POLITICAL POLARIZATION DYNAMICS IN A MULTI-AGENT SYSTEM

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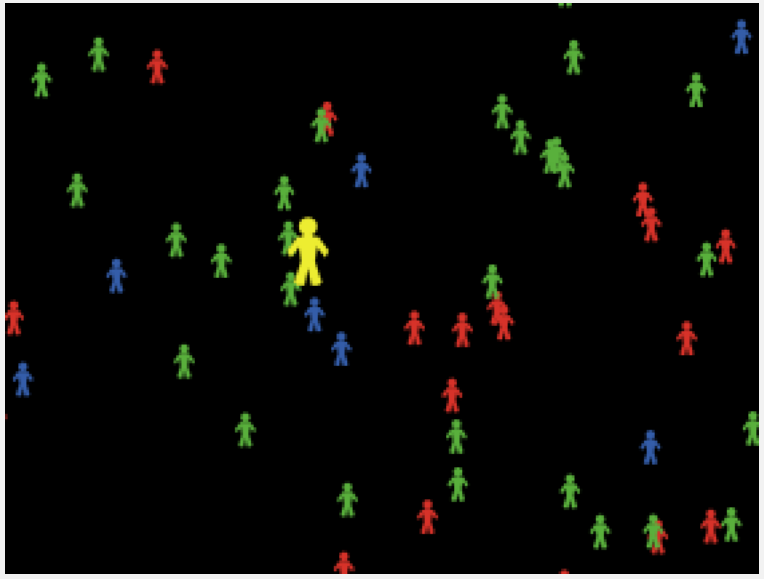
Distributed Artificial Intelligence Project

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:

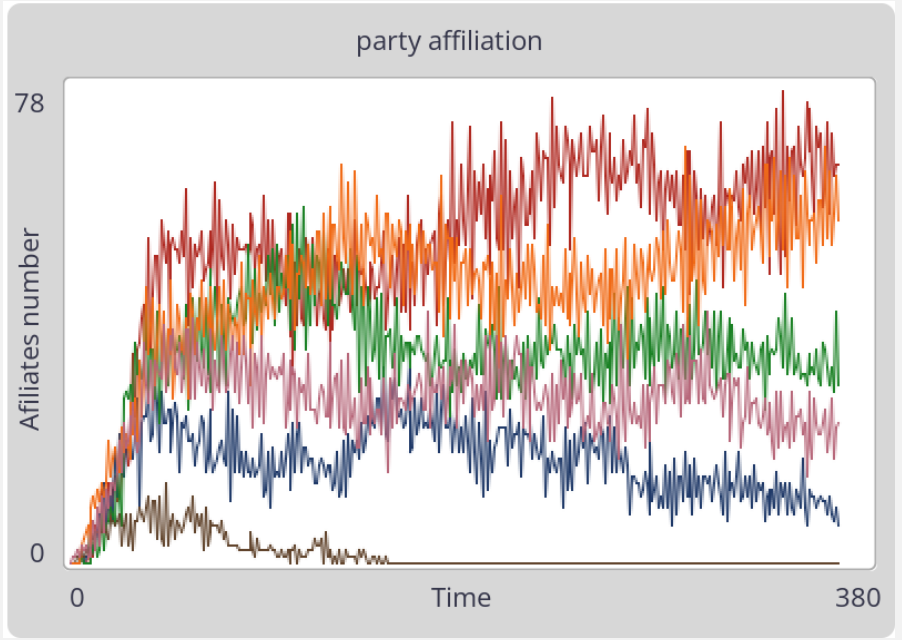
- starts no political affiliation
- is influenced by social interactions
- gradually forms political preferences
- may eventually decide to vote for a party

