TRANSFER CROSS ENTROPY FOR FAST SOCIOMETRIC INFERENCE IN LONGITUDINAL COLLECTIONS OF MULTI-PARTY CONVERSATION

Kornel Laskowski

Carnegie Mellon University, Pittsburgh PA, USA

Goals

Propose a means of measuring pair-wise influence in coupled Markov chain representations

Why?

of conversational behavior.

For large-scale studies of heterogenous conversations.

Want fast, computationally inexpensive, and zero-manual-effort.

Currently Possible

- 1. social network analysis
- but sociomatrix construction is out-of-scope
- 2. sociograms easy to construct for discrete units
- can model lexical usage or adjacency pairing
- need language-specific speech processing tools
- precludes studies e.g. across languages
- 3. only rarely considered for low-level, frame-synchronous streams of state
- point-wise influence of speaker on group as a whole, rather than pair-wise influence

Proposed Procedure

0. Time-align Markov chains representing speakers in a group conversation, yielding a *chronogram*.

2. Compute the *cross entropy rate* of the *k*th chain, before and after ablating the *j*th chain.

$$\xi_{k} = -\frac{1}{\tau} \log P \left(\mathbf{Q} \left[k \right] \mid \mathbf{Q}, \Theta \right)$$

$$\xi_{k,\neg j} = -\frac{1}{\tau} \log P \left(\mathbf{Q} \left[k \right] \mid \mathbf{Q}_{\neg j}, \Theta \right)$$

4. Normalize transfer cross entropy by dividing by the total speaking time of *j*.

1. Infer a speaker-independent predictor of the future of *any* chain, conditioned on the past of *all* chains, known as a *stochastic turn-taking model*.

$$P\left(Q\left[k\right] \mid Q,\Theta\right) \doteq \prod_{t=1}^{T} P\left(q_{t}\left[k\right] \mid q_{t-1}^{t-\tau}\right)$$

3. Difference the two to yield the *transfer cross entropy*, a measure of the "influence" of *j* on *k*.

$$\mathsf{Infl}_{j o k} = \xi_{k, \neg j} - \xi_{k}$$

Where desired, threshold the normalized quantity to yield a directed relation from j to k, producing a social network for the group.

Conclusions

- 1. Successfully demonstrated feasibility of computing a transfer cross entropy for speech activity chronograms.
- 2. Rank of influence correlates strongly with organizational seniority.
- 3. Sociograms computationally easy to obtain, since no speech processing or analysis tools necessary except VAD.
- 4. End-to-end system is privacy-sensitive, since chronograms are.
- 5. Absence of lexical components makes system language-independent.

