Marked Temporal Point Processes for simulating and capturing coordinated behaviour campaigns

Models for enhancing disinformation detection

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Coordinated behaviour

Definition

Coordinated Inauthentic Behaviour (CIB): Groups of individuals working together to mislead other users about who they are and what they are doing.

Issue

CIBs pose a significant **societal threat** by spreading confusion, division, and fear.

Research objectives

Detection

CIB's systematic and synergistic activities appear anomalous with respect to authentic users' **temporal patterns.**

Objective

Exploit *Marked Temporal Point Processes* for modelling social media activities and identify CIB's clusters

Simulation

The absence of ground truth data and the **wide number of existing strategies** pose serious difficulties for evaluation

Objective

Exploit *Marked Temporal Point Processes (MTPP)* for creating a CIB's simulation framework

Detection

1. Co-Activity cascades
Data as MTPPs' realisation
Preprocess social media data

2. AMDM-HAGE extensions:
Retrieve users' clusters U
Use MTPP and GMM and DL

- **Clustering techniques**
  On users' embeddings E

- **Exploit influences**
  On users' influences

Date	Content:	Post (**P**) or Repost (**R**)	User
September 12, 2022 at 10:57 AM	**P** *Studies show that drinking bleach can cure COVID. Many hospitals are hiding this information to keep their profits up*		User A
September 17, 2022 at 05:50 PM	**R** *Studies show that drinking bleach can cure COVID. Many hospitals are hiding this information to keep their profits up*		User B
September 20, 2022 at 02:04 AM	**R** *Studies show that drinking bleach can cure COVID. Many hospitals are hiding this information to keep their profits up*		User A
November 15, 2022 at 07:05 PM	**R** *Studies show that drinking bleach can cure COVID. Many hospitals are hiding this information to keep their profits up*		User C

... ...

$$\mathbf{C_s} = [(t_1, u_1 = \text{User A}), (t_2, u_2 = \text{User B}), (t_3, u_3 = \text{User A}), (t_4, u_4 = \text{User C}), \dots]$$

$$\log p_{\theta_a, \theta_b}(C_s, U \mid E) = \underline{\log p_{\theta_a}(C_s \mid U, E)} + \underline{\log p_{\theta_b}(U \mid E)}$$

$$\log p(C_s \mid U, E, \theta_a) = \sum_{i=1}^{|C_s|} [\log p_{E, \theta_a}(t_i \mid H_{t_i}) + \log p_{E, \theta_a}(m_i \mid H_{t_i})] \qquad \log p(U \mid E, \theta_b) = \sum_{j=1}^{|U|} \log \left[\sum_{i=1}^{N} w_i \cdot p\left(E_{u_j} \mid \mu_i, \Sigma \right) \right]$$

Simulation

1. Bayesian Parameters
Authentic users and CIBs
Set up based on real datasets

Authentic users
$$\mu_i \sim \Gamma(\mu, \sigma_\mu^2)$$
$$\alpha_{i,j} \sim \Gamma(\alpha, \sigma_\alpha^2)$$
$$\beta_i \sim \Gamma(\beta, \sigma_\beta^2)$$

Inauthentic users
$$\mu_i = c_\mu \mu Z$$
$$\alpha_{i,j} = c_\alpha \alpha Z$$
$$\beta_i = c_\beta \beta Z$$