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



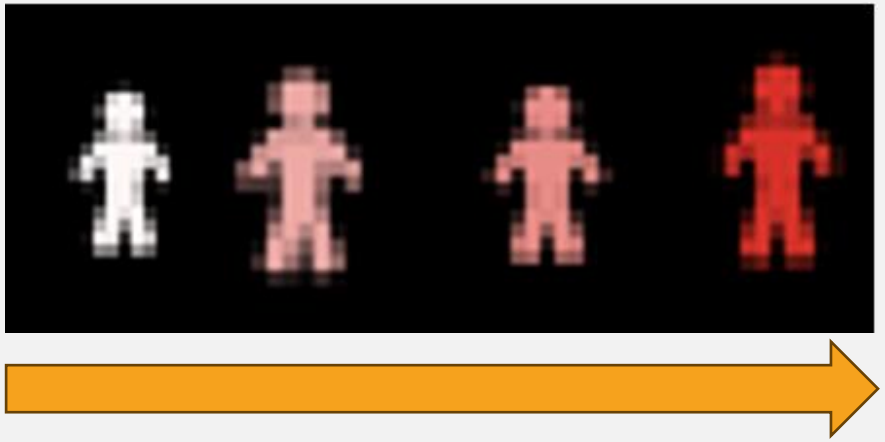
AGENTS OVERVIEW

Agents are characterized by:

- Political beliefs
- Conversion threadshold
- Influence rate

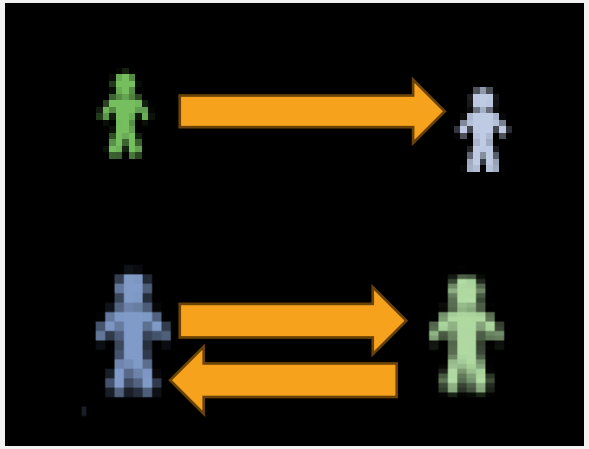
Possible States of an Agent:

- 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 enviroment
- 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 exanges 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 form the balance between social influence and memory decay

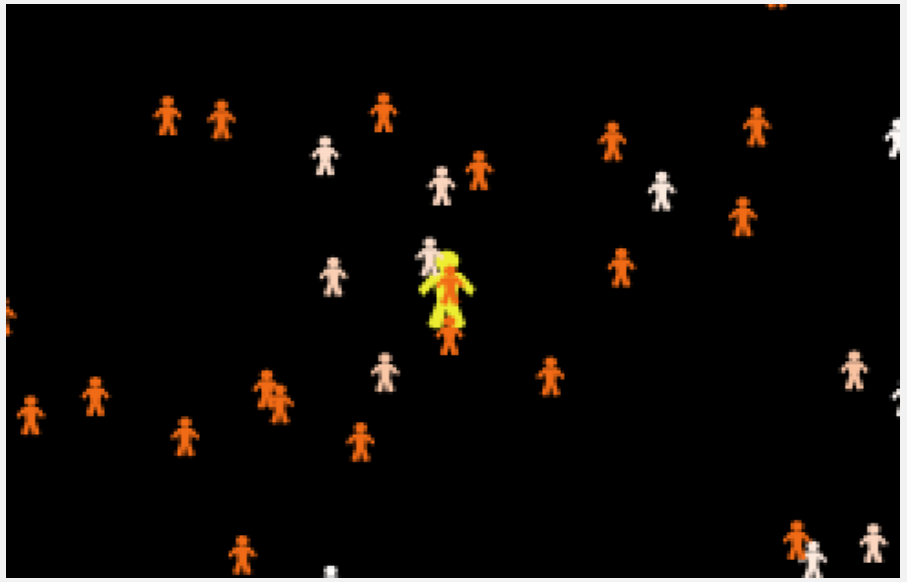
ELECTORAL PROCESS

Party Elections:

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

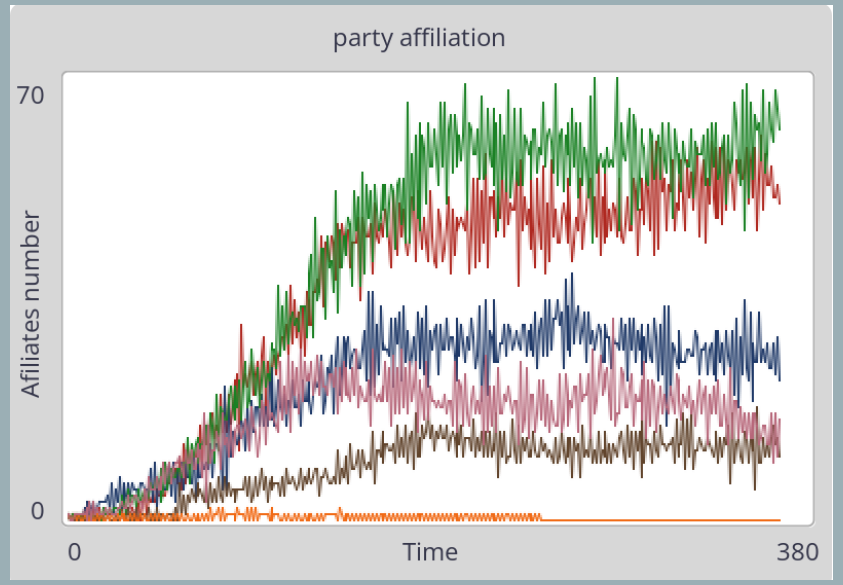
Leader elections:

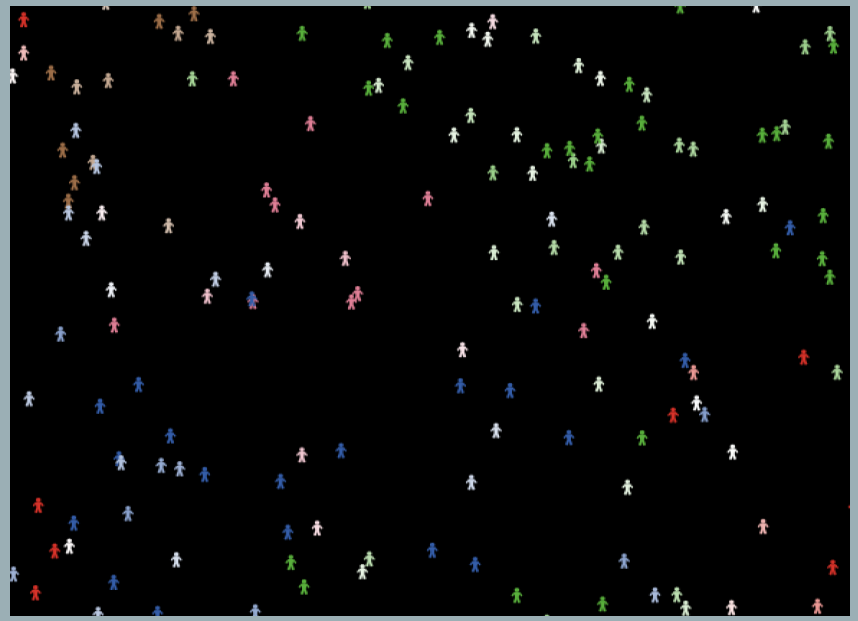
- Inside the winning party
- Chosen as a leader the one with the highest party beliefs



