# Leveraging **Frustration-Based** Clustering Approaches to Identify Societal Fault Lines and Issue Alignment in **Signed Networks** of Online Interaction

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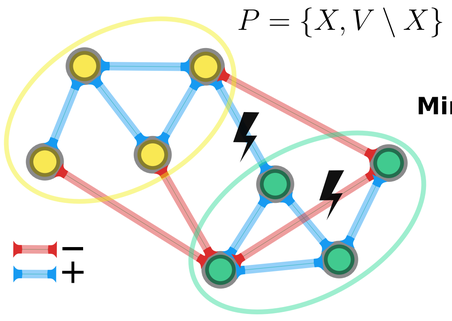
Political conflict is an essential element of democratic systems, but can also threaten their existence if it becomes too intense. This happens particularly when most political issues become aligned along the same major fault line, splitting society into two antagonistic camps. In the 20th century, major fault lines were formed by structural conflicts, e.g. owners vs workers. These classical cleavages have since lost their explanatory power.

## Methods

Instead of theorizing new cleavages, we present the **FAULTANA pipeline**, a computational method to uncover **major fault lines** in data of **signed online interactions**. Our method makes it possible to quantify the degree of **antagonism** prevalent in different online debates, as well as how **aligned** each debate is to the major fault line.




$G = (V, E, \sigma)$

$P = \{X, V \setminus X\}$

**Frustrated edge count (given P)**

$$f_G(P) = \sum_{(i,j)\in E} f_{ij}$$

**Minimization problem (NP Hard)**

$$P^* \dashrightarrow L_G^* = \min_P f_G(P)$$

**Global Alignment**

$$SAI_G = \langle 1 - \frac{L_G^*}{L_{\widetilde{G}}} \rangle$$

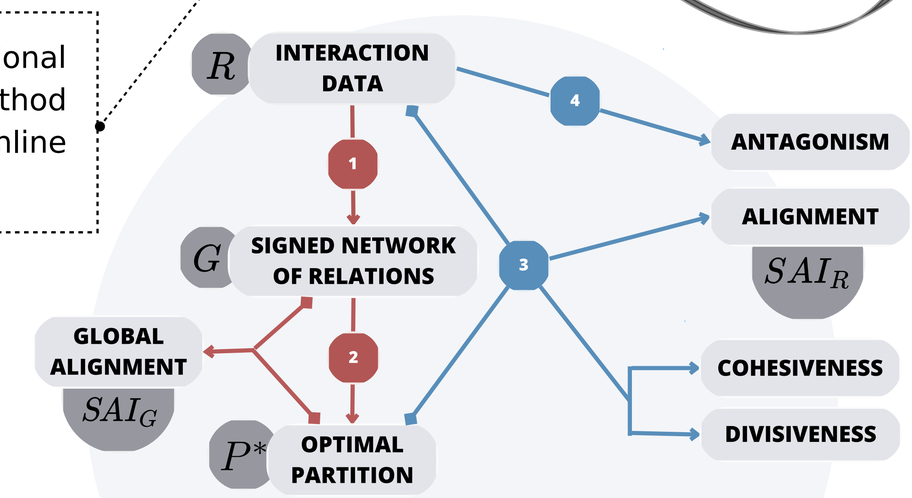
## Metrics

| | |
|---|---|
| **ANTAGONISM** | % of negative interactions in R |
| **ALIGNMENT** | $SAI_{R(t/i)} = \langle 1 - \frac{L_{R(t/i)}}{L_{\widetilde{R}(t/i)}} \rangle$ |
| **COHESIVENESS** | % of Internal Edges that are Positive - % of Positive Edges |
| **DIVISIVENESS** | % of External Edges that are Negative - % of Negative Edges |

We apply our approach to: *Birdwatch*, a US-based Twitter fact-checking community
*DerStandard*, an Austrian online newspaper.
We find that both communities are divided into two large groups following political identities and topics.

