Temporal Pattern Recognition with a Time Delay Neural Network

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Abstract

Patterns embedded in noisy time series signals pose numerous challenges for sequence detection algorithms:

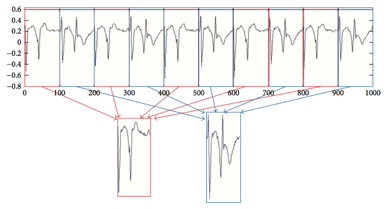
1. **The absence of delimiters to signify the beginning and end of a sequence greatly complicates subsequence induction.**
2. **The ever persistent and dynamic nature of noise! Time series patterns are not absolutely fixed and possess features that vary depending on signal source and transmission medium.**
3. **The duration of a sequence may be warped in time.**

We propose an *unsupervised* algorithm implemented in an artificial neural network inspired by temporal plasticity in biophysical systems to address these challenges with minimal model specification. Signal features are represented with a set of time delay functions, such that an *output neuron only reaches firing threshold upon receiving coincident input from converging time-delayed presynaptic inputs*. The weighting of time delay functions is iteratively adapted based on the temporal structure of the input relative to output neuron firing times, resulting in an entrainment of spike times to pattern presentation. Here we show our model can segment temporal sequences by evaluating performance on simple temporal patterns with varying signal to noise ratios.

Problem

Time Series Subsequence Induction

Grouping correlated spatiotemporal patterns



Proposed Solutions

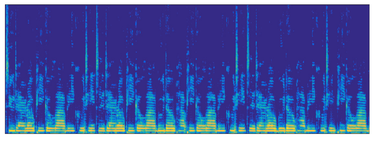
- ❒ Hierarchical Clustering
- ❒ Partitioning Clustering
- ❒ Density-based Clustering
- ❒ Pattern Discovery
- ❒ Delay & Reservoir Computing

Remaining Challenges

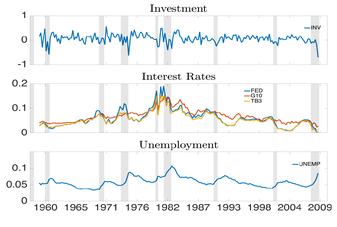
- ⛌ High Memory Usage
- ⛌ Complex Model Specification
- ⛌ First Order Pattern Recognition
- ⛌ Noise Elimination & Tolerance
- ⛌ Real Time Segmentation