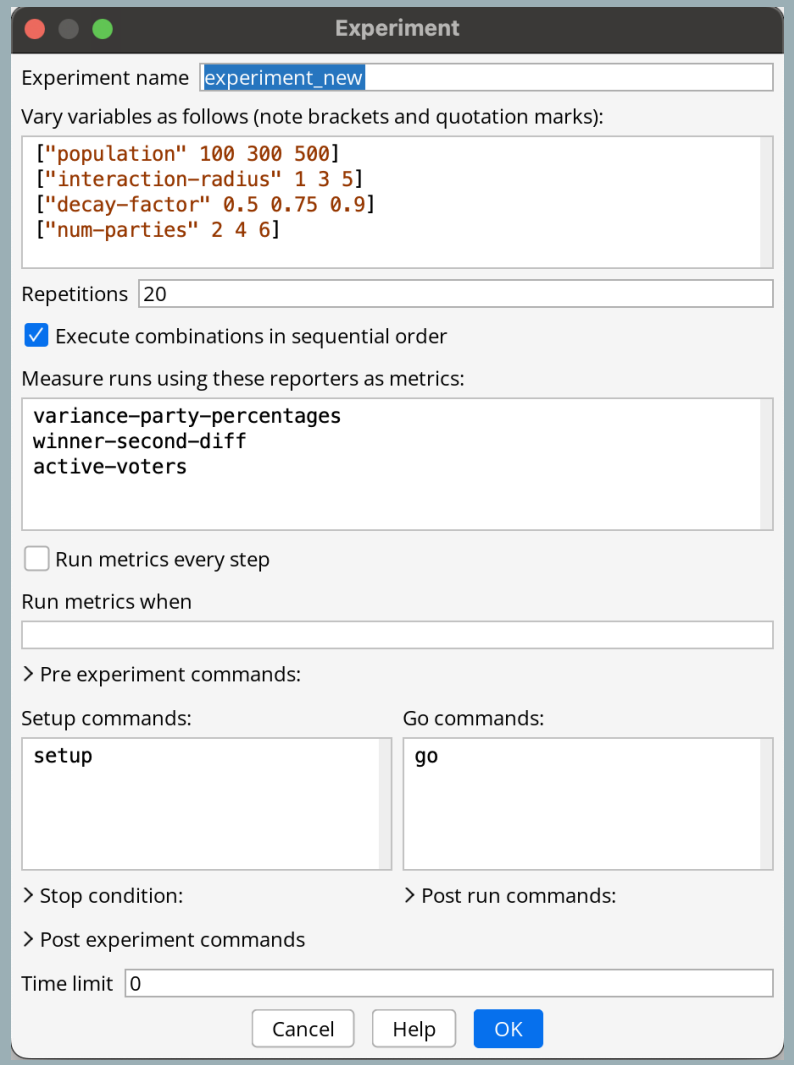
METRICS OF INTEREST

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





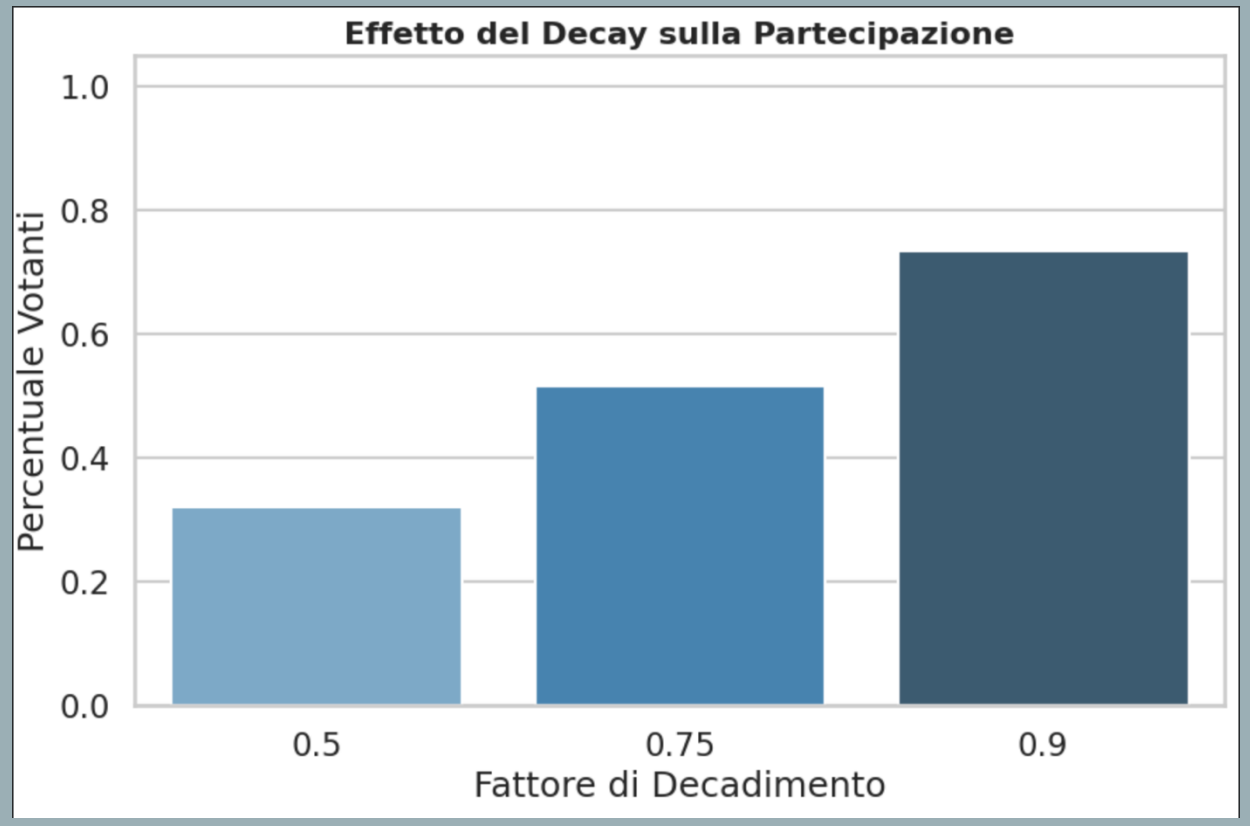
EXPERIMENTAL DESIGN



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



