter models

Rules :

1. For every time step, an agent is selected at random.
2. The Von Neumann neighborhood of the agent is considered. The sum of the opinions of the five agents is considered (The opinion is either 0 or 1). A probability mass function is used to decide whether the agent remains with party/opinion 1.



Probability mass functions of different models:

Sum of opinions in neighborhood	0	1	2	3	4	5
p.m.f for Majority model	0	0	0	1	1	1
p.m.f for Linear voter model	0	0.2	0.4	0.6	0.8	1
p.m.f for Threshold model	0	0.5	0.5	0.5	0.5	1

Sub Models

1. **Majority rule model** -

- The agent always goes with the **majority** in the group/locality.
- This reflects **crowd mentality** of being influenced by the majority rather than sticking to your own opinion.

2. **Threshold model** -

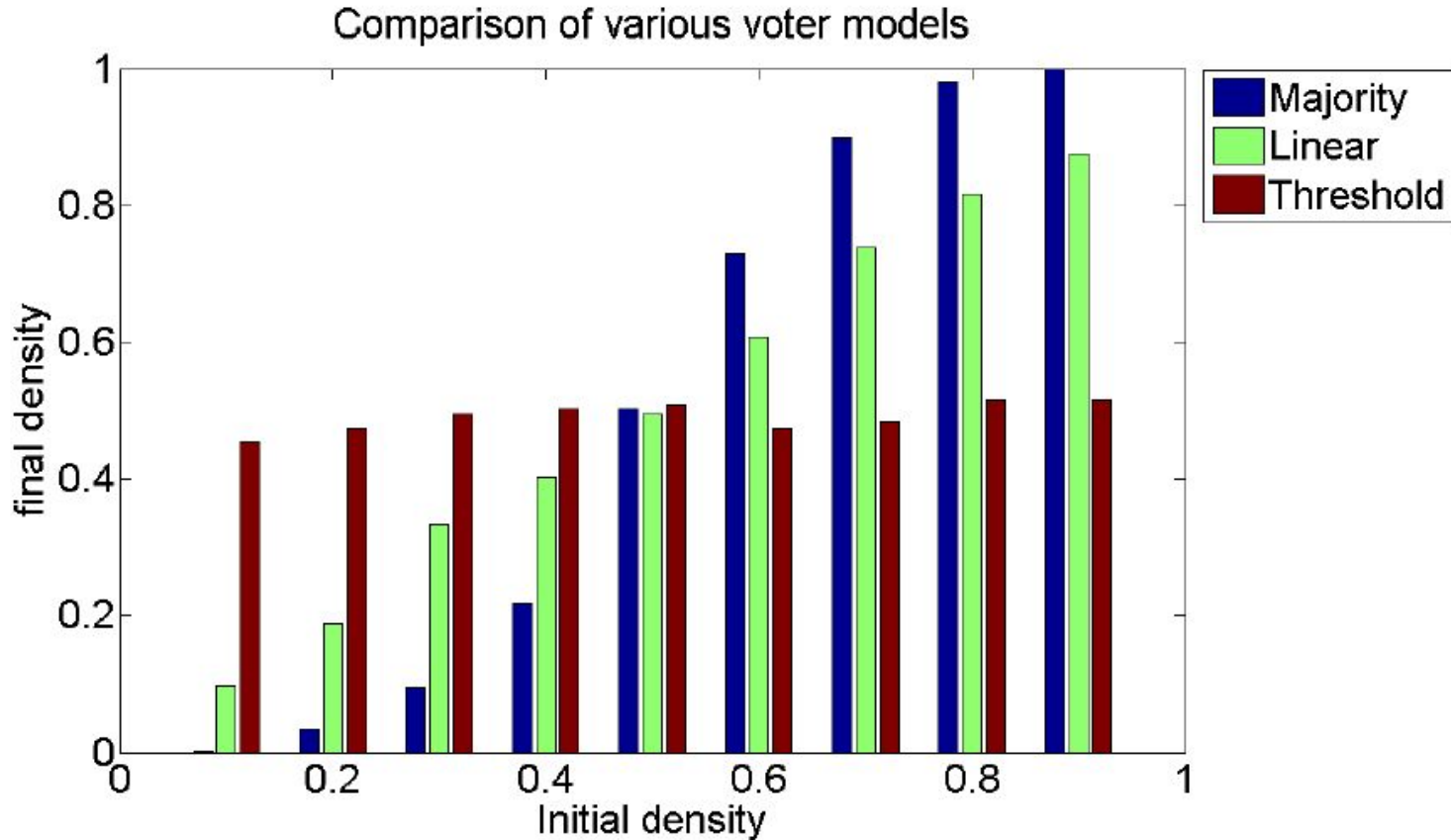
- The agents' thinking is binary. If the neighborhood has absolute majority, they remain in the same state.
- Otherwise, the agent flips a coin to decide the party.
- Illiterate voters



