A New Optimal Matching Approach to Uncovering Neighborhood Sequencing Structure

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Neighborhood Change Research

- Variable diagram
  - Specific variables: racial composition, median household income
  - Composite indexes: urban deprivation index, opportunity index, socioeconomic status
  - Neighborhood change: value increments
    - Continuous
- Contextual mode of analysis
  - Neighborhoods as ensembles of variables
  - Clustering - discrete neighborhood classifications/types
  - Geodemographic typology
  - Neighborhood change: change of types
    - Discrete
  - Statistically suitable for small area estimates potentially suffering from large margins of errors (e.g. American Community Survey (ACS) census tracts) (Spielman and Singleton, 2015)

Multidimensional neighborhood change

- A white-flight/filtering process
- Densification of neighborhoods: single-family house to multi-family dwellings
- White single-family neighborhood obtain higher socioeconomic status
- Gentrification
- Establishment of a multiethnic/global neighborhood
- Stability: highest poverty, majority black, wealthiest and whitest neighborhoods

(Delmelle, 2017)

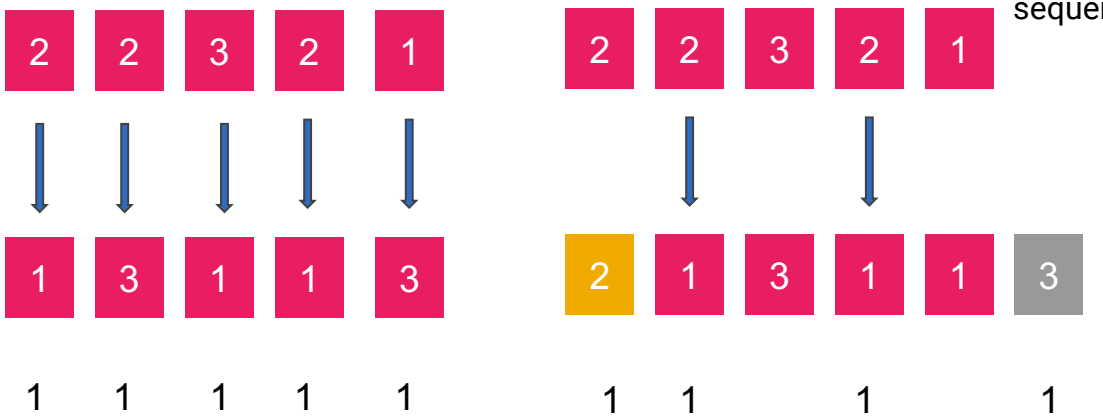
Workflow of Multidimensional Neighborhood Change Analysis

Geodemographic Analysis → Sequence Analysis → Neighborhood sequence typology

Use clustering algorithm to find similar neighborhoods. Each cluster is summarized as a neighborhood type.

To evaluate similarity or distance between every pair of neighborhood sequence. Optimal Matching (OM)

Input the distance matrix of neighborhood sequences into proper clustering algorithm to obtain a neighborhood sequence typology.



Motivation

- Sequence methods origin from DNA matching
- Exploration in its application to the life course research
- Whether the available sequence methods satisfy the needs for neighborhood change research?
    - Theoretical foundation: invasion/succession, neighborhood decline, new pathways of neighborhood change - global neighborhoods?
    - Temporal dimension: contexts?
    - Neighborhoods as social constructs
    - Neighborhoods as spatial constructs
- Current literature: Focus more on the contemporaneous differences

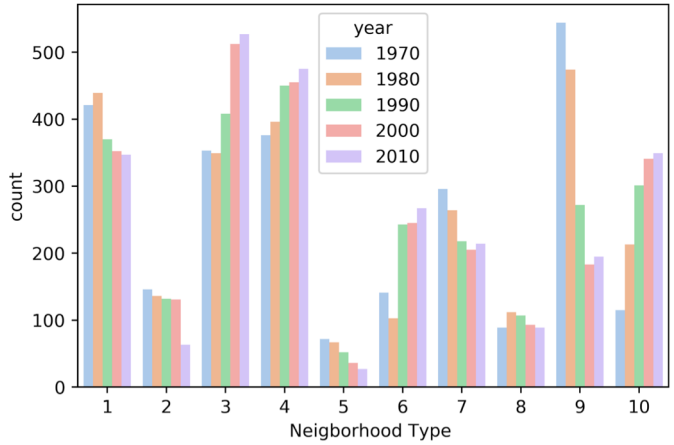
Neighborhood change in LA 1970-2010

- Data: 1970, 1980, 1990, 2000, 2010 census/ACS
- 14 tract-level variables
- Geolytics Neighborhood DataBase 2010 (NCDB 2010)
- POP>500
- 2,553 tracts

TABLE 1 Neighborhoods as ensembles of 14 variables.

Category	Variable	Description
Demographic	CHILD	% persons who are children under 18 years old
	OLD	% persons who are 65+ years old
	SHRWHT	% white population
	SHRBLK	% black/African American population
Socioeconomic	UNEMPRT	% persons 16+ years old who are in the civilian labor force and unemployed
	PRFE	% persons 16+ years old employed in manufacturing, transportation, and public administration
	POVRAT	% total persons below the poverty level last year
	EDUC	% persons 25+ years old with at least a 4-year degree
Housing	BL30OLDPRO	% total housing units built MORE than 30 years ago
	TTMULTI	% total multiunit structures
	YRMV10PRO	% occupied housing units where household heads moved in less than 10 years ago
	MNVALHS	Mean value of specified owner-occupied housing units
	OWNO	% total owner-occupied housing units
	VACHUPRO	% total vacant year-round housing units

Neighborhood Typology (10)

