

# POLITICAL POLARIZATION DYNAMICS IN A MULTI-AGENT SYSTEM

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Distributed Artificial Intelligence Project

# PHENOMENON UNDER STUDY: POLITICAL ELECTIONS

## The Idea Behind the Simulation

We model a simplified society where:

- individuals interact locally with others
- political opinions evolve over time
- elections periodically take place

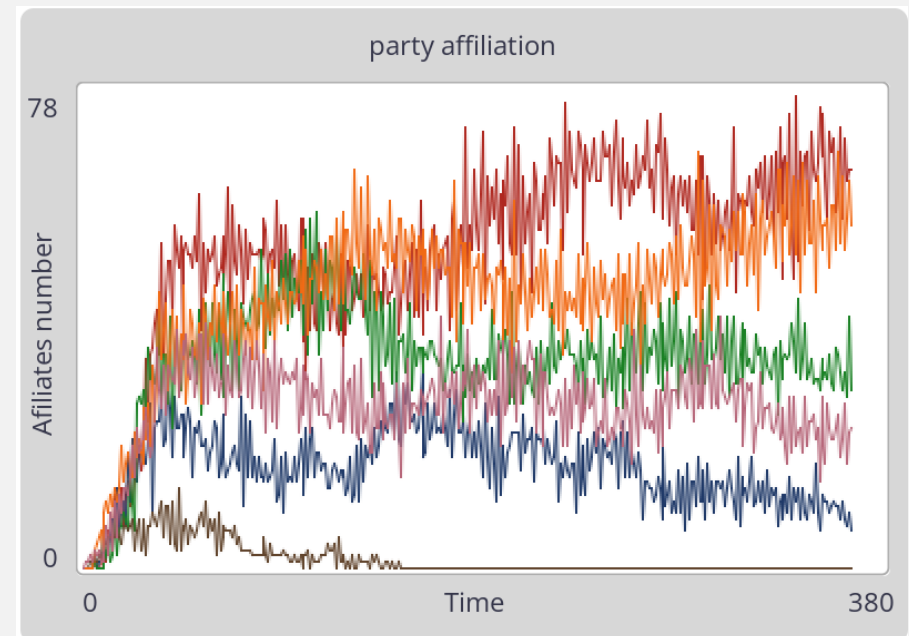
Each agent:

- starts no political affiliation
- is influenced by social interactions
- gradually forms political preferences
- may eventually decide to vote for a party



## MOTIVATION & OBJECTIVES

1. Investigate political polarization in a multi agent system
2. Analyze the impact of:
  - opinion memory (decay)
  - number of political parties
  - social interaction structure
3. Measure the effects on:
  - Voter turnout
  - Vote polarization
  - Winner Gap



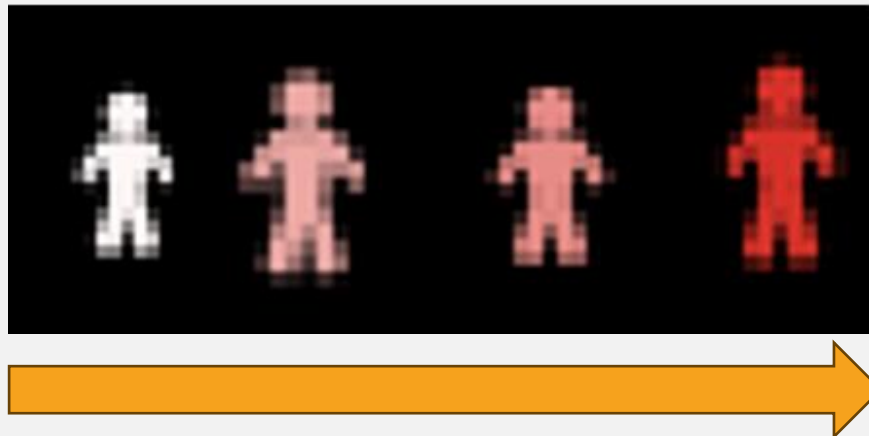
# AGENTS OVERVIEW

Agents are characterized by:

- Political beliefs
- Conversion threshold
- Influence rate

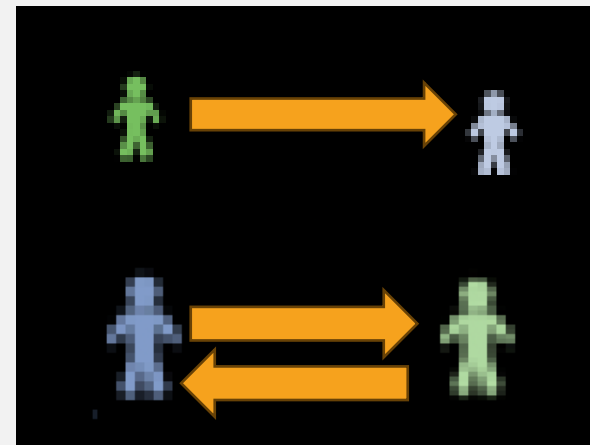
Possible States of an Agent:

- Neutral (color gray or shades of the color)
- Affiliated to a party (colored with the party color)
- Leader of the winner party (yellow)



## INTERACTION DYNAMICS

- Agents move randomly in the environment
- Interact locally with other agents within a social radius
- Interaction represent informal social exchanges like discussions
- An agent can be influenced only if it is not already affiliated to a party
- During an interaction an agent:
  - Exchanges his political beliefs with a neighbor
  - The influence that the exchanges has depends on his influence rate (social susceptibility)



## BELIEFS EVOLUTION

- Each agent maintains a set of beliefs, one for each party
- Beliefs will be increased during time through social interaction
- To model the opinion forgetting:
  - At each iteration the beliefs will be decreased by a decay factor
- If the corresponding belief of an agent exceeds the threshold the agent will be affiliated to a party

**Political preferences emerge from the balance between social influence and memory decay**

# ELECTORAL PROCESS

## Party Elections:

- Occur periodically ( $365 * \text{chosen number}$ )
- Only affiliated agents can vote
- Winning party has the most votes

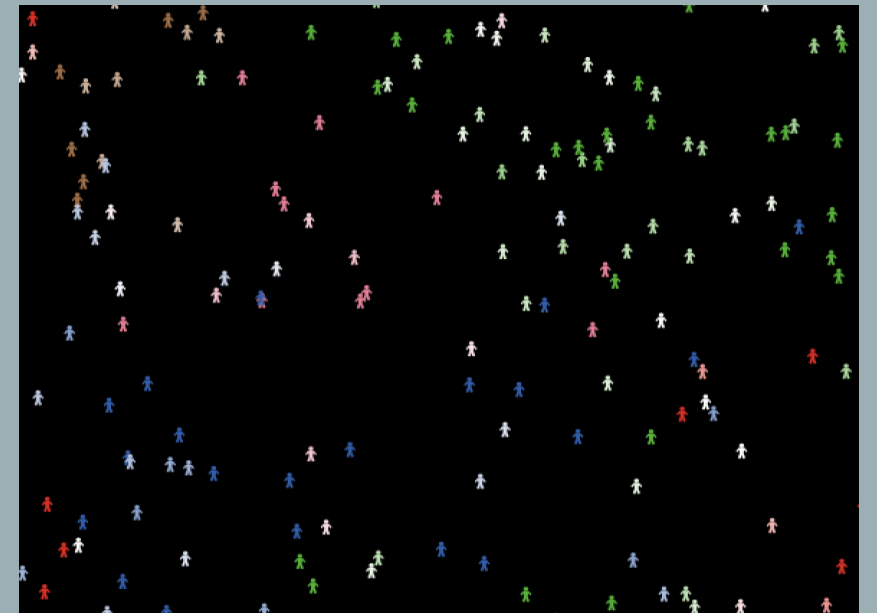
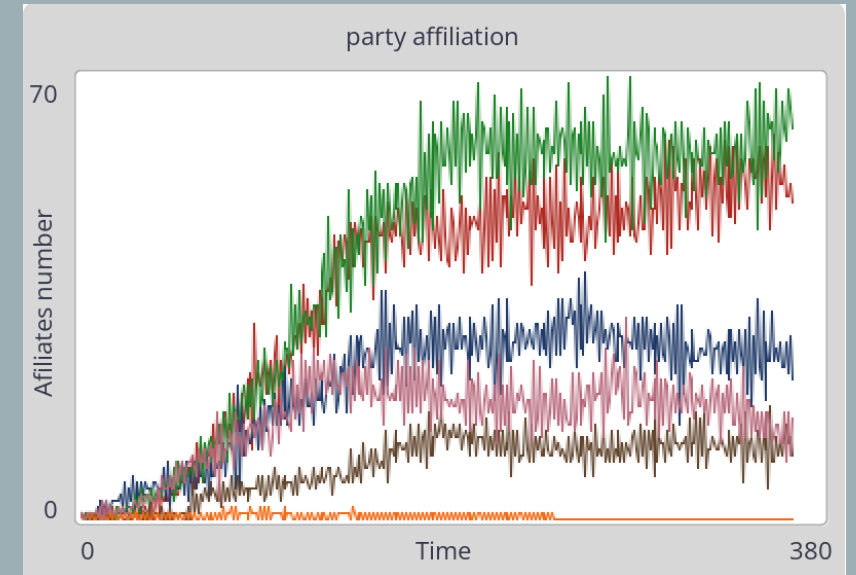
## Leader elections:

- Inside the winning party
- Chosen as a leader the one with the highest party beliefs



# METRICS OF INTEREST

- **Key metrics:**
- Turnout:
  - fraction of active voters
- Polarization:
  - variance of votes across the parties
- Winner gap:
  - difference between the first and second party





# EXPERIMENTAL DESIGN

Experiment name

Vary variables as follows (note brackets and quotation marks):

```
[ "population" 100 300 500 ]  
[ "interaction-radius" 1 3 5 ]  
[ "decay-factor" 0.5 0.75 0.9 ]  
[ "num-parties" 2 4 6 ]
```

Repetitions

☒ Execute combinations in sequential order

Measure runs using these reporters as metrics:

```
variance-party-percentages  
winner-second-diff  
count turtles with [party != 0]
```

☐ Run metrics every step

Run metrics when

> Pre experiment commands:

Setup commands:  Go commands:

> Stop condition: > Post run commands:

> Post experiment commands

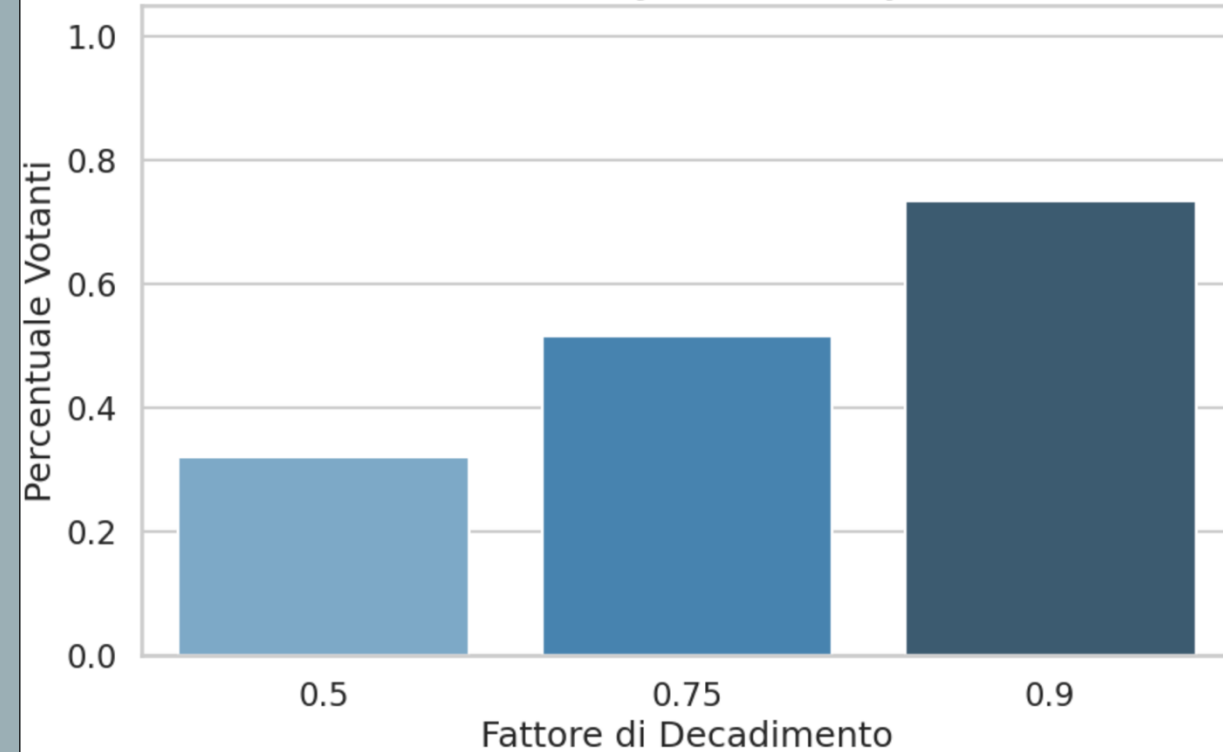
Time limit

## BehaviorSpace tool of NetLogo

- Parameters Explored:
  - Population: 100 – 300 – 500
  - Interaction radius: 1 – 3 – 5
  - Decay factor: 0.5 – 0.75 – 0.9
  - Number of parties: 2 – 4 – 6
- Measured the 3 metrics (polarization, winner gap and turnout)
- 20 runs for each combination of parameters:
  - 1620 runs in total described through a CSV table
- Results analyzed with standard libraries of data analysis: pandas, matplotlib and seaborn