Comparison of linear and non-linear models:

- Grid size
of 50*50
is used

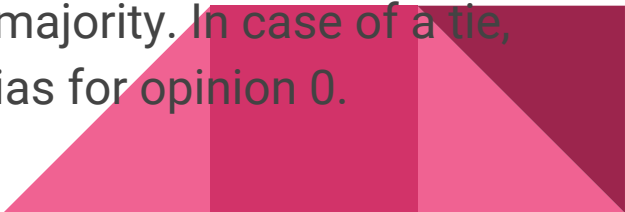
- Number
of Time
steps =
30000



Basic 3: Random Discussion Groups

In this model, **spatial locality** (local neighbourhood) is not considered. In the real world, this model can be used to model voter behaviour due to **interactions** between voters in offices, markets, public transport facilities and other public places.

Rules:

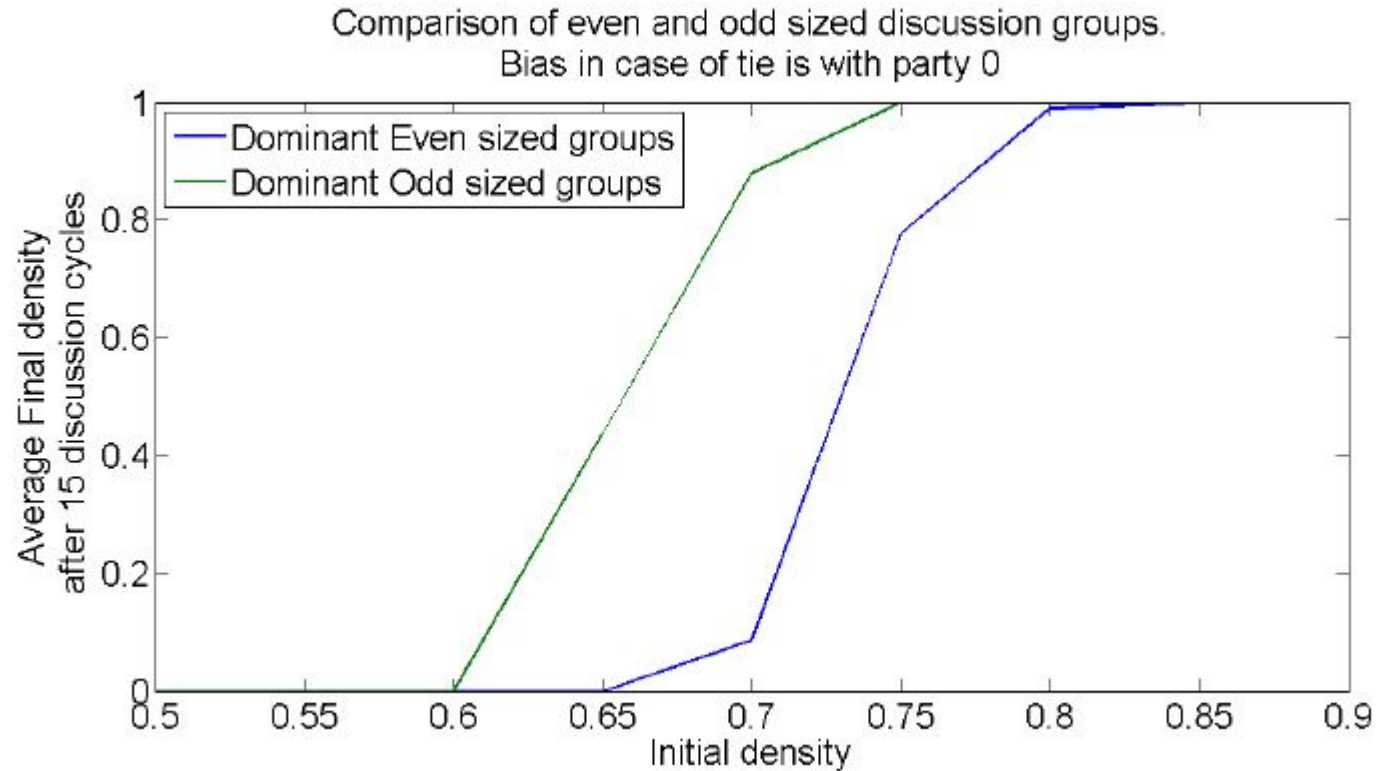
1. In each discussion cycle, the entire population is divided into **randomly sized discussion groups**. The size of the discussion group is decided by a **probability mass function**.
 2. The entire group adopts a single opinion decided by majority. In case of a tie, opinion 0 is adopted. This represents some sort of bias for opinion 0.
- 