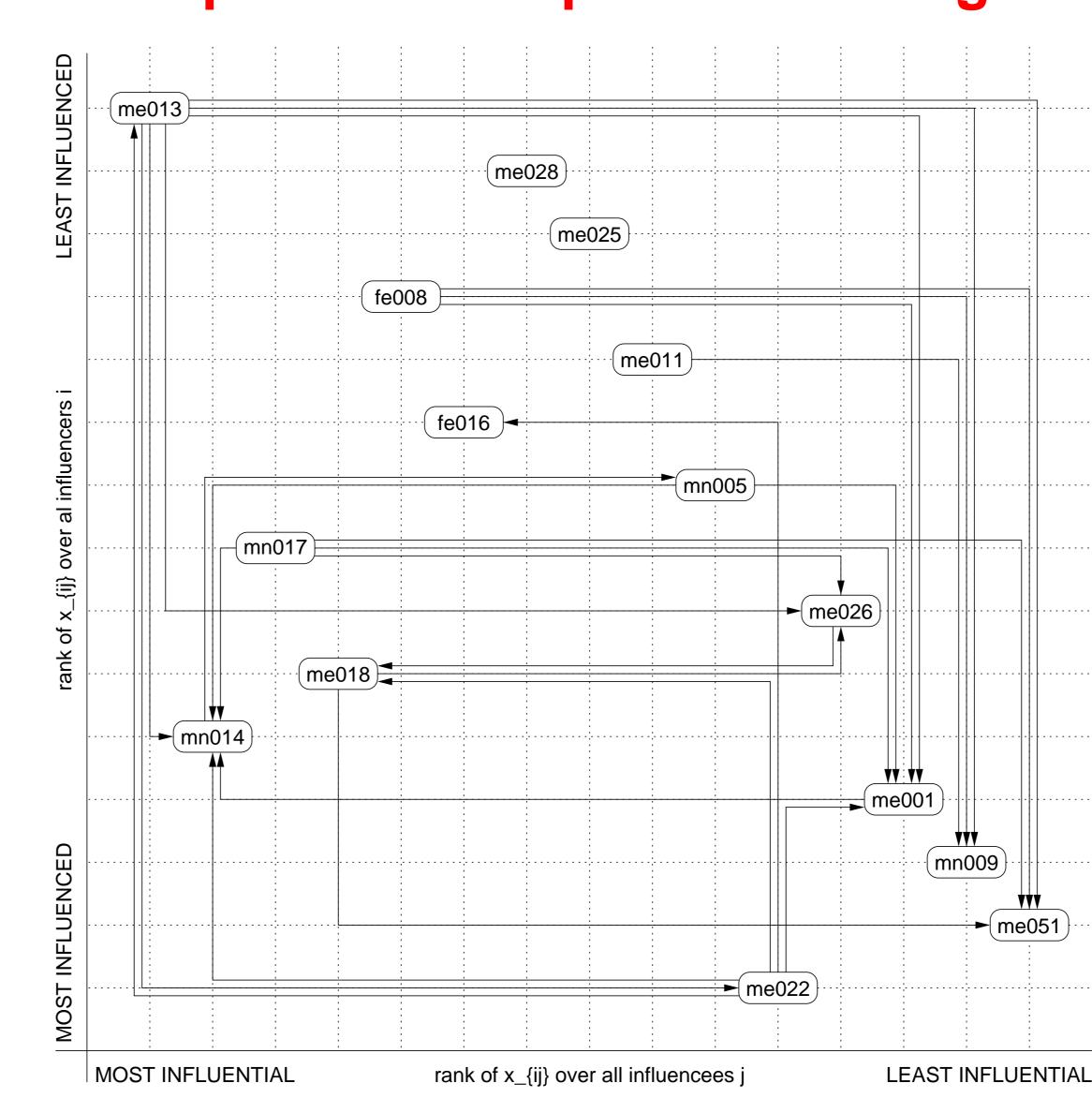
Impact

- I. Can be extended to measure conditioning using any frame-synchronous, discrete-valued activity chronogram.
- II. Enables comparative exploration of large collections of conversational recordings, without requiring that they share a vocabulary or language.
- III. Enables comparative exploration of human relationships in terms of conversation, without intrusive transcription of sensitive material.
- IV. Can be used to validate sociolinguistic hypotheses, where annotated conversational data is available.

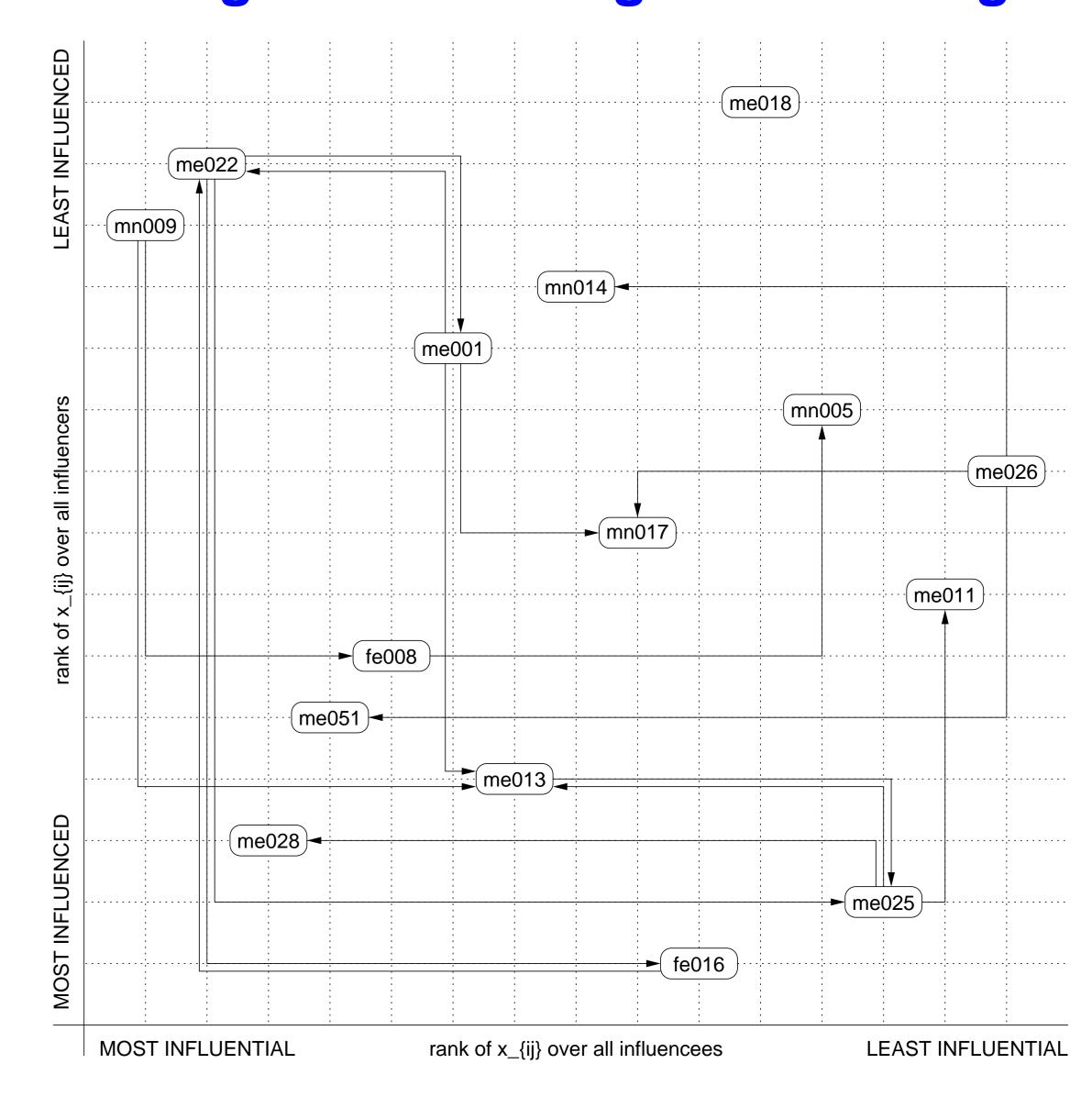
The 29 Bmr Meetings in the ICSI Meeting Corpus

Build one sociogram by computing cross transfer entropy using round-robin-trained turn-taking models.

Speech/Non-Speech Chronograms



Laughter/Non-Laughter Chronograms



IEEE ICASSP, Kyoto, Japan