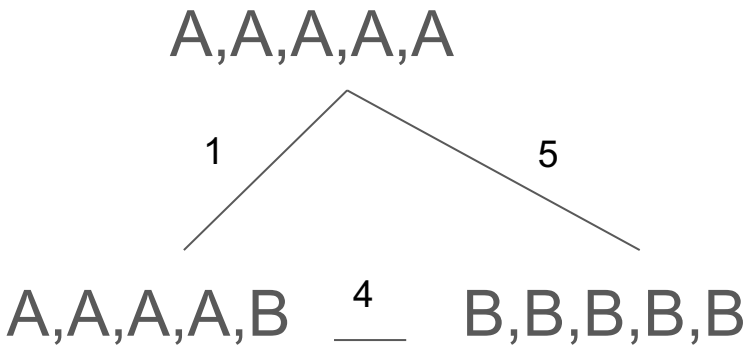


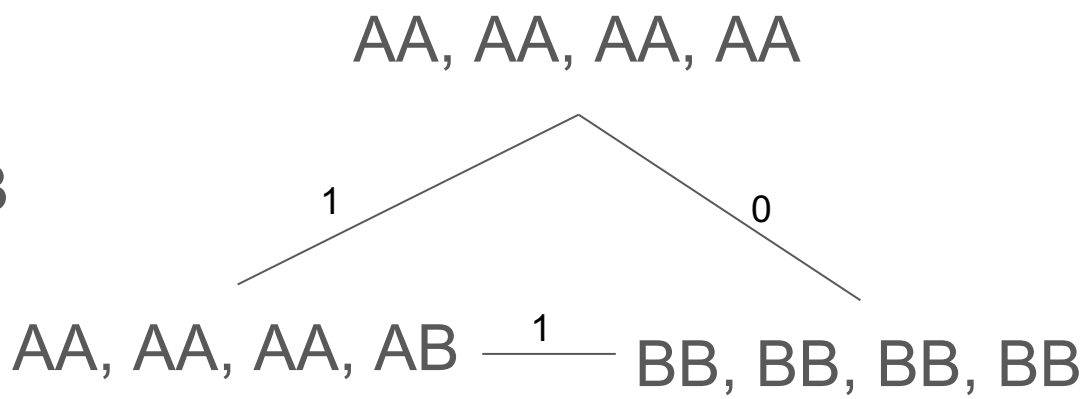
Index	Composition	Classification
1	Mixed race, renters, recent in-movers, median house value	Middle-class Renter
2	Black, high poverty, high unemployment, older homes	Struggling African American
3	Mixed race, low poverty, low unemployment, owners	Mixed Race Owner
4	Less educated, blue collar	Blue Collar
5	Educated, high vacancy, newer homes	New Starts
6	White, educated, wealthy, owners	White Elite
7	Old residents, educated, renters	Aging Community
8	Black, medium poverty/unemployment, older homes, some owners	Ascending African American
9	Owners, newer homes	Newer Suburb
10	Mixed race, high poverty, high unemployment, renters	Struggling Renter

Process of sequence

- Common ancestors
  - DNA sequences: difference due to mutation
  - OM: works by reverse the mutation
- Unfolding process (Biemann, 2011)
  - Social sciences: life/career course
  - Contextual factors
  - Recoding sequences as sequences of transitions