Impact & Applications

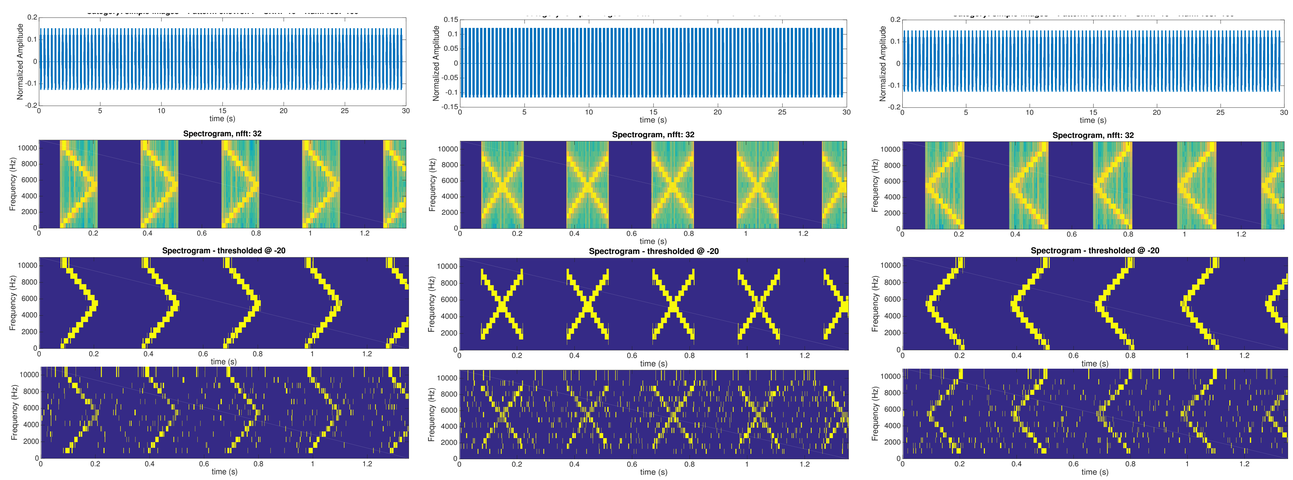
Speech Recognition



Macroeconomic Trends



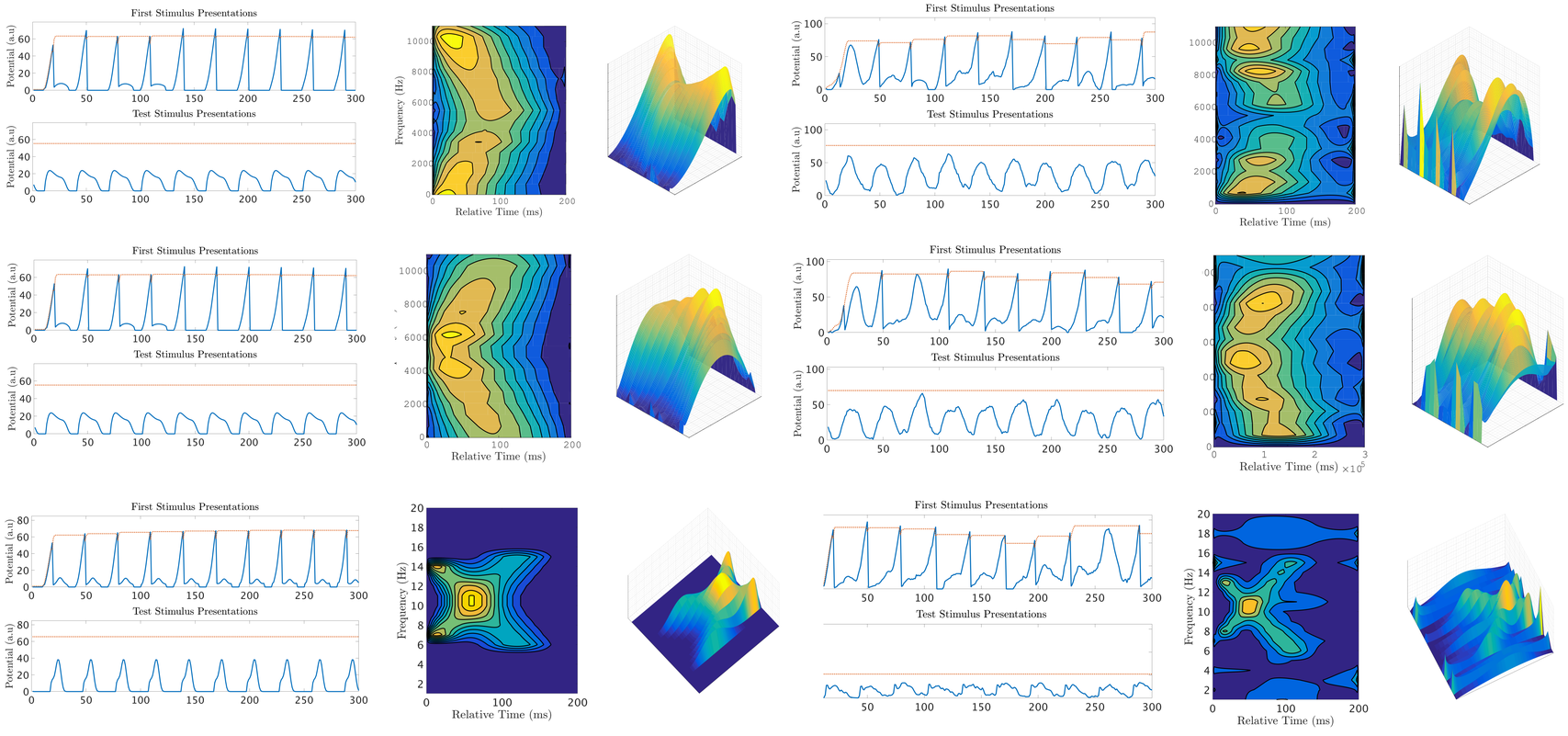
Data



Preprocessing

1. FFT of time series into spectral domain. Symmetric transform window of 32 frequency bins, yielding 16 inputs.
2. Padding & concatenation to generate 500 presentation long stream.
3. Poisson noise insertion (lambda=2, SNR -10 dB)
4. Power spectrum thresholded @ at 20 dB

Results



Future Directions

- Construct inhibitory connections for multi-neuron networks for multiple pattern decomposition and learning.
- Experiment with multilayer networks to determine their ability to hierarchically organize and generate higher order patterns.