Mixed interactions

$$(\alpha_{i,j})_{i,j} = \begin{pmatrix} \alpha_{i,j} & \cdots & \alpha_{i,j} & 0 & \cdots & 0 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ \alpha_{i,j} & \cdots & \alpha_{i,j} & 0 & \cdots & 0 \\ c_\alpha \alpha Z & \cdots & c_\alpha \alpha Z & c_\alpha \alpha Z & \cdots & c_\alpha \alpha Z \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ c_\alpha \alpha Z & \cdots & c_\alpha \alpha Z & c_\alpha \alpha Z & \cdots & c_\alpha \alpha Z \end{pmatrix}$$
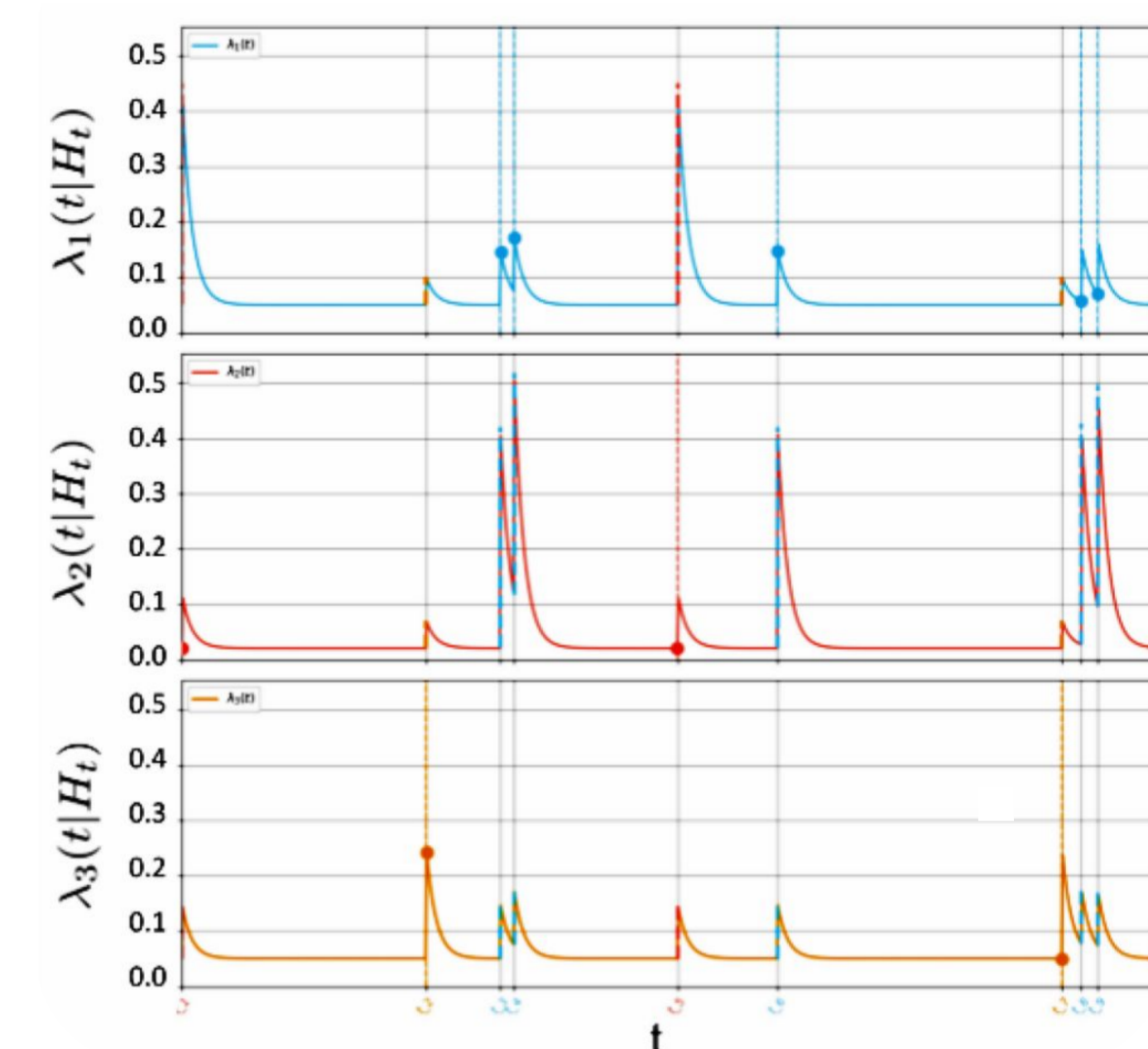
The *percentage of mixed interactions* is controlled by parameter *p*