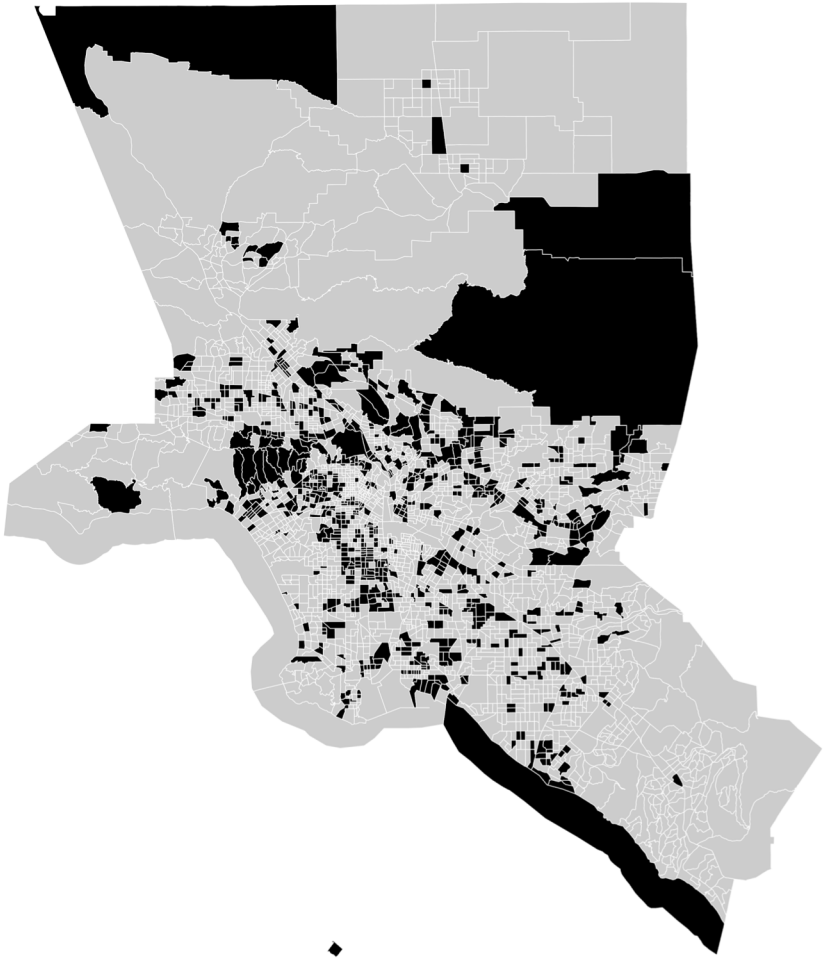
Recoding sequences





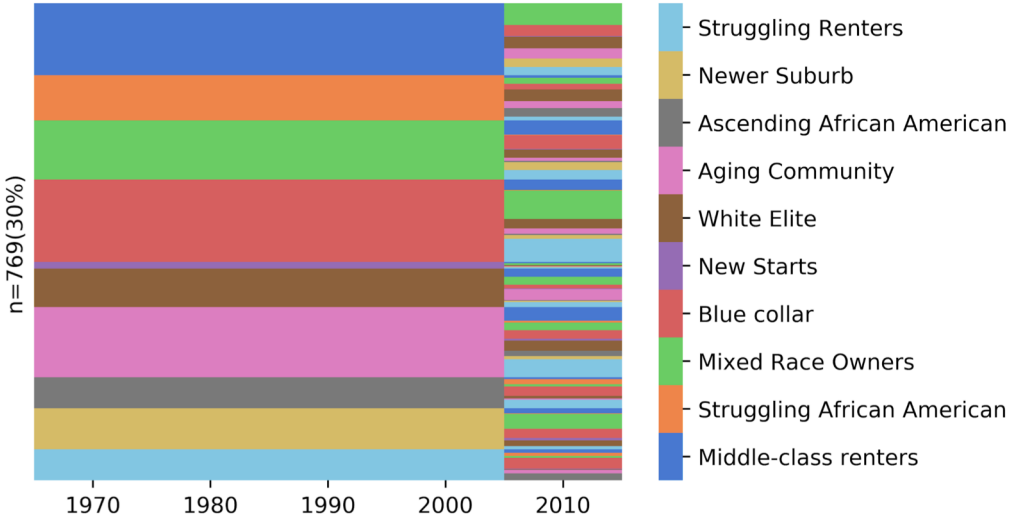
Second order property of the sequence (16)

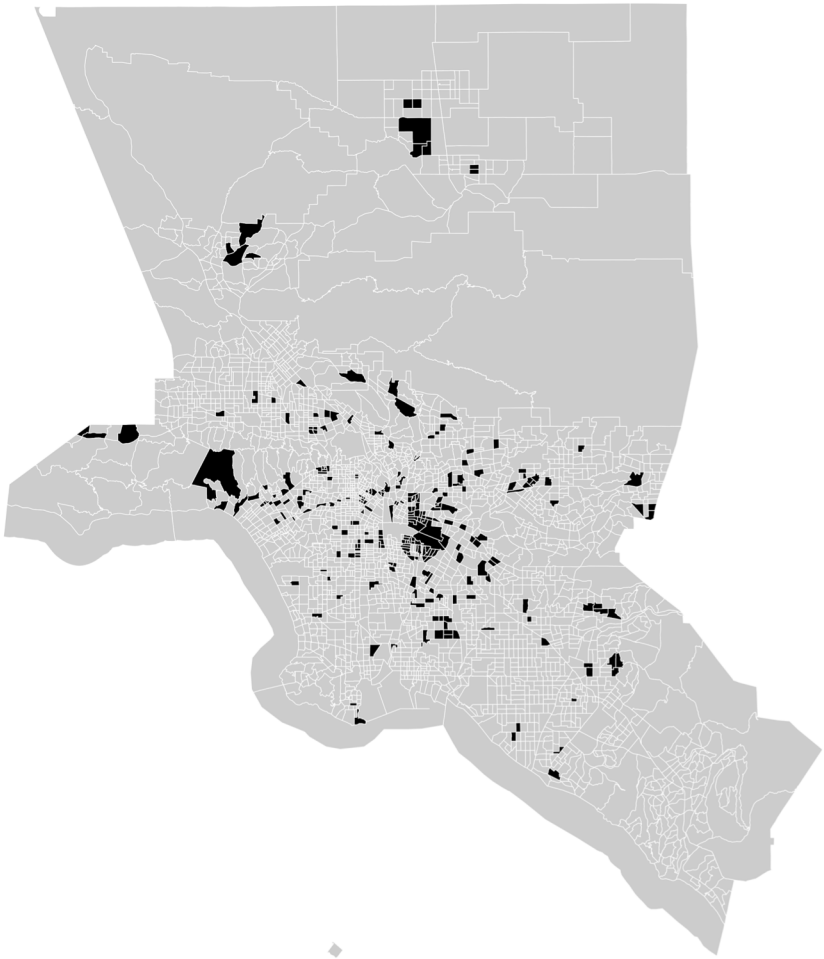
- Stability
  - Stay: AA, BB
  - Change: AB, BA
- Neighborhood sequence clusters/typology
  - How many stays/changes?
  - When/where are the stays/changes?