## The **FAULTANA** pipeline

**FAULT**-*line* **A**lign*ment* **N**etwork **A**nalysis



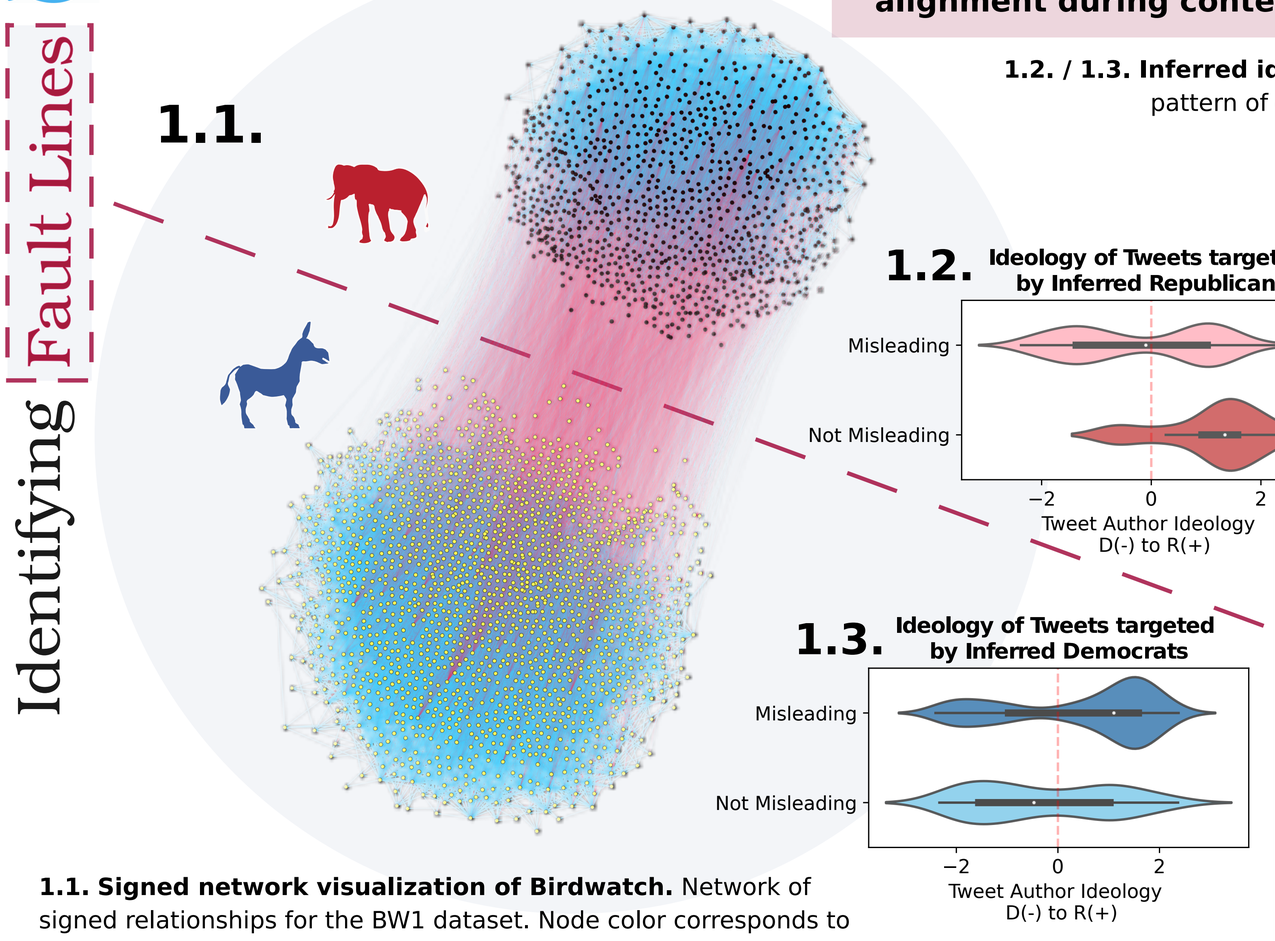

1. Network creation (Bayesian model)
2. Optimization algorithm based on Frustation
3. 4. Computing re-normalized metrics of interest

* $\widetilde{G}$ and $\widetilde{R}(t/i)$ are the the full network of relations and sub-set of the network of interactions with shuffled signs.