2. MTPP model
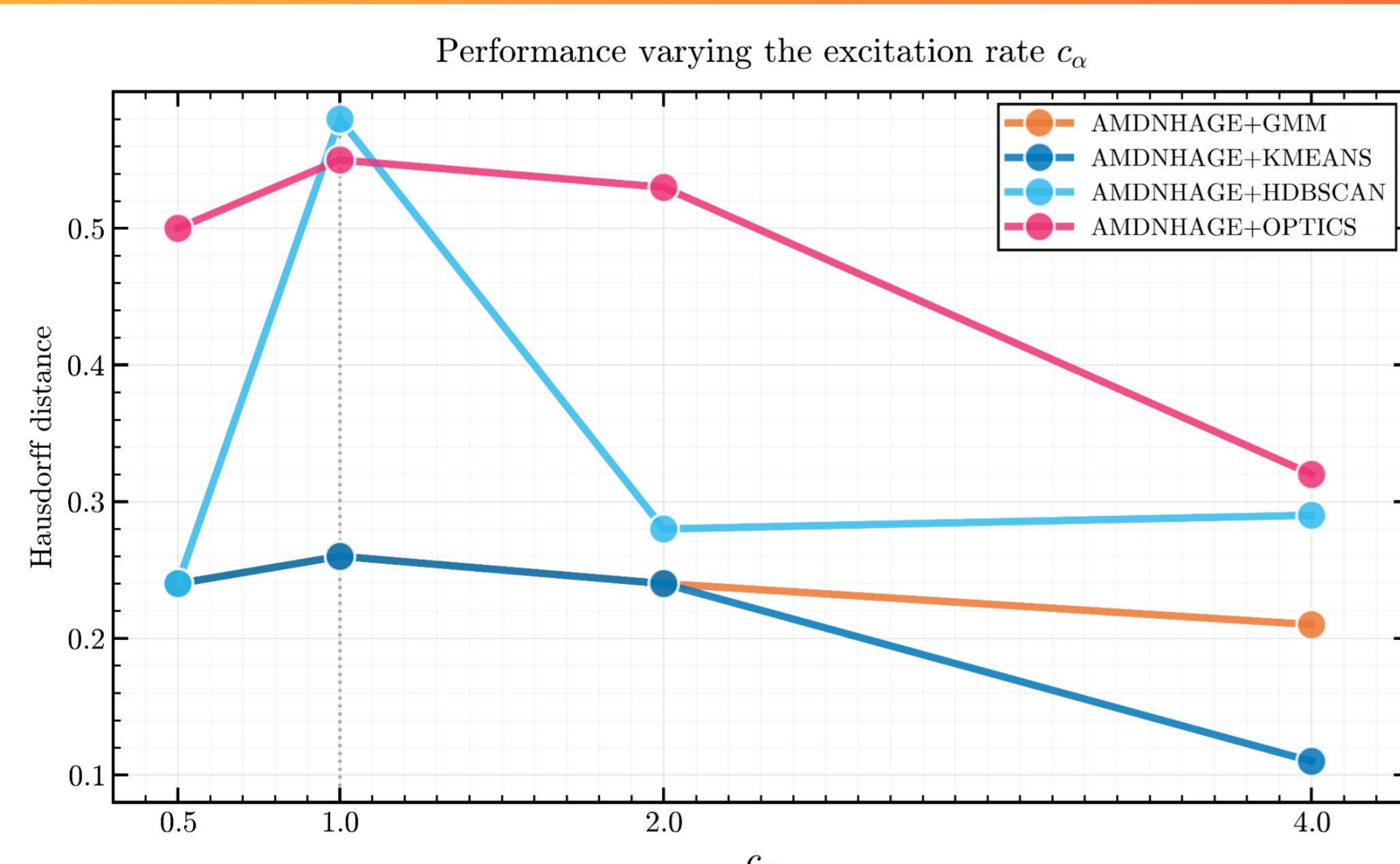**Co-Activity cascades**
Generate data

- $\alpha_{k,m}$ excitation rate
- $\beta_{k,m}$ decay rate
- μ_k baseline rate

Simulation of users' activities

$$\lambda_k(t \mid H_t) := \frac{\mathbb{E}\left[dN_t^k \mid H_t\right]}{dt}$$
$$= \mu_\mathbf{k} + \sum_{m=1}^{K} \sum_{t_{i,m} < t} \alpha_{\mathbf{k,m}} e^{-\beta_{\mathbf{k,m}}(t - t_{i,m})}$$