Stable until last period

- Most frequent neighborhood trajectory type!
- Spatially compact

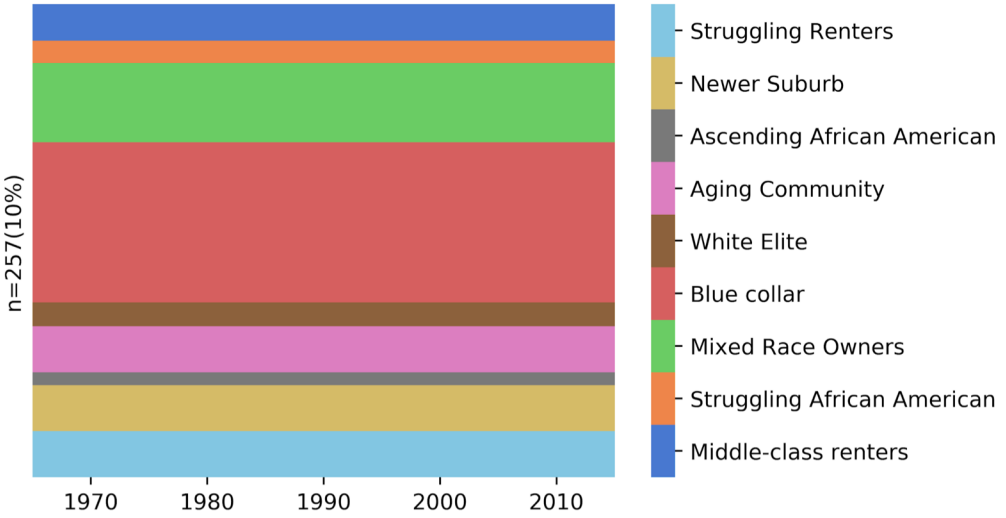


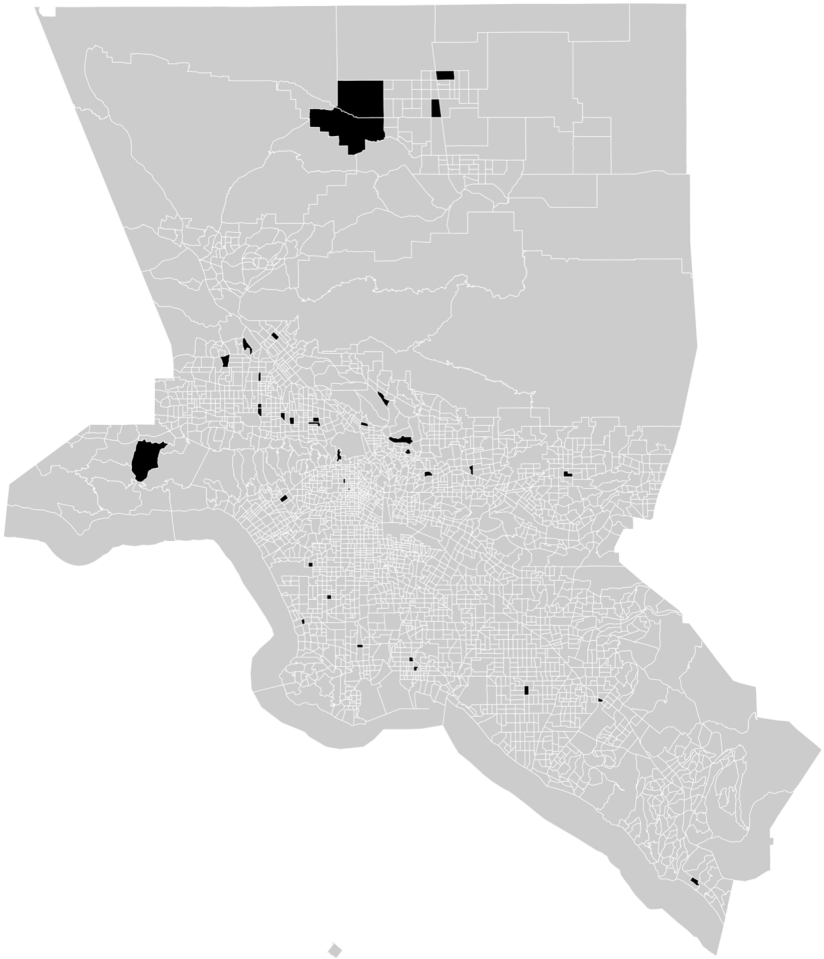


Stability

Not as frequent as the last trajectory type - not that stable after all?

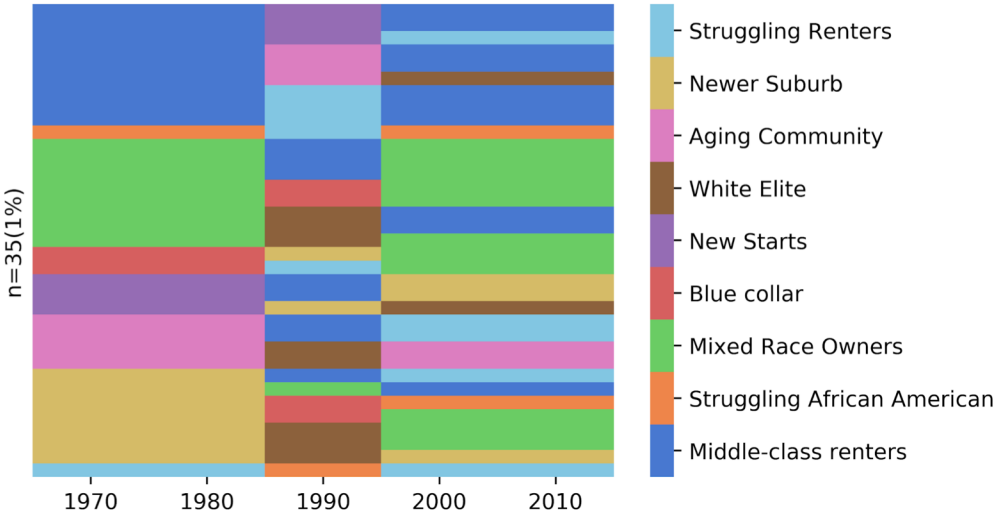
- “New Starts” missing
- Spatially compact





