TECHNISCHE UNIVERSITÄT DRESDEN

SynoSys

Opinion Dynamics

Narrative review

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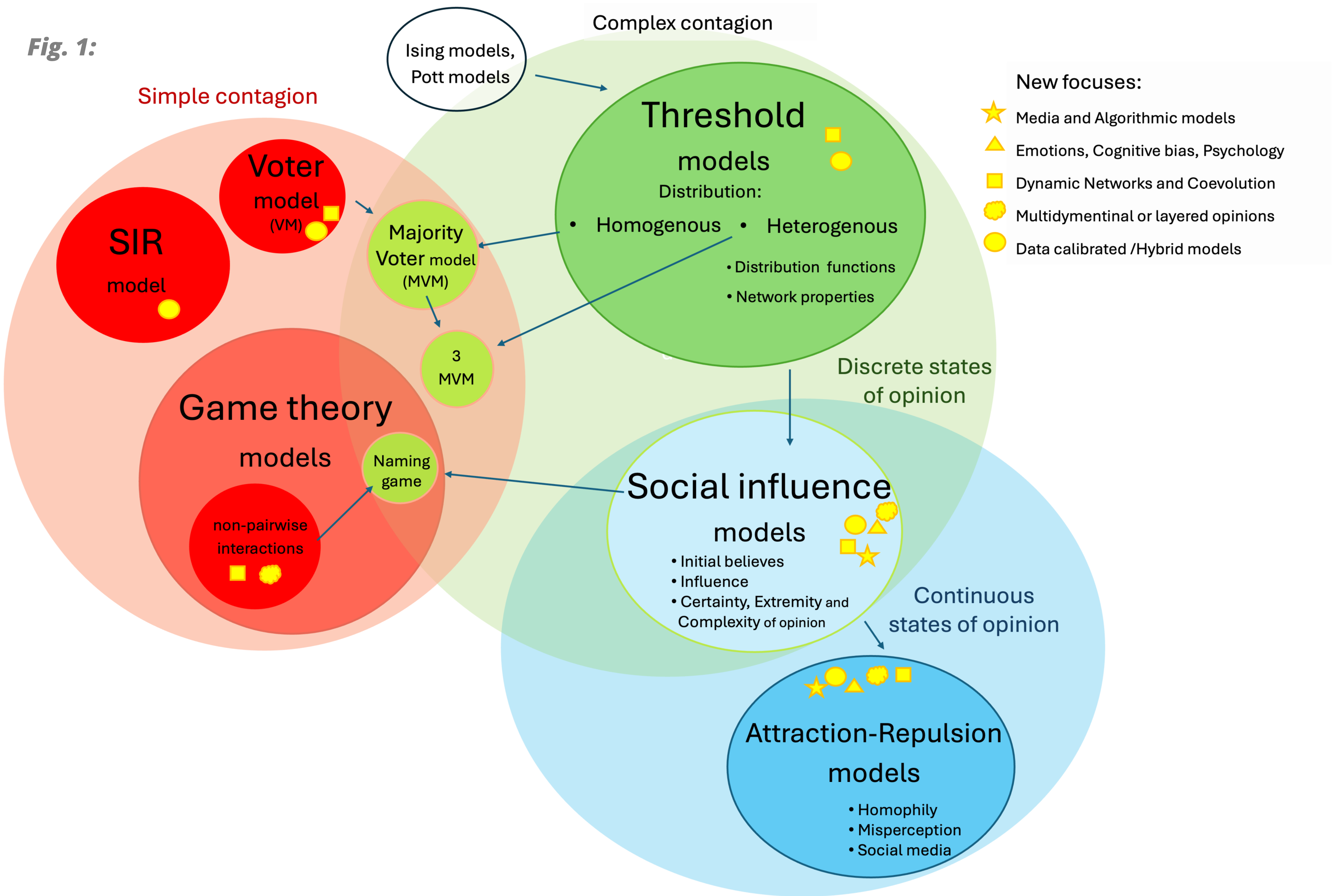
Motivation

Opinion dynamics research has produced a vast set of models with diverse assumptions, from simple to complex contagion and averaging to bounded confidence, adaptive networks, and algorithmic influence. This work tries to sort and structure existing approaches into a topography (Fig. 1) through a narrative review and complements it with a unified agent-based comparison of classical assumptions to establish a baseline for interpreting contemporary extensions.