Probability mass function for different group sizes used for simulation

Size of Group	1	2	3	4	5	6
Probability for odd dominance	0	0.3	0.6	0.05	0.05	0
Probability for even dominance	0	0.3	0.3	0.3	0.1	0

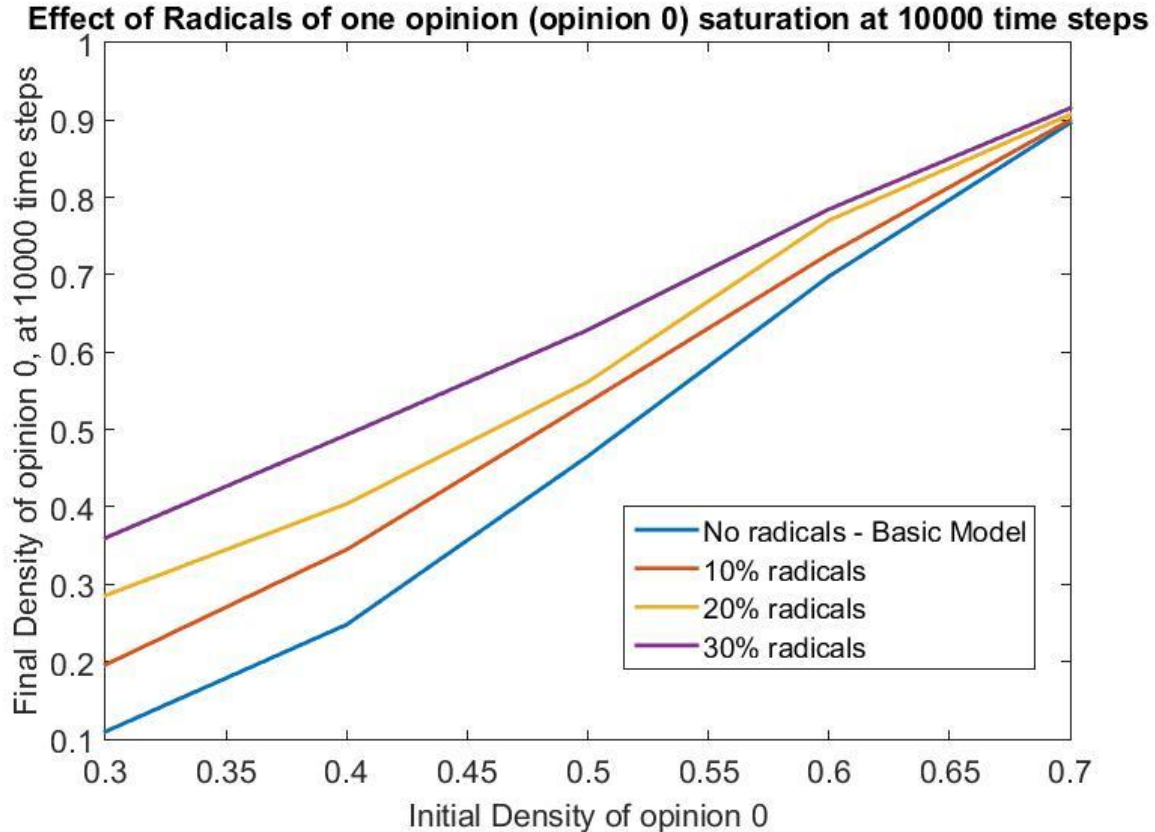
Random Discussion: Comparison of Even-Odd Group