Two changes

Spatially dispersed



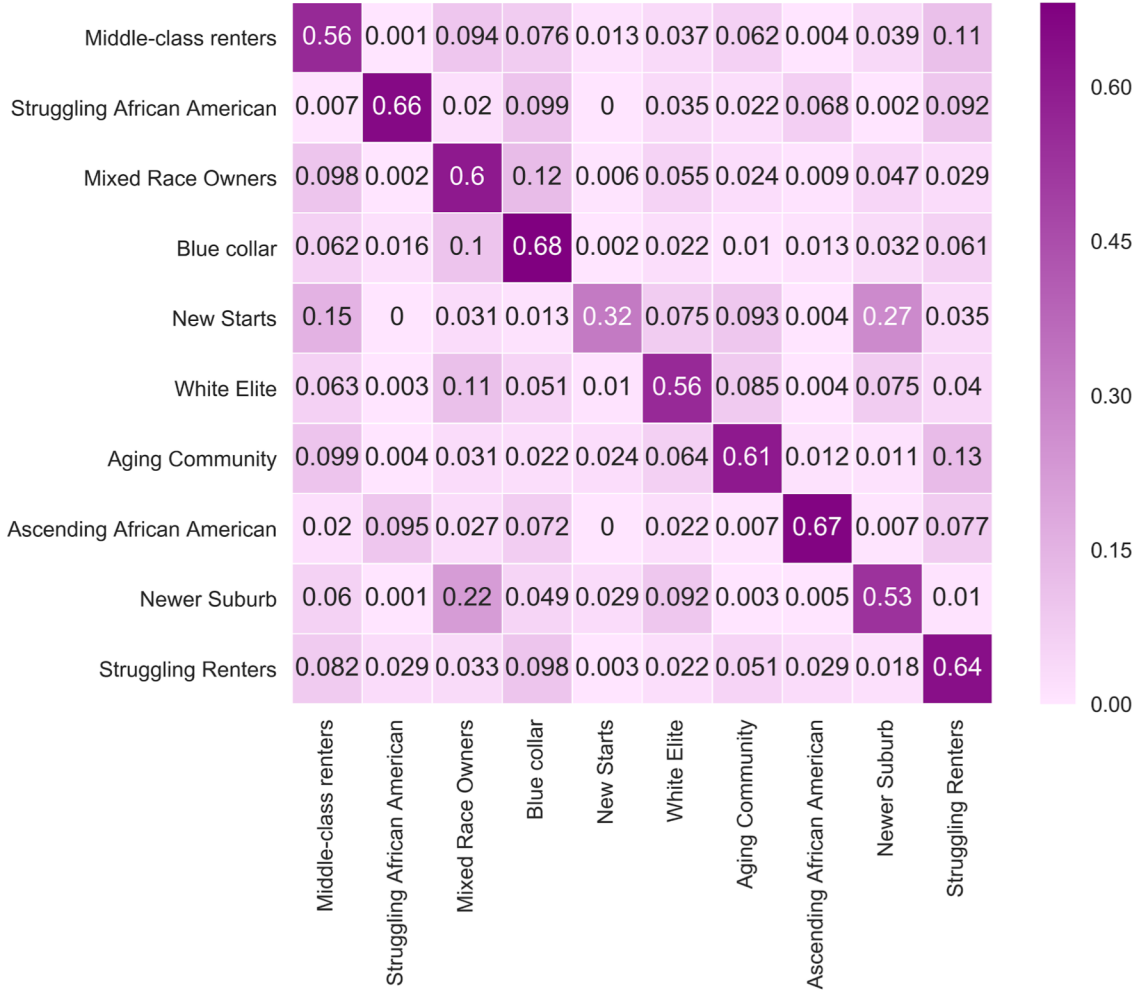
“Stability” defined with empirical transition rates (21)

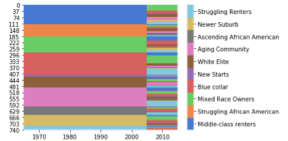
Substitution cost

$$s(a \to b, c \to d) = \left| p(a \to b) - p(c \to d) \right|$$

↑ *transition rate*

↑ *stability (easier to occur in the system)*





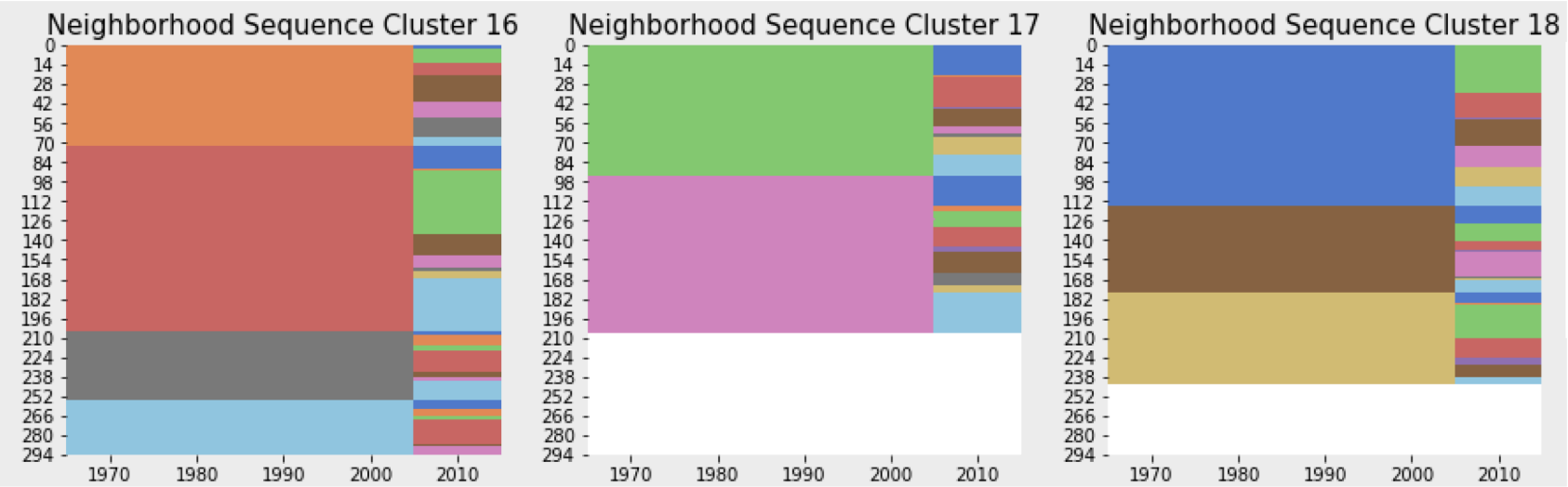
Stable until last period - more details

3 instead of 1 sequence clusters

Higher

Middle

Lower



First + Second Order (39)

- First order:
  - How different are two neighborhood types
  - Neighborhood category as a social construct:
    - Euclidean distance between two respective cluster centers
- Difference between states + Difference between transitions

