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Functional Change Point Detection with Nonnegative Matrix Factorization

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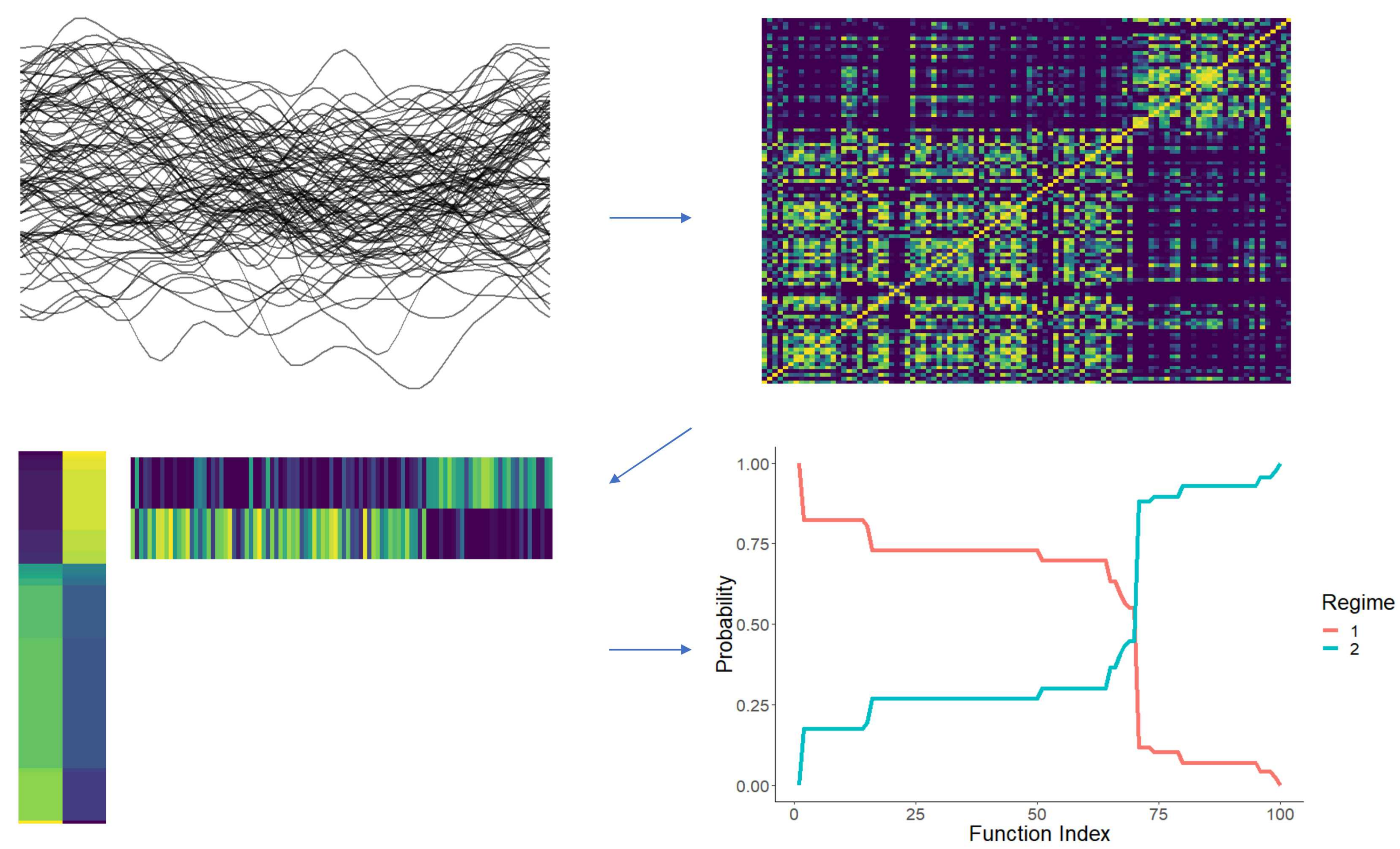
Abstract

A structural break occurs when some aspect of the functional generating process suddenly changes or drifts over time to a new equilibrium. We propose a new matrix factorization based approach that is computationally efficient, online, and nonparametric. This allows us to provide nearly real time detection for arbitrary changes in a stream of functions



Problem

Observe a continuous stream of functions. Want to detect structural changes in **real time.**