- Grid size -
20*20



Extensions 1: Effect of Radicals

- Extension of Majority Model
- Radicals: Never change their opinion
- Radicals of One opinion
- Effect of radicals decreases with increase in initial density.



Extension 2: Tri-Party System

Basic Model: Random Discussion Group

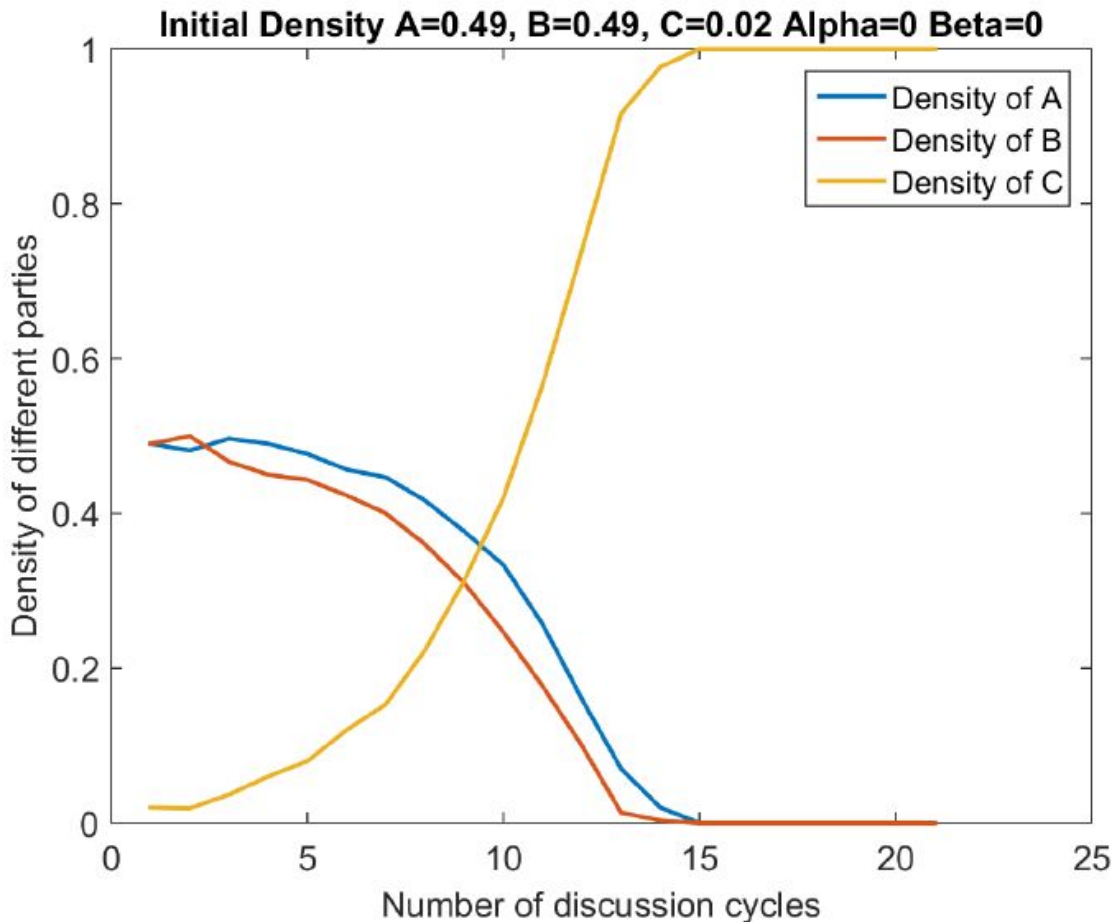
Rules:

1. In each discussion cycle, the entire population is divided into discussion groups of size 3.
2. The entire group adopts a single opinion decided by majority of the 3 people.
3. In case of a tie,
 - a. Opinion A is adopted with probability α
 - b. Opinion B is adopted with probability β
 - c. Opinion C is adopted with probability $(1 - \alpha - \beta)$



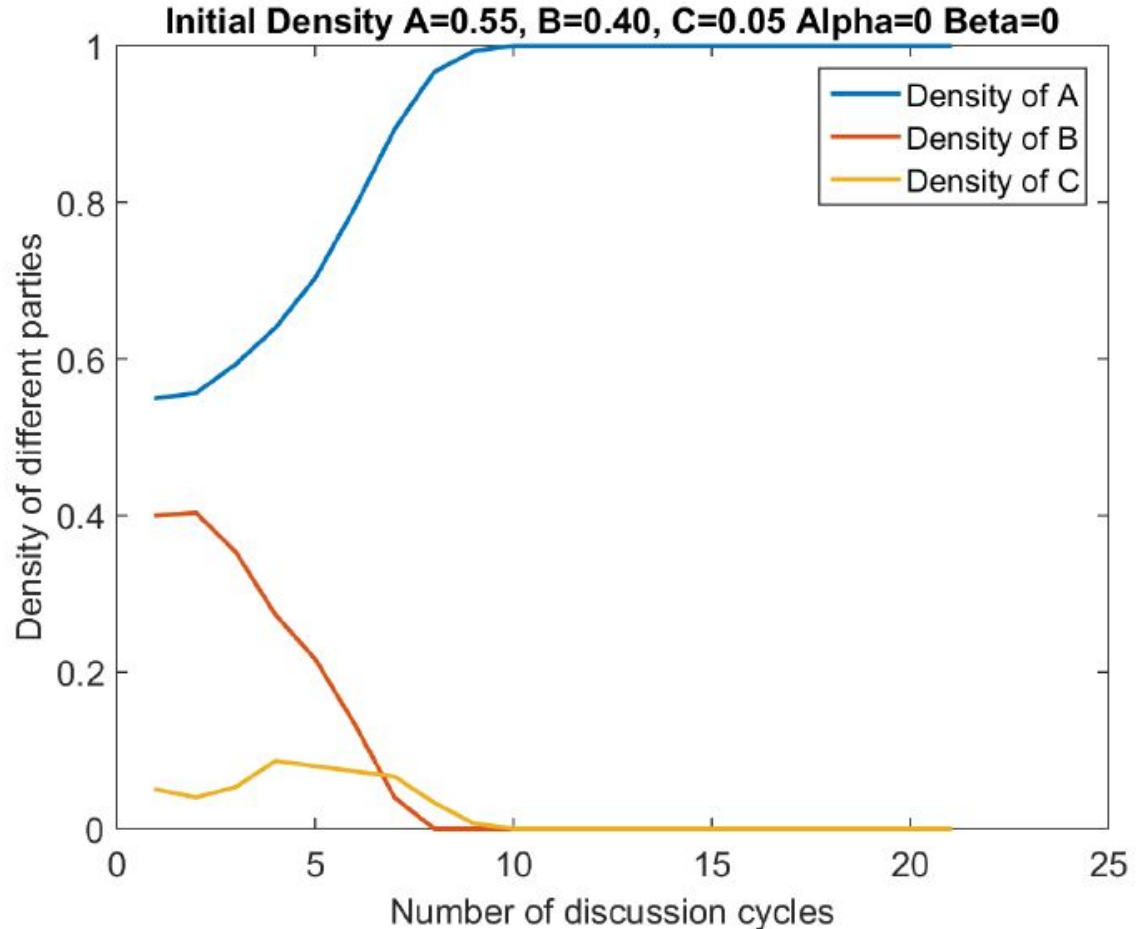
Case I

- Initially no opinion has majority.
- Grid - 30*30
- Mathematics behind Opinion C winning
- While two fight, the third wins!