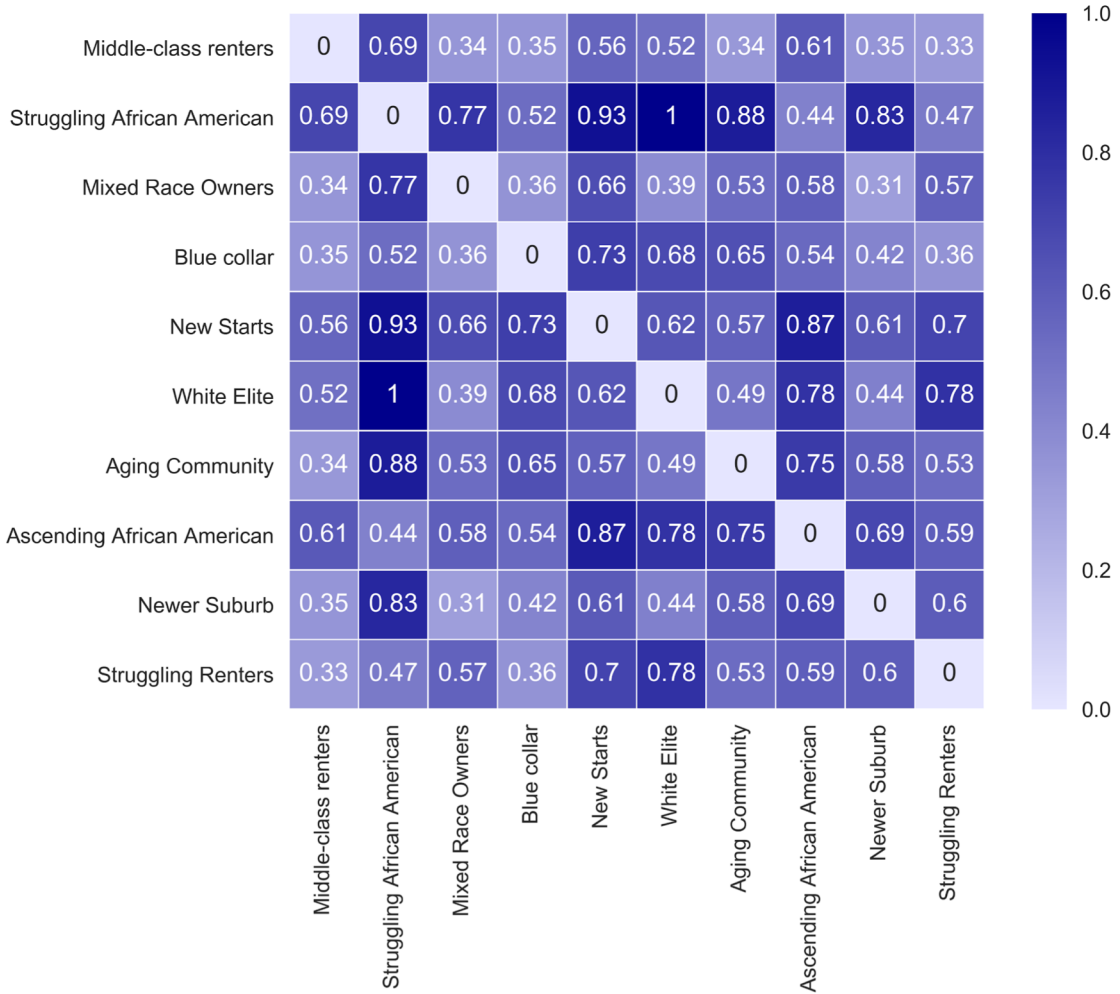
$$s(a \to b, c \to d) = ws(a, c) + (1 - w)\left|p(a \to b) - p(c \to d)\right|$$

or

$$s(a \to b, c \to d) = ws(b, d) + (1 - w)\left|p(a \to b) - p(c \to d)\right|$$

First-order difference

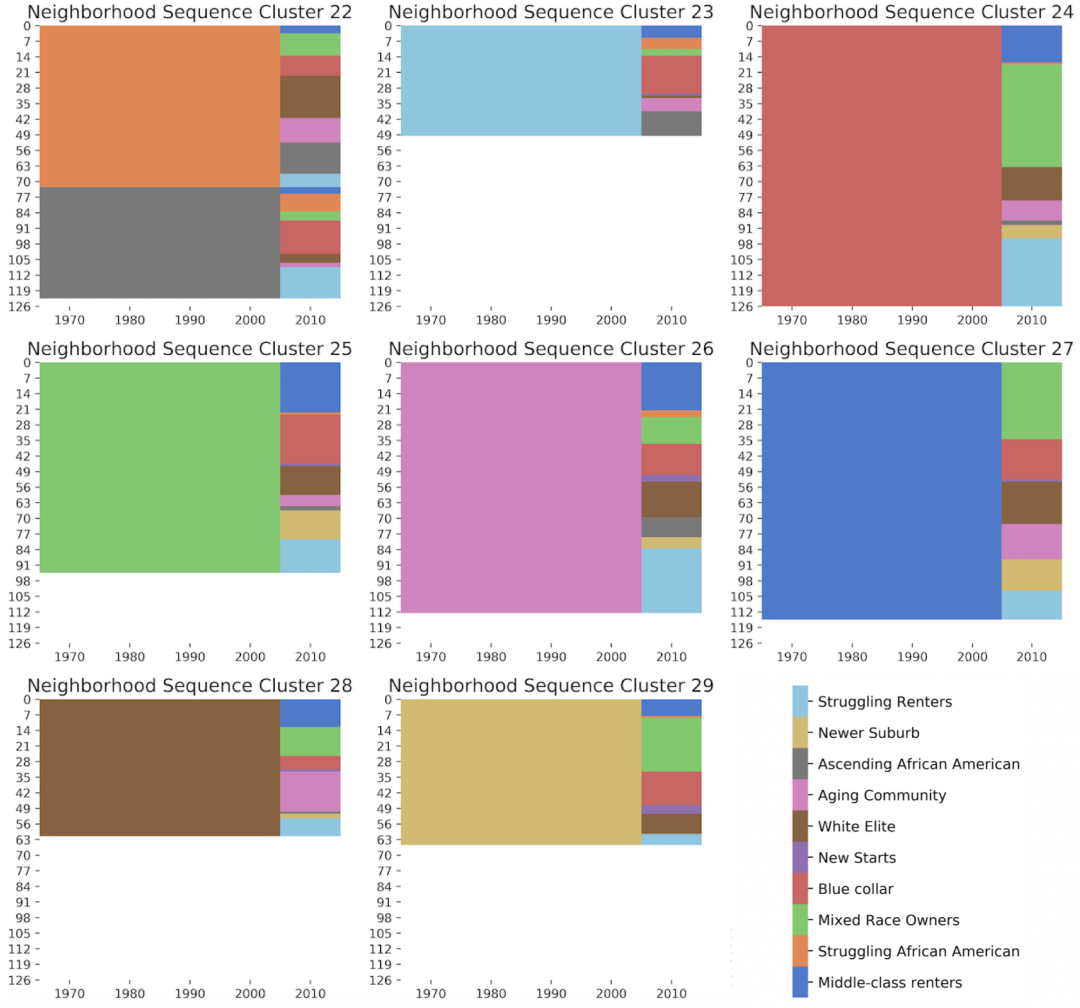
Euclidean distances between neighborhood types