Results

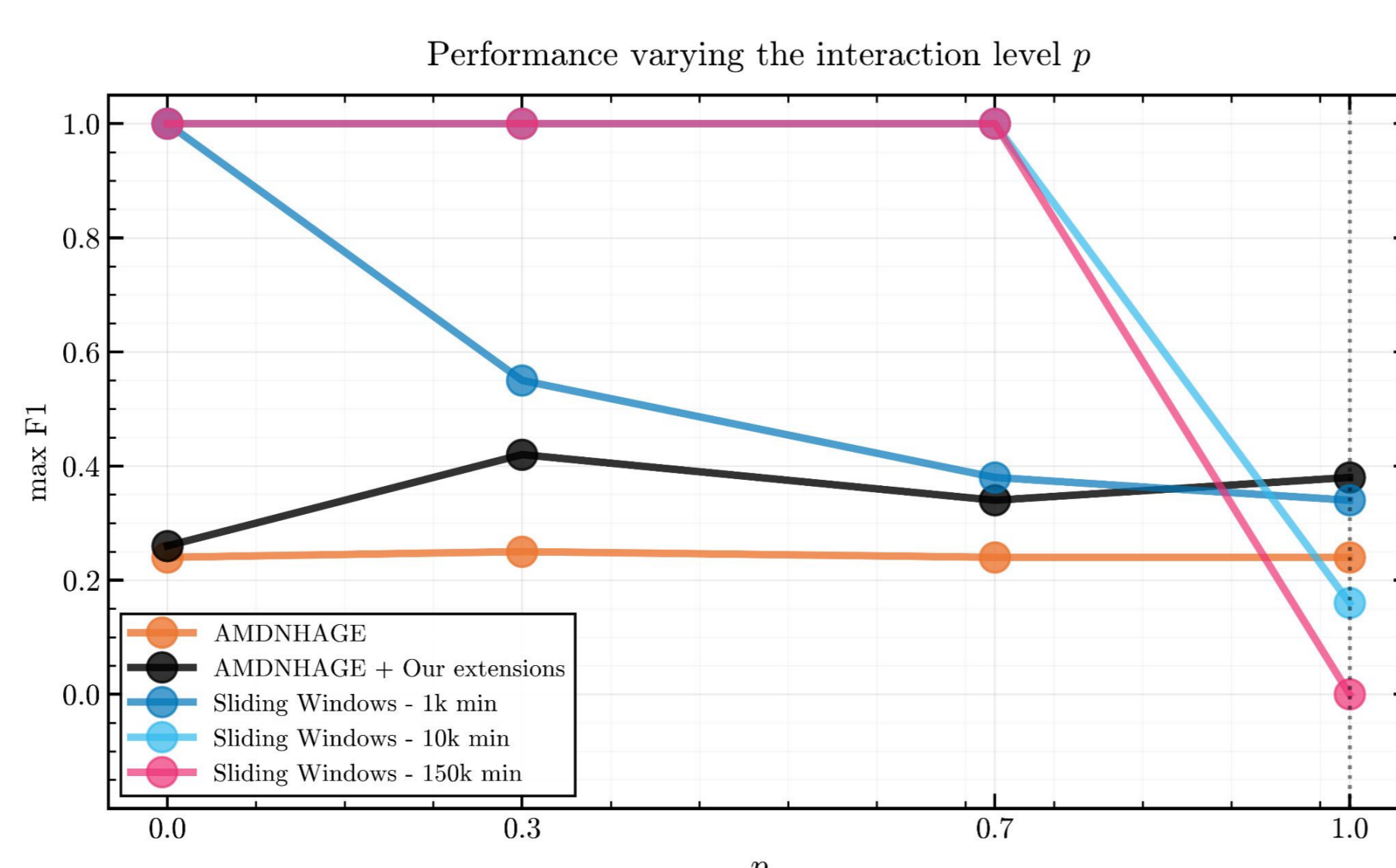**Performance varying the excitation rate c_α**

AMDNHAGE + KMEANS achieves the best performance in all these cases, no matter what value of the excitation parameter *c_α* is considered

Changing the interaction level *p* has a big effect on the performance: no method outperforms the others in all these scenarios

Performance varying the interaction level p

Conclusions

- **Detection and simulations:**
  ○ Clustering and users' influences for **detection enhancement**
  ○ **Novel suite** for a comprehensive and systematic evaluation

- **Importance of the objective:**
  ○ Different methods may excel depending on the **CIBs nature**

  ○ Careful consideration of the **data features and detection goals**

Main References

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Contacts