## RESULTS: DECAY VS VOTER TURNOUT

Effetto del Decay sulla Partecipazione



Analysis conducted with seaborn's bar chart

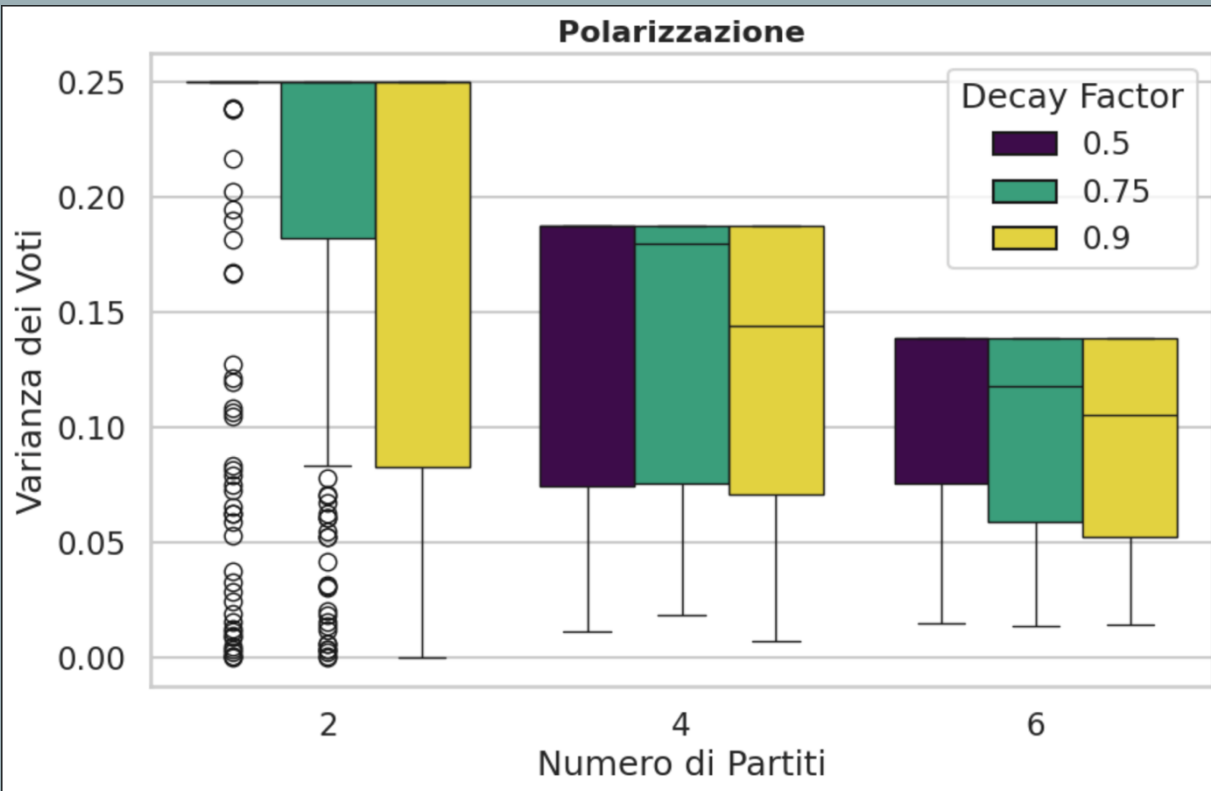
### Observations:

- High decay factor (long term memory):
  - Strong beliefs
  - results in a higher voter turnout
- Low decay (short term memory):
  - Unstable beliefs, agents return to neutral state
  - Low voter participation
  - Apathy of agents

### Interpretation:

Without a long term memory social influence will vanish before they can consolidate into a vote. Meaning that the capacity to remember is a prerequisite for democracy