## Identifying Fault Lines on Birdwatch

*Take away message:*

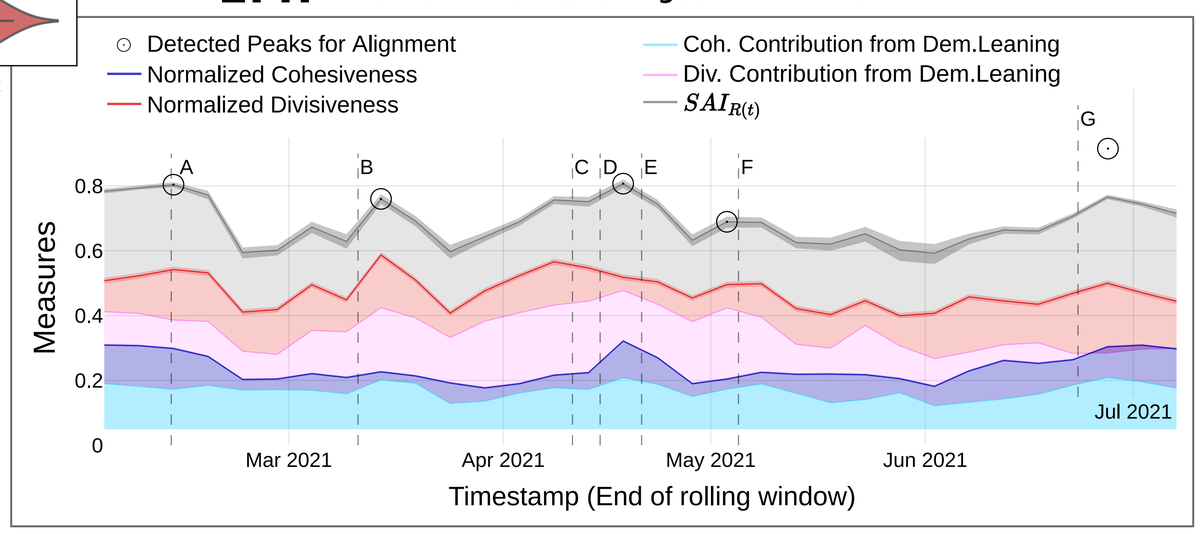
**Our methods allow us to construct a time-resolved picture of affective polarization that shows the separate contributions of cohesiveness and divisiveness to the dynamics of alignment during contentious events.**




**1.1. Signed network visualization of Birdwatch.** Network of signed relationships for the BW1 dataset. Node color corresponds to their partition group membership.

**1.2. / 1.3. Inferred ideology of the targeted tweet's author separated by the nature of the note.** We find a pattern of cheer-leading within Republicans (1.2.) and counter-partisan policing by Democrat users (1.3.).

