



# Inferring networks of diffusion using Maya inscriptions

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# Overview

## Inferring paths of influence

Given:

- ▶ set of “entities” (sites)  $S = \{s_1, s_2, \dots, s_n\}$ ,
- ▶ set of well defined inscriptions  $G = \{g_1, g_2, \dots, g_m\}$ ,

Observations:

$$s_1 \quad \{(g_i, \{t_j, \dots, t_{j+k}\}), (g_l, \{t_m, \dots, t_{m+n}\}) \dots, (g_p, \{t_q, \dots, t_{q+r}\})\}$$

$$s_2 \quad \{(g_u, \{t_x, \dots, t_{x+y}\}), (g_v, \{t_z, \dots, t_{z+u}\}) \dots, (g_p, \dots, \{t_q, t_{q+r}\})\}$$

⋮

⋮

$$s_n \quad \{(g_h, \dots, \{t_i, t_{i+j}\}), \dots, (g_e, \{t_j, \dots, t_{j+k}\})\}$$





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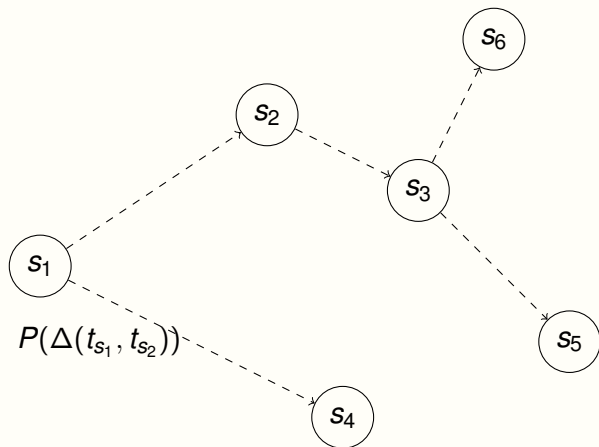
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# Overview

## Inferring paths of influence





# Maya Hieroglyphic Database

- ▶ ~ 75,000 inscription records from 79 distinct sites.
  - ▶ glyph blocks(graphemes): ~ 956.
  - ▶ content: 415 records of social and political relationships.





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# Methodolgy

## Inference

- ▶ a set of geographical Maya sites  $S = \{s_1, s_2, \dots, s_n\}$ ,
- ▶ a set of discrete and finite time steps  $T = \{t_1, t_2, \dots, t_o\}$ ,
- ▶ a finite set of well defined graphemes  $G = \{g_1, g_2, \dots, g_m\}$ ,
- ▶ a finite set of relationships  $R = \{r_1, r_2, \dots, r_l\}$ ,
- ▶ Network of influence (of graphemes):

$$(s_i, g_j, t_k) : s_i \text{ inscribes } g_j \text{ at } t_k$$

- ▶ Network of relationships:

$$(s_i, s_j, r_k, t_l) : s_i, \text{ mentions } s_j \text{ in terms of } r_k \text{ at } t_l$$







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# Methodology

## Network of influence

- ▶ Given a grapheme  $g_h$ :

$$O = \{(s_1, \{t_i, t_{i+1}, \dots, t_{i+l+p}\}), (s_2, \{t_j, t_{j+m}, \dots, t_{i+m+r}\}), \dots, (s_n, \{t_k, t_{k+n}, \dots, t_{k+n+r}\})\}$$

$$P(s_i, s_j | t_{s_i}, t_{s_j}) = P(\Delta(t_{s_i}, t_{s_j})) \propto e^{-\frac{\min \Delta(t_{s_i}, t_{s_j})}{\alpha}},$$

if  $t_{s_i} \leq t_{s_j}$

- ▶ Pick the top  $k$  edges.
- ▶ Most-likely influence tree





# Methodology

## Network of relationships

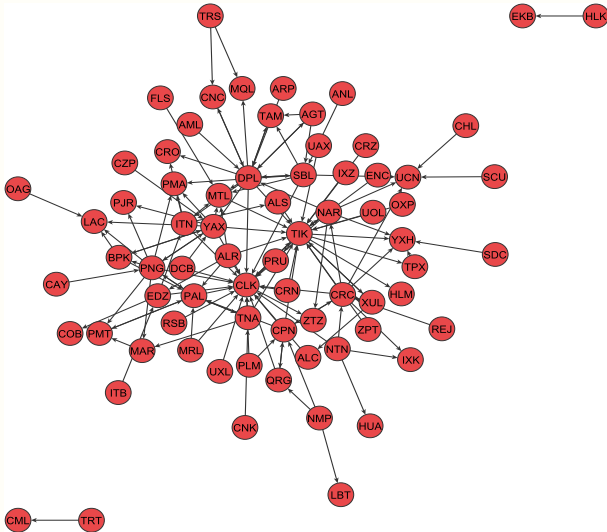
- ▶ How to verify the inferred network of diffusion is meaningful?
- ▶ dyadic relationship
- ▶ independent source of information
- ▶ correlation between pairwise site relationship and co-occurrence of graphemes not straight forward





