Advances in the Analysis of Discrete Resonance Spectrograms

Using the DSR for Source Separation and Sequential Prediction

Nick Harley & Steve Homer
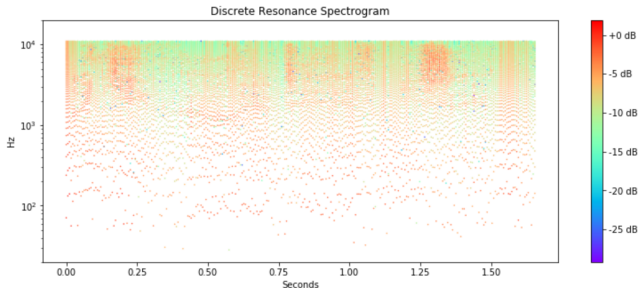
ARTIFICIAL
INTELLIGENCE
RESEARCH GROUP

From Vertical to Horizontal Analysis

- ► Source separation looks at dependencies between frequencies **within a slice**, i.e. vertical analysis.
- ► Temporal correlations can be exploited to observe dependencies **between slices**, i.e. horizontal analysis.

Boundary Entropy

► Online chunking according to **pairwise sequential** regularities in order to compress a stream of symbols

► **Unexpectedness**: current symbol is relatively more rare

► **Uncertainty**: current symbol has more options to follow

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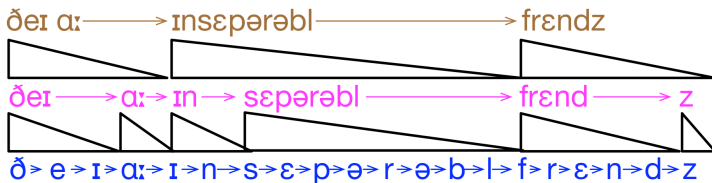
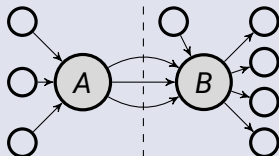# SEQUENCE VS NETWORK INTERPRETATION OF BES

Sequence Interpretation
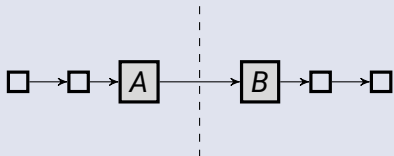
Information Content

$$h(x) = -\log p(x)$$

Entropy

$$H(x) = -\sum_{y \in Y} p(y|x) \log p(y|x)$$

Network Interpretation
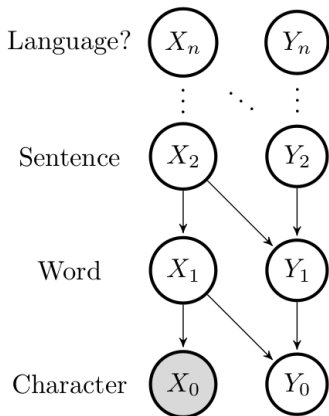

In-Entropy

$$H_{in}(x) = -\sum_{y \in In(x)} p(x|y) \log p(x|y)$$

Out-Entropy
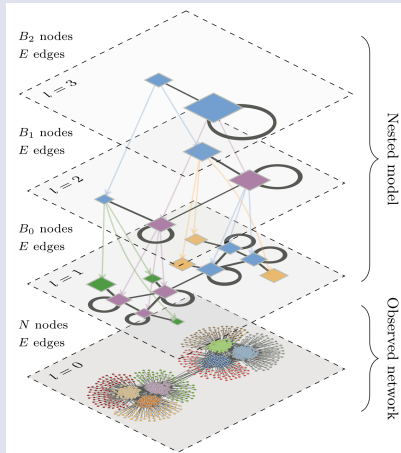
$$H_{out}(x) = -\sum_{y \in Out(x)} p(y|x) \log p(y|x)$$

HIERARCHICAL STRUCTURE AND DYNAMICS

Hierarchical Prediction

Language? X_n Y_n

Sentence X_2 Y_2

Word X_1 Y_1

Character X_0 Y_0

Hierarchical Structure

B_2 nodes
E edges
$l = 3$

B_1 nodes
E edges
$l = 2$

B_0 nodes
E edges
$l = 1$

N nodes
E edges
$l = 0$

Nested model

Observed network

INFORMATION EFFICIENCY AND THE MDL PRINCIPLE

Memory Consolidation

- ► According to the **information efficiency** criterion of IDyOT, online boundary entropy segmentation is likely suboptimal
- ► **Offline memory consolidation** can fix some missteps that occurred online by lowering the total entropy of the model

Minimum Description Length Principle

- ► Σ (Description) = $\mathcal{L}$ (Model) + $\mathcal{S}$ (Data) (in bits)
- ► Least complex model that accurately describes the data
- ► Used for **model selection** in AIT and complex networks

Placement of Research

- ► **Online vs offline** community structure detection
- ► **Topological vs causal** structure inference in networks
- ► **Static vs temporal** system dynamics and link prediction

Immediate Next Steps

- ► Causal network topology **inference** and sequence prediction through boundary entropy segmentation
- ► Memory **consolidation** based on MDL principle for networks

Applications

- ▶ Voice extraction in noisy industrial environments
- ▶ Pitch tracking and pitch to midi
- ▶ Straight up compression

Future Work

- ▶ Information-theoretic **categorization** of frequency space
- ▶ Robot route finding structure
- ▶

THANK YOU!

Computational Creativity Lab