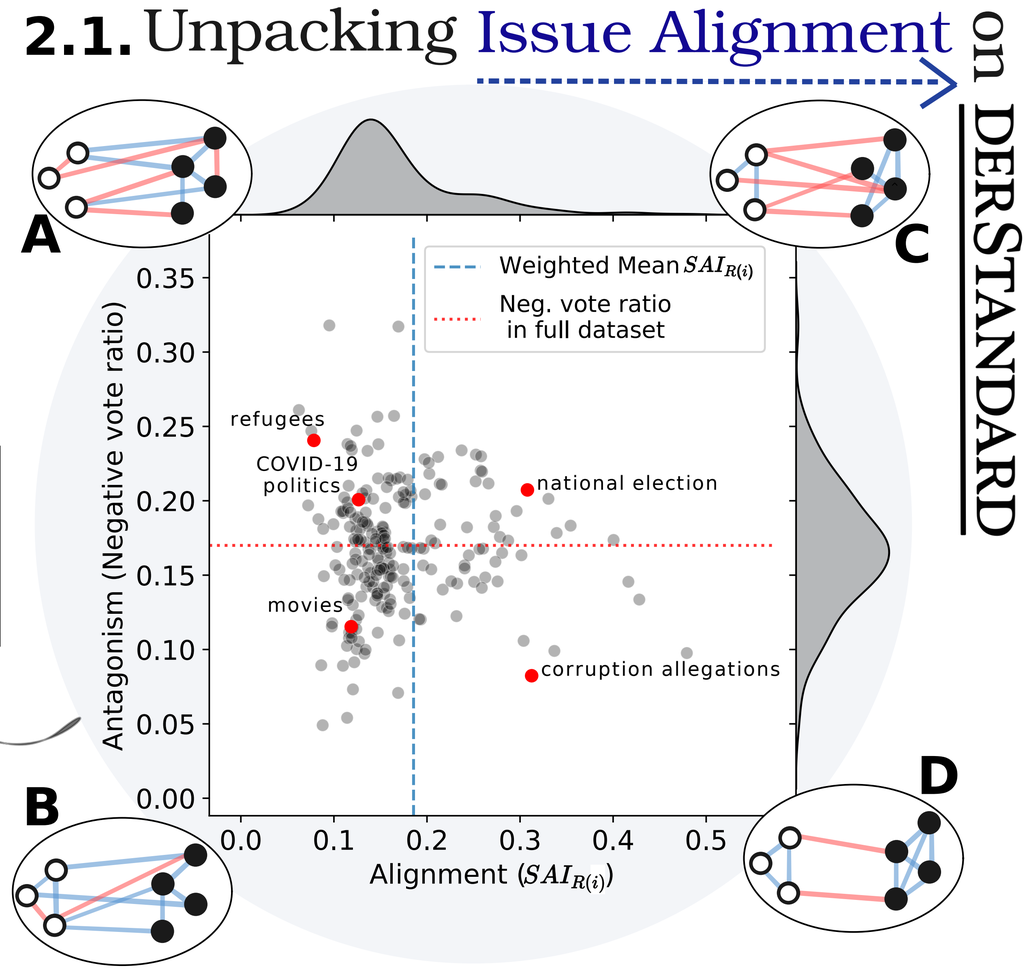
**1.4. Timeline of Alignment, Cohesiveness and Divisiveness in Birdwatch.** Divisiveness stays consistently above Cohesiveness, showing that negative interactions are the main driver of Alignment. Detected peaks in Alignment are marked with circles and notable political events in the US are marked with vertical dashed lines for reference, which can be further contextualized as increases in Cohesiveness, Divisiveness, or both.




*Take away message:*

**For DerStandard, we pinpoint issues that reinforce societal fault lines and thus drive polarization, characterized by both intense antagonism and alignment (2.1. C). These issues are mostly related to political topics. We also identify issues that trigger online conflict without strictly aligning with those dividing lines (2.1. A), such as COVID-19 policies.**

## 2.1. Unpacking Issue Alignment on DERSTANDARD




**2.1. Antagonism and Alignment of the ratings of each news topic in DerStandard.** Topics have been selected based on the topic/subtopic tags associated with the articles located above the postings (e.g., sports, climate change, etc.). Dashed lines show the mean values of each metric to identify relative quadrants.

**Check the paper!**

**An interactive version of this figure with all the topic labels can be found here:**

*Unpacking polarization: Antagonism and Alignment in Signed Networks of Online Interaction*, PNAS Nexus, 2024

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