New Approaches

Since the rise of social media, opinion dynamics has undergone a profound shift. Traditional models have been expanded to account for algorithmic filtering, emotional amplification, and the co-evolution of networks and beliefs. Recent approaches explore how repeated exposure, cognitive bias, and group-level interactions drive polarization and fragmentation. These developments integrate insights from psychology, network science, and empirical calibration—providing a more realistic lens on how collective attitudes form and spread in today's digitally mediated environments.

Fig. 1:



Comparable Simulations

To systematically compare classical opinion dynamics models, we implemented a unified agent-based toy model that varies core mechanisms such as contagion type (simple vs. complex), opinion states (discrete or continuous), tolerance thresholds, repulsion, rewiring, stubbornness and network topology. This allows us to test how foundational assumptions translate into measurable outcomes like consensus, polarization, or radicalization. By establishing these controlled baselines, the simulations provide a reference point for interpreting the more elaborate dynamics proposed in recent models.

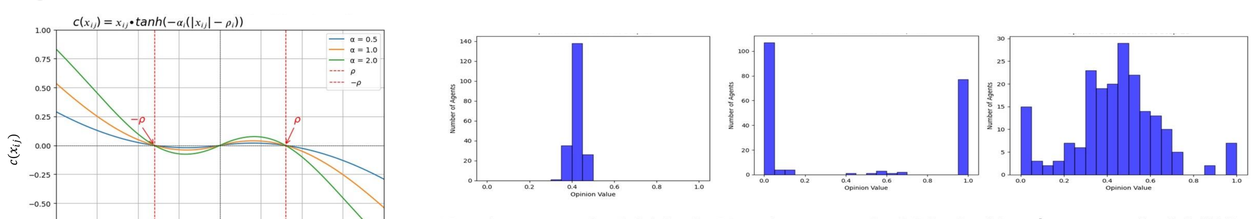
Some results for social influence assumptions (Eq. 1) and threshold assumptions (Eq. 2) are shown below:

Eq. 1:

$$x_i(t+1) = x_i + \frac{\beta_i}{\sum_{j\neq i} w_{ij}} \sum_j w_{ij}\ x_{ij} \cdot \tanh(-\alpha_i(|x_{ij}| - \rho_i))$$

- $x_i(t), x_j(t) \in [0,1]$ → opinions of individual i and its neighbours j
- $x_{ij}(t) = x_j(t) - x_i(t) \in [-1,1]$ → difference of opinion
- $w_{ij} \in [0,1]$ → social influence parameter (asymmetric influence)
- $\alpha_i \in [0,+\cdots]$ → controversy of the topic (nonlinearity parameter)
- $\rho_i \in [0,1]$ → max opinion difference before repulsion
- $\beta_i \in [0,+\cdots]$ → coupling strength (stubborn agents)

Fig. 2:



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Variance: 0.000618  Variance: 0.22913  Variance: 0.04452
Bipolarity: 0.0     Bipolarity: 0.94   Bipolarity: 0.125
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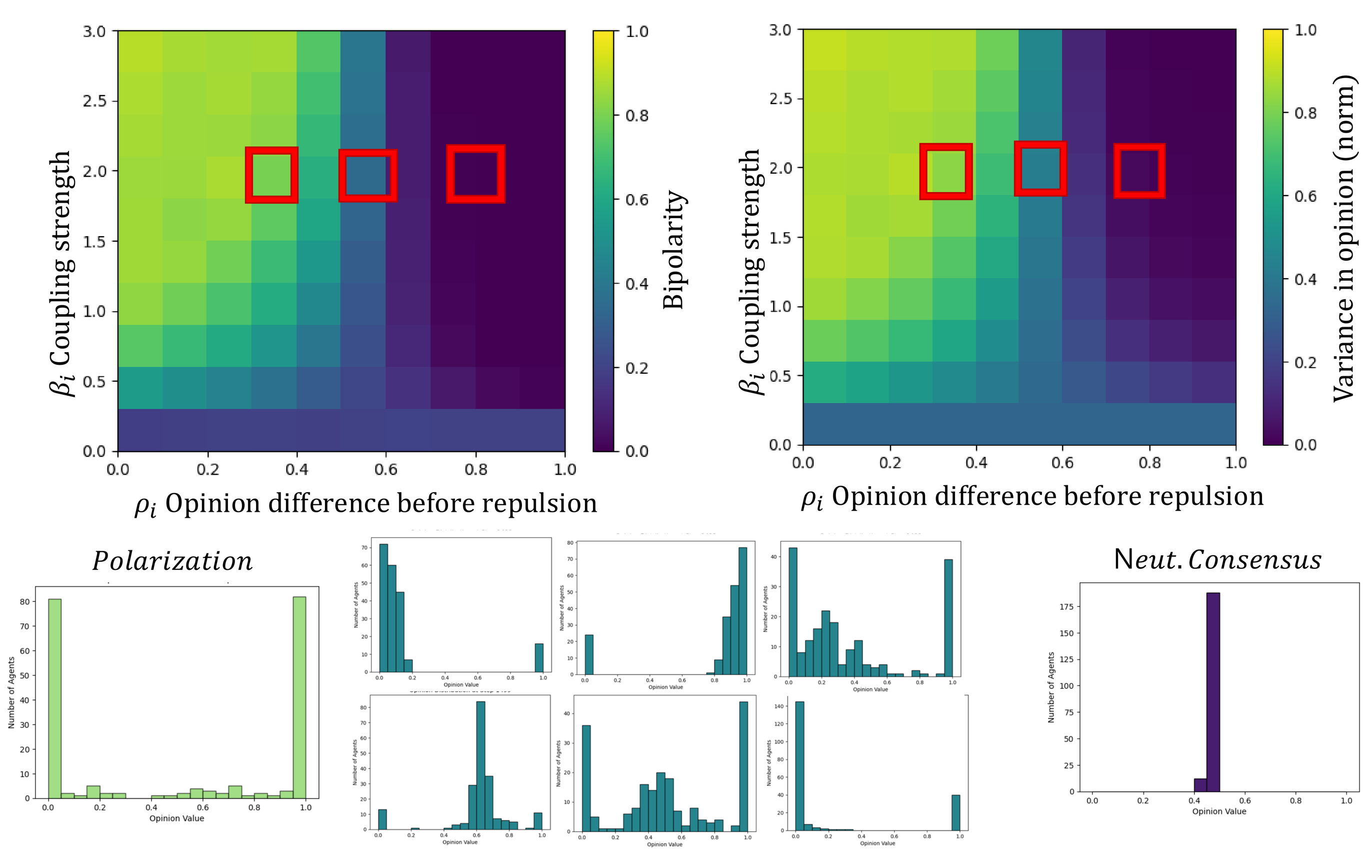
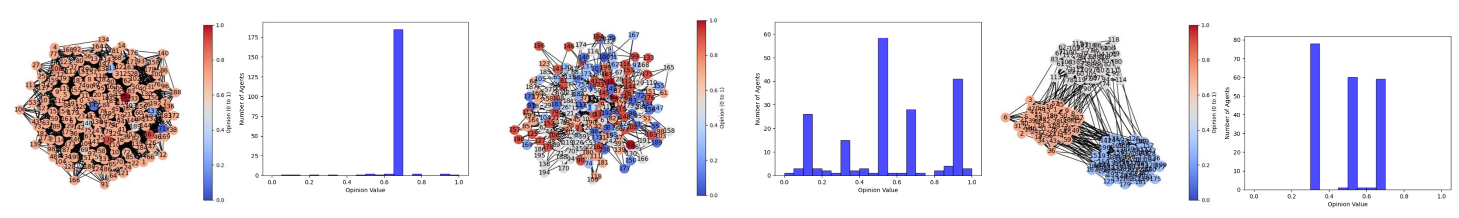
Fig. 3:



Eq. 2:

$$x_i(t+1) = \begin{cases} x_j & for \quad majority(\{w_{ij}x_j(t): j\in N(i)\}) > \beta_i \\ x_i & else. \end{cases}$$

Fig. 4:



Figures:

Fig. 1: Taxonomy of opinion dynamic models and their assumptions

Fig. 2: Plotted partial update function for social influence (Eq.1) and Attraction/Repulsion models in (left) and exemplary opinion distributions in steady state with measurements for bipolarity (right)

Fig. 3: Heatmaps of bipolarity and dispersion of opinion for different parameters of coupling strength and opinion difference thresholds. Underneath representing opinion distributions from the marked squares. (rand Network, settings: no rewiring, with repulsion)

Fig. 4: Exemplary opinion distributions in steady state for threshold model update functions (Eq. 2) with corresponding network type.

Conclusions

- Numerous existing models originate from diverse disciplines and often overlap in methodology and assumptions.
- The advent of social media has shifted attention toward new mechanisms and emergent behaviors (see Fig. 1).
- Social influence and attraction–repulsion models tend to be robust to initial conditions and network topology. However, varying the repulsion threshold reveals a sharp transition from polarization to neutral consensus (see Fig. 3), while other parameters induce softer transitions.
- Classical threshold-based models—such as the Majority Vote Model (MVM)—exhibit strong sensitivity to initial conditions and spatial configuration (see Fig. 4).

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