Analysis conducted with seaborn's bar chart

Observations:

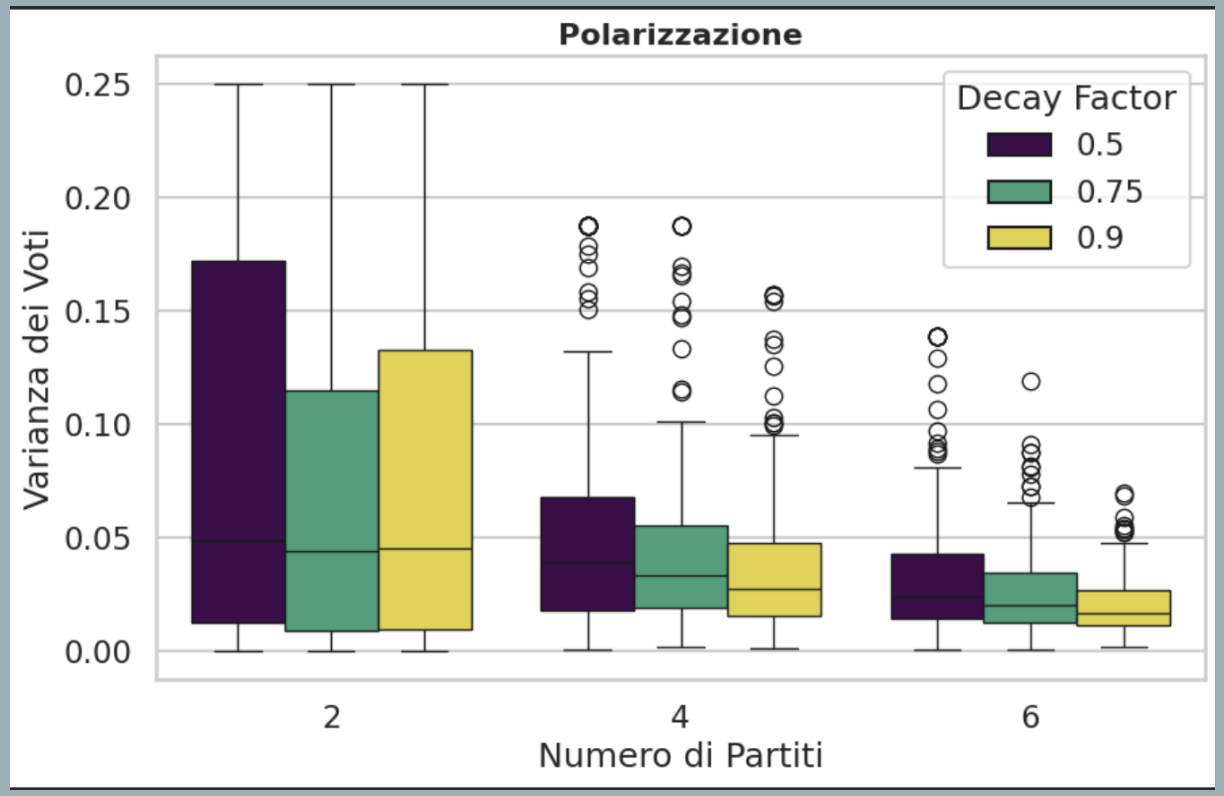
- High decay factor (long term memory):
  - Strong beliefs
  - results in a higher voter turnout