## RESULTS: NUMBER OF PARTIES & POLARIZATION



Analysis conducted with seaborn's box plot

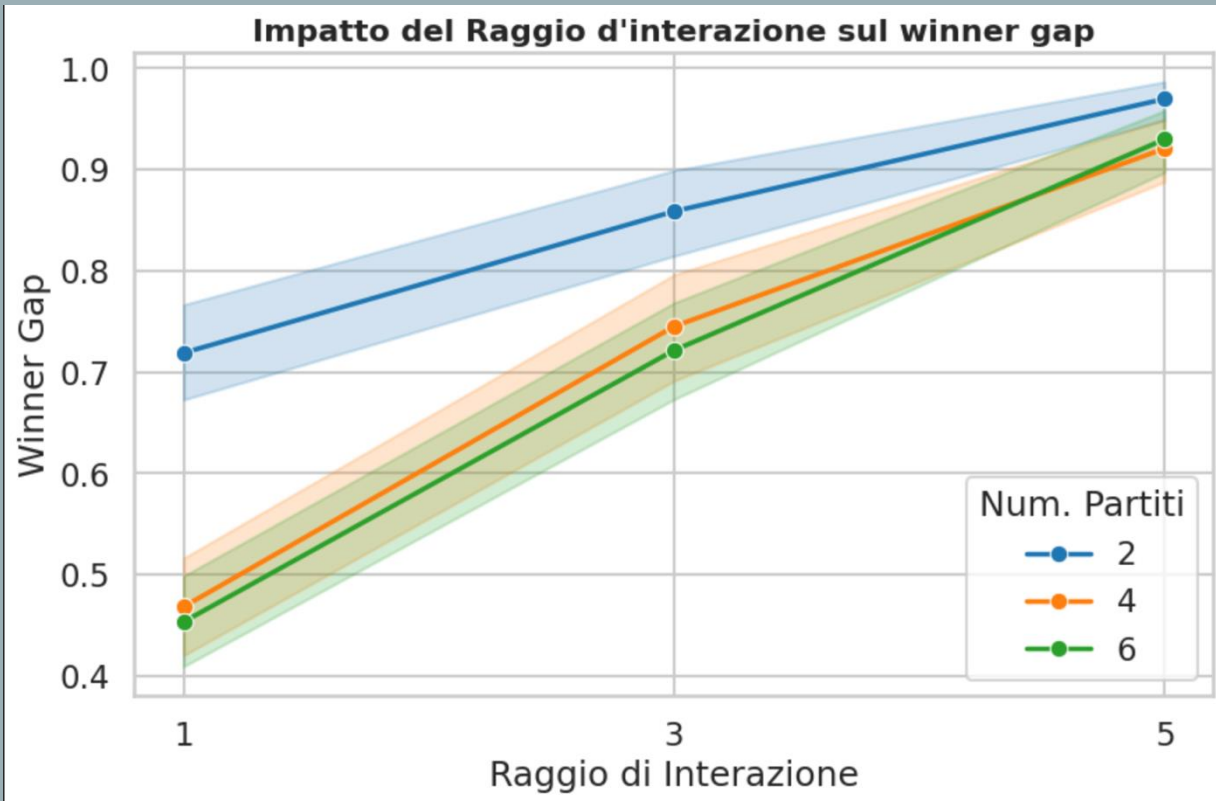
### Observations:

- Two-parties:
  - High variance and instability
  - The winner party gets the totality of votes
  - High decay amplifies polarization effect (low number of voters)
- Multi-parties
  - Increasing number of parties reduce variance
  - Votes are more distributed on parties

### Interpretation:

- Low polarization: votes are equally distributed in all the parties
- High polarization: extreme imbalance, results in a dictatorship scenario
- Higher number of parties prevent a dominance of one ensuring greater equilibrium

## RESULTS: INTERACTION RADIUS & WINNER GAP



Analysis conducted with seaborn's line plot

### Observations:

- Two-parties (blue line):
  - results in an high winner gap regardless the interaction radius (as seen before)
- Multi-parties:
  - with low interaction radius the winner gap is low: at the end of computation there will be heterogeneity of parties
  - High interaction radius will increase the gap

### Interpretation:

In situations where interactions occur with distant entities, a dominant party tends to emerge.

This is a surprising result, as the intuitive expectation is that connecting more people would create a more balanced mix of opinions.

# FINAL CONSIDERATIONS ABOUT RESULTS

## **Key findings:**

**Memory:** essential prerequisite for voter turnout

**Number of parties:** determines the stability of elections

**Connectivity:** High interaction radius drives more decisive victories

THANK YOU FOR YOUR ATTENTION