Case II

- One opinion has clear Majority (>50%).
- It eventually wins irrespective of other conditions.



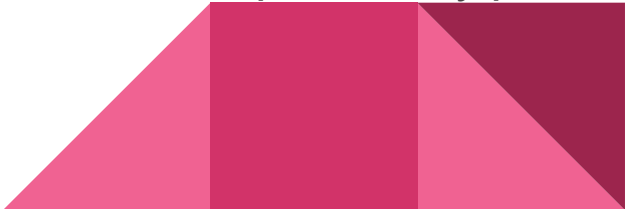
Extension 3: Effect of Mass Media - Consensus

A) Media influence in a population with consensus based decision rule.

Basic Model: Global Effect of Media - Reaches Consensus (Media Opinion) - Trivial

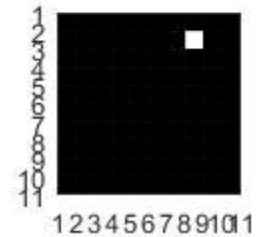
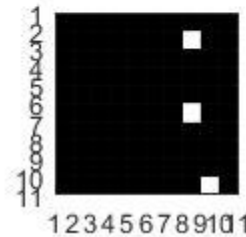
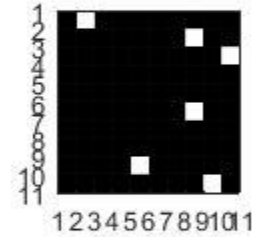
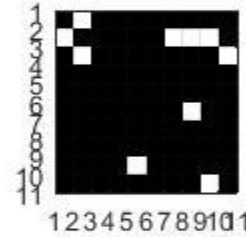
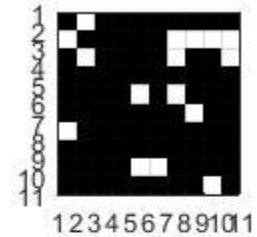
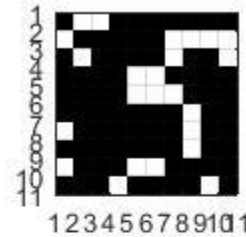
Modification:

Rule:

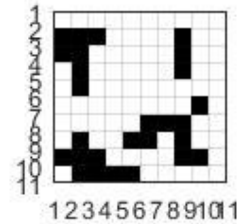
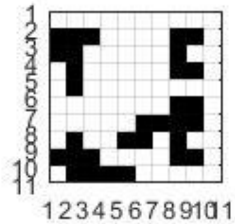
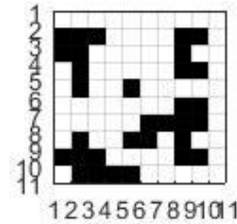
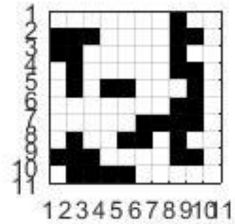
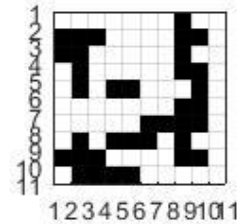
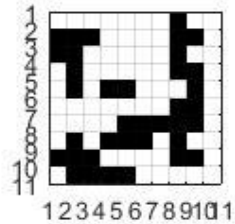
1. Pick a random cell. Appoint cells in its Von Neumann neighbourhood as its advisers.
 2. If they are able to reach a consensus, the cell takes their opinion.
 3. If this fails, the person takes the opinion of the media with some probability p .
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Media hegemony in consensus based society ($p=1$)

- No. of Iterations = 200
- Randomly initialize the grid with 50:50 density of opinions.
- Media is able to quickly establish its hegemony over public opinion.
- Probability of a consensus is just $\frac{1}{8}$ for Von Neumann neighbourhood.