# Methodology

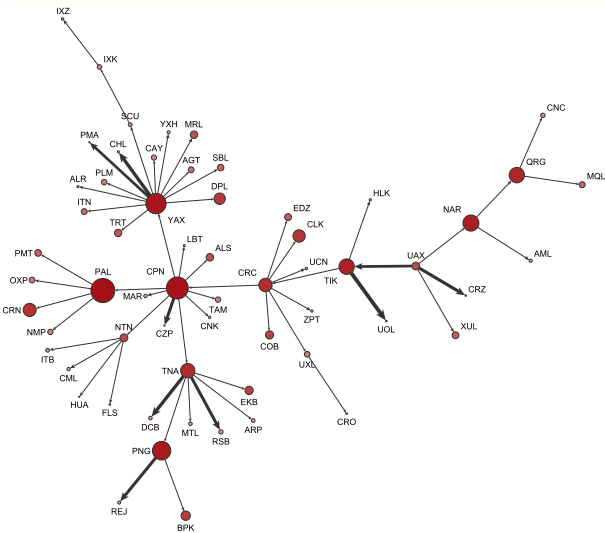
Ground truth





# Preliminary results

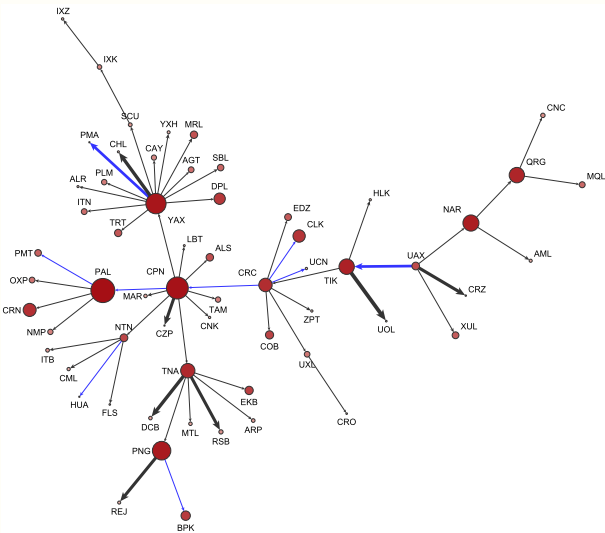
Influence tree: ZZ1





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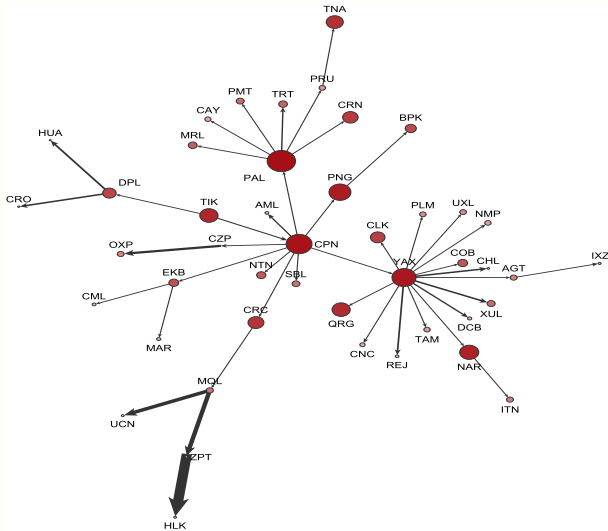
Comparison of influence tree to ground truth: ZZ1





# Preliminary results

Influence tree: 1B2



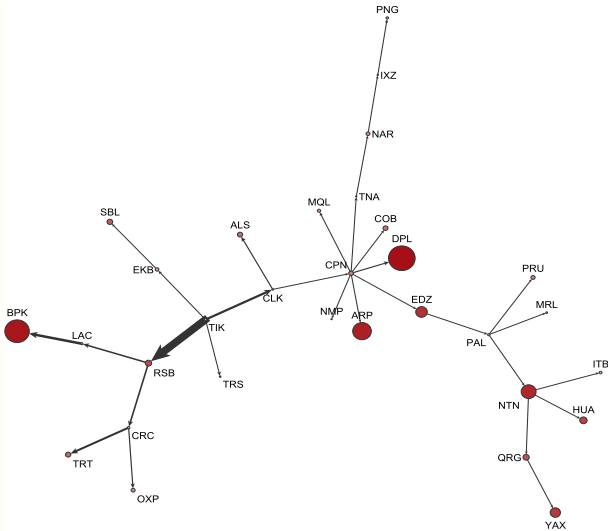






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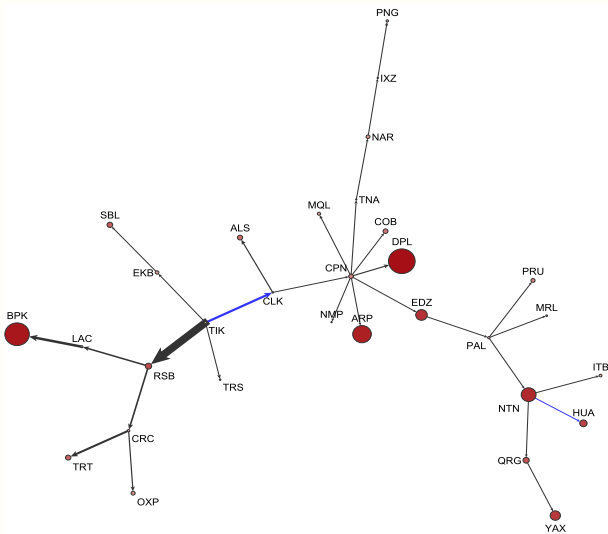
Influence tree: 3M7





# Preliminary results

Comparison of diffusion tree to ground truth: 3M7









# Future steps

- ▶ inferring more complex diffusion graphs: multiple sources of influence, aggregation of multiple diffusion trees
- ▶ incorporating proximity of sites as an explanatory variable
- ▶ incorporating ritual data as an explanatory variable
- ▶ incorporating relationship data as an explanatory variable
- ▶ sampling issues: no. of inscriptions, no. of graphemes
- ▶ meaning of graphemes