Reveal More details

8 trajectory clusters

Would have a different result if the first-order difference is focused on the latter neighborhood state.



Findings

- The most frequent pathway: change between 2000-2010
  - In contrast to the past findings
  - Possible reasons:
    - Finer neighborhood typology (10 VS 5/9)
    - Choice of neighborhood variables
- Proposed approach
  - Picks up temporal changes, stability structure
  - More details revealed by incorporating first-order + second-order differences

Future directions

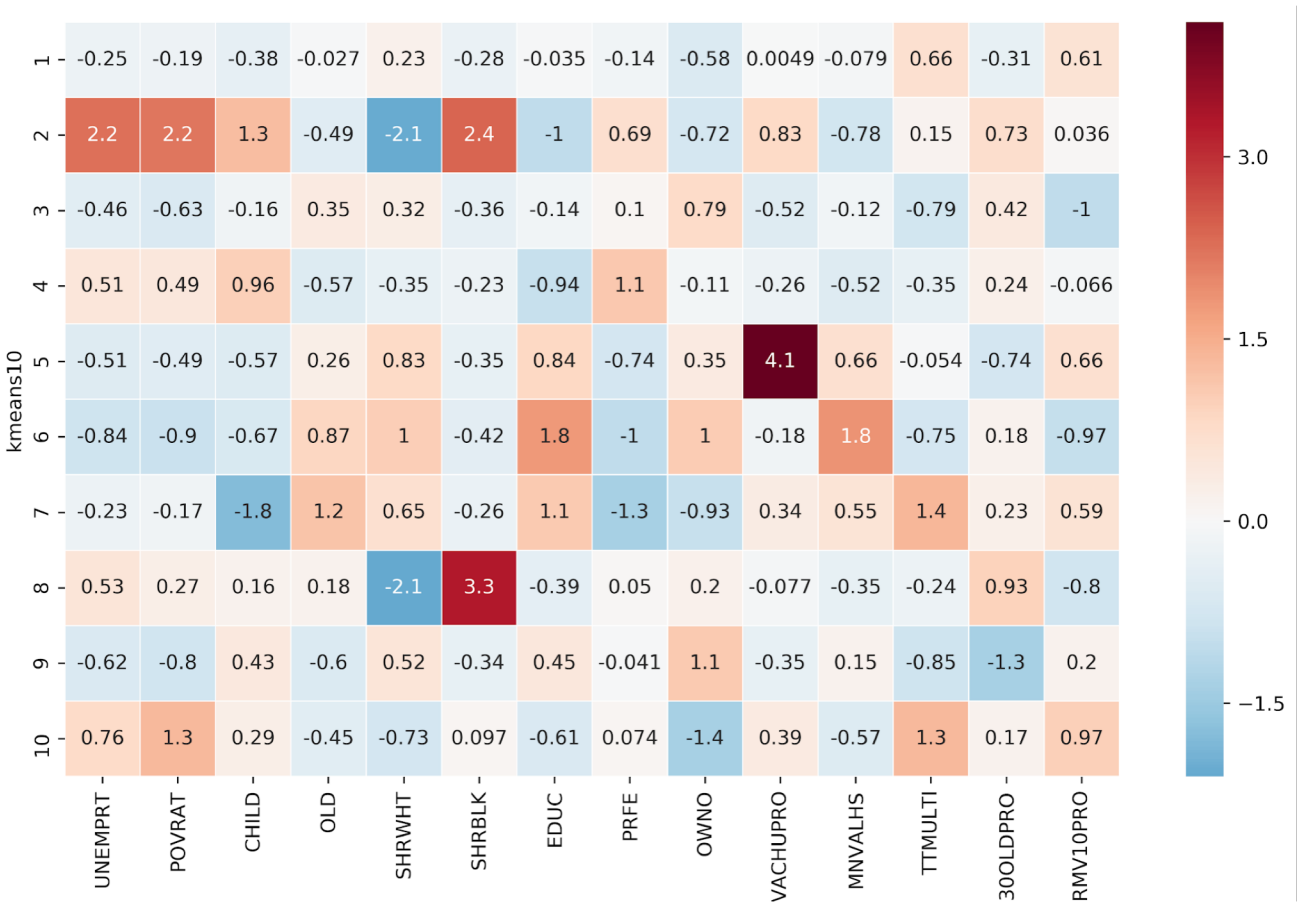
- Controlled simulation experiments
  - duration, sequencing, stability, timing
- Try on different values of weight
- Work with metro areas other than LA
- More thorough interpretation
- Spatially constrained clustering algorithm

References

- Elizabeth C Delmelle. Differentiating pathways of neighborhood change in 50 U.S. metropolitan areas. Environment and Planning A, 49(10):2402–2424, 2017.
- Torsten Biemann. A transition-oriented approach to optimal matching. Sociological Methodology, 41(1):195–221, 2011.
- S. E. Spielman and A. Singleton. Studying neighborhoods using uncertain data from the American community survey: A contextual approach. Annals of the Association of American Geographers, 105(5):1003–1025, 2015.
- Matthias Studer and Gilbert Ritschard. What matters in differences between life trajectories: a comparative review of sequence dissimilarity measures. Journal of the Royal Statistical Society: Series A (Statistics in Society), 179(2):481–511, 2016.