Stalemate when media is ineffective ($p=0$)



Effect of Mass Media


- Consensus based systems are too boring. Can effect of media be studied in more interesting systems?
- Use mass media in a system where decision making is very effective, a majority based system.
- Can we use mass media to subversively?



Extension 3: Effect of Mass Media - Majority

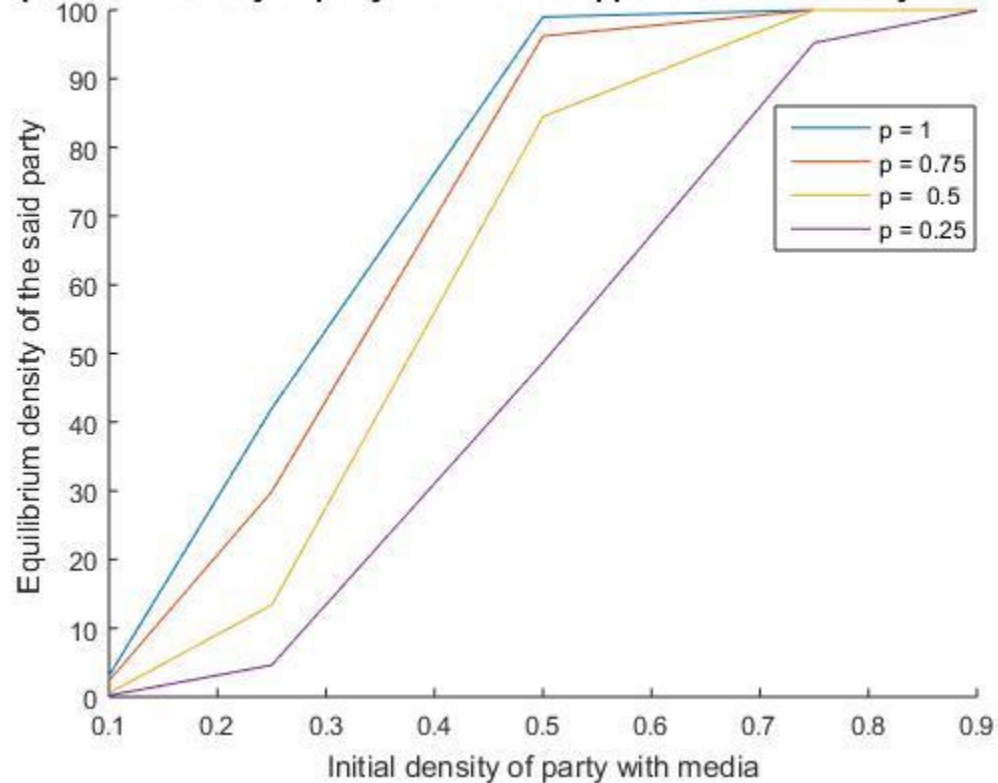
Extension of majority model

Rules -

1. Same as in consensus, but this time the voter seeks media's opinion in case a tie happens.
 2. Note that the probability of media affecting the proceedings is low because ties happen rarely.
 3. But we will see that in spite of this in some situations the media is able to influence the voter opinion.
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Influence of media in majority based system

Equilibrium density of party with media support vs initial density of that party




Conclusion

- Several factors considered in isolation to ensure we are able to analyze them systematically without them interacting with each other.
- Simple local rules lead to emergent global behaviours which we can interpret and get insights about the real politics and complex voter behaviour.
- Effect of Random Discussion Groups - more realistic insights.
- Impact of important real world factors like mass media and radicals.
- Tri-Party model to observe basic behaviour of multi-party systems.



References

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 2. Alexandru Agapie and Robin Hons, Analysis of a voter model, AMS 2000.
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 7. S.Gekle, L.Pelitia and S.Galam, "Opinion Dynamics in a three-choice system", EDP Sciences, Springer-Verlog (2005).
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Thank you! Long live democracy.
Any questions?