Solution

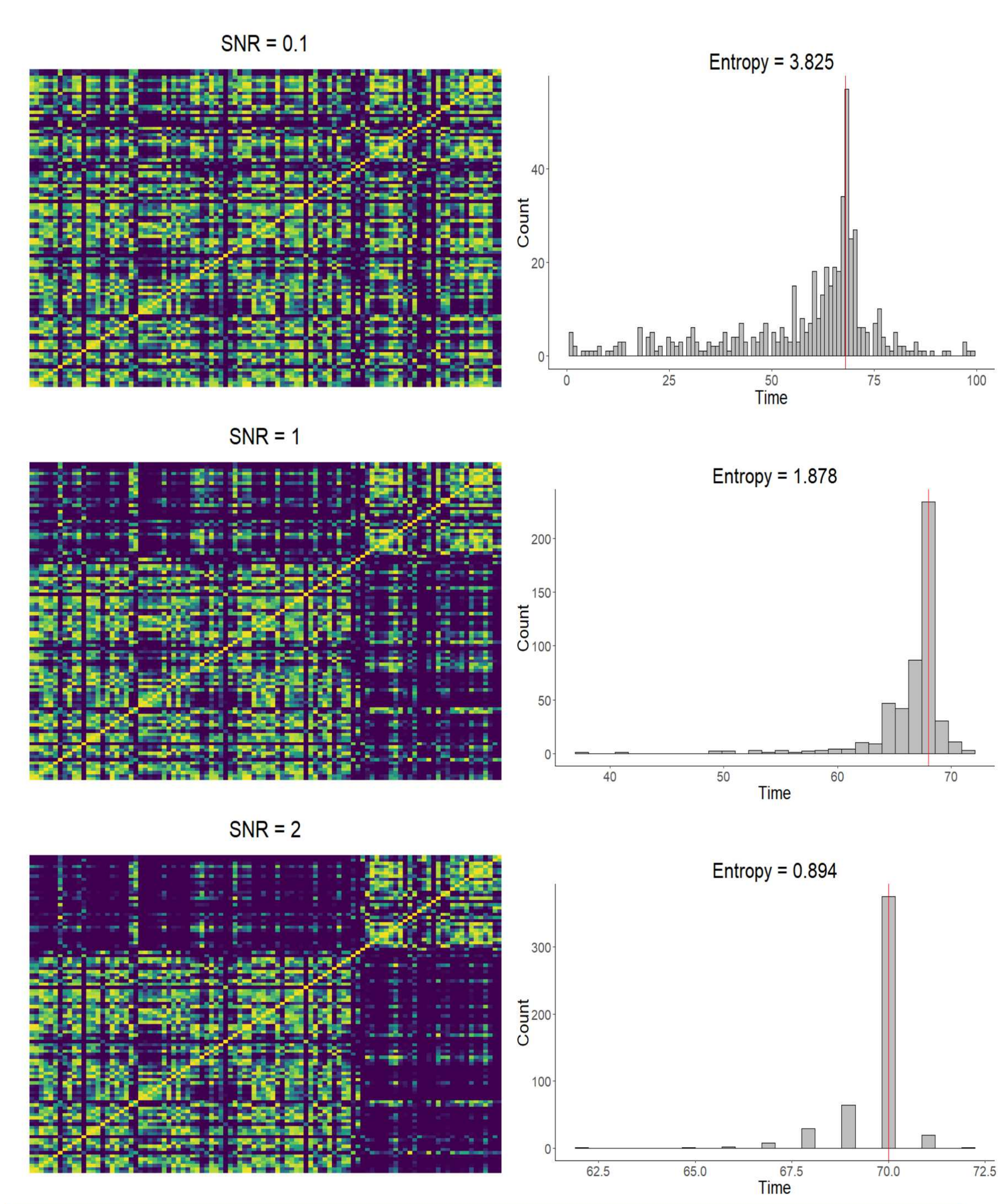
Within a moving time window:

1. Calculate *similarity matrix*
2. Factor similarity matrix with *Monotonic* Non-Negative Matrix Factorization into *two factors*
3. Identify change point as *crossing point* of the factors

- Each factor represents the probability of being in Regime 1 or Regime 2
- Factor 1 decreases monotonically and Factor 2 increases monotonically
- Crossing point is the time when Regime 2 becomes *more likely* than Regime 1

Uncertainty

- Use a block circular bootstrap on function residuals to estimate uncertainty in the break date.
- Block circular means "blocks" of functions in the times series are resampled with equal probability of selecting any given function
- Residual avoids stationarity assumptions on the data



Applications

- Climate and heat waves
- Bond yield inversions
- Stock price regime change
- fMRI and brain activity

Advantages

- Computationally efficient
- Rigorous uncertainty quantification
- Accurate on even very noisy data with low SNR
- Extends to multiple change points