- 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

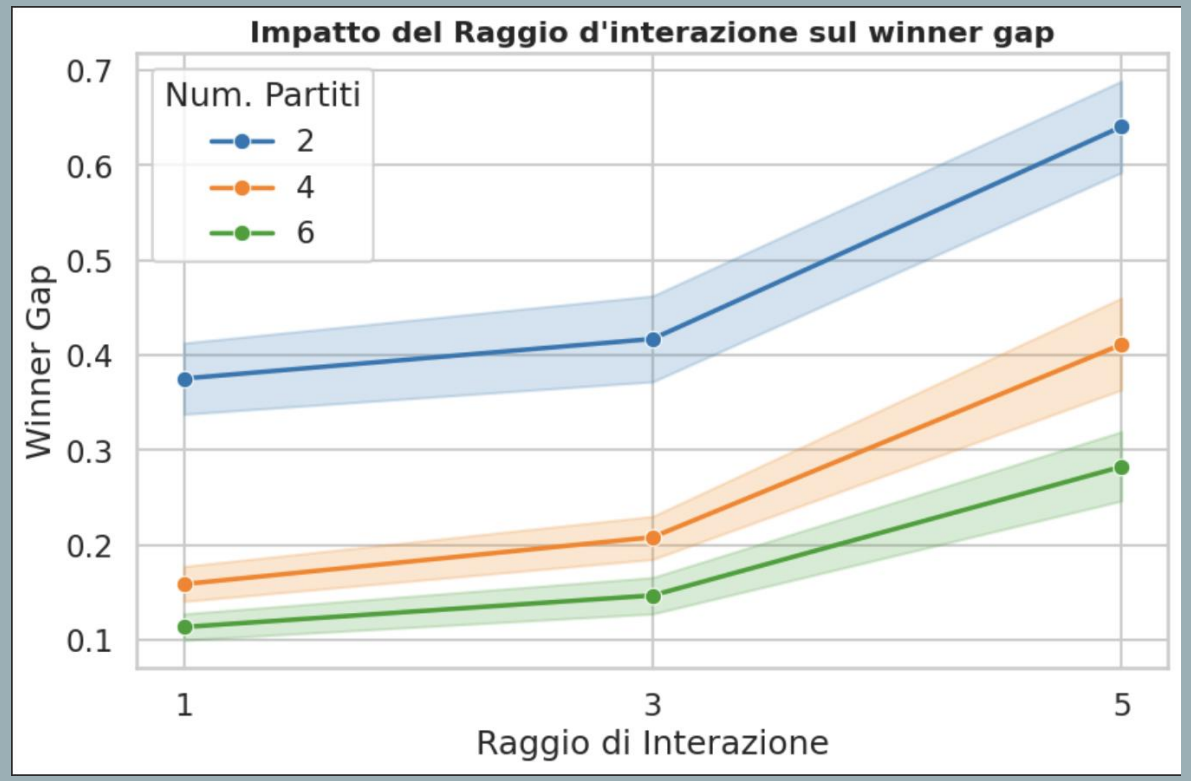
Observations:

- Two-parties:
  - High variance and instability
  - The winner party gets the majority 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 higher 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 heterogenity 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