Thank you!

Questions?


kmeans10
1 -0.25 -0.19 -0.38 -0.027 0.23 -0.28 -0.035 -0.14 -0.58 0.0049 -0.079 0.66 -0.31 0.61
2 2.2 2.2 1.3 -0.49 -2.1 2.4 -1 0.69 -0.72 0.83 -0.78 0.15 0.73 0.036
3 -0.46 -0.63 -0.16 0.35 0.32 -0.36 -0.14 0.1 0.79 -0.52 -0.12 -0.79 0.42 -1
4 0.51 0.49 0.96 -0.57 -0.35 -0.23 -0.94 1.1 -0.11 -0.26 -0.52 -0.35 0.24 -0.066
5 -0.51 -0.49 -0.57 0.26 0.83 -0.35 0.84 -0.74 0.35 4.1 0.66 -0.054 -0.74 0.66
6 -0.84 -0.9 -0.67 0.87 1 -0.42 1.8 -1 1 -0.18 1.8 -0.75 0.18 -0.97
7 -0.23 -0.17 -1.8 1.2 0.65 -0.26 1.1 -1.3 -0.93 0.34 0.55 1.4 0.23 0.59
8 0.53 0.27 0.16 0.18 -2.1 3.3 -0.39 0.05 0.2 -0.077 -0.35 -0.24 0.93 -0.8
9 -0.62 -0.8 0.43 -0.6 0.52 -0.34 0.45 -0.041 1.1 -0.35 0.15 -0.85 -1.3 0.2
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UNEMPRT
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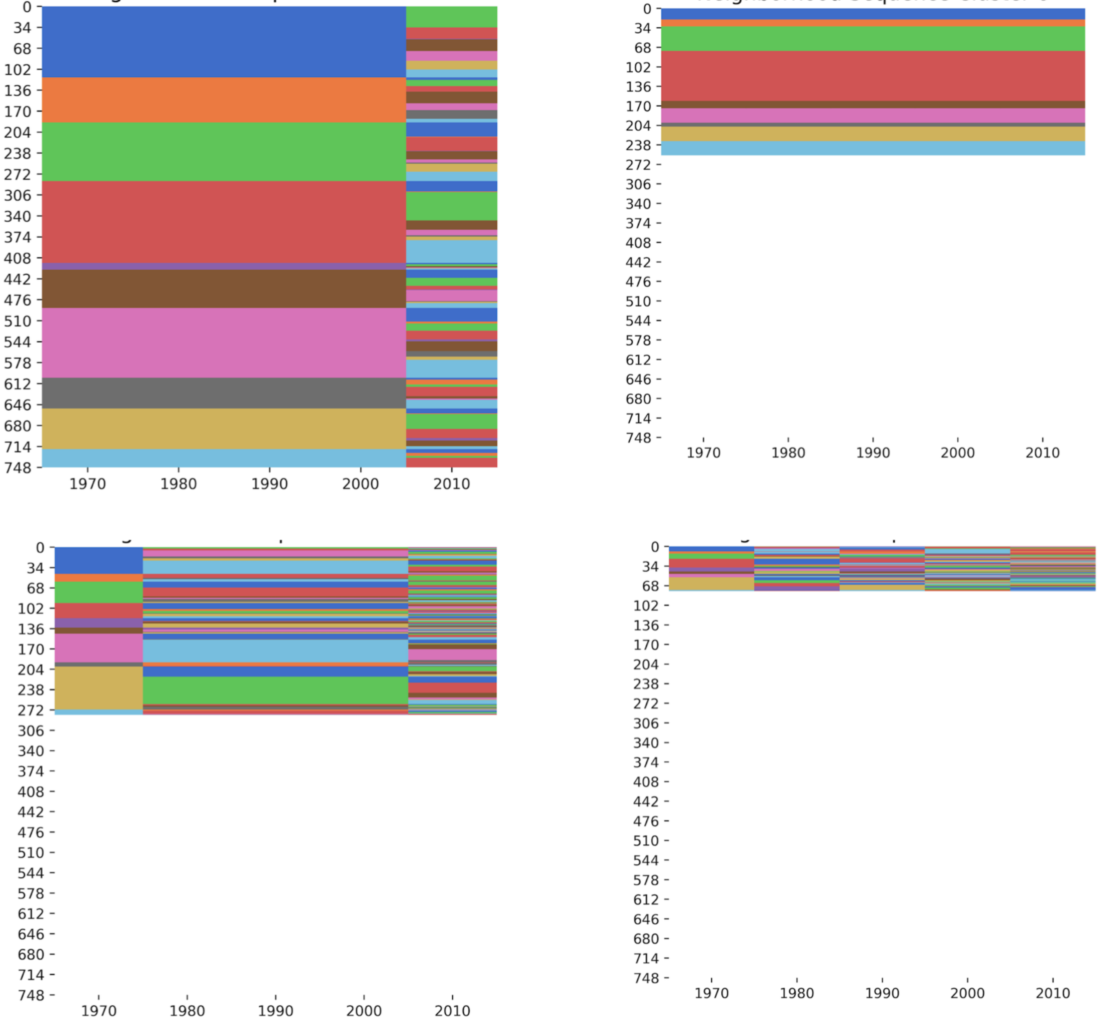
Stability?



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1970
1980
1990
2000
2010

Approaches to Studying Neighborhood Change

- A dynamic perspective
  - Focus on focal events/transitions
    - Markov models
    - Event History Analysis
  - Data model
- A holistic perspective
  - Neighborhood trajectories/sequences as meaningful units
    - Sequence Analysis (SA)
    - Optimal matching
  - Data mining or algorithmic model