MINING SEQUENCES DATA

STQD6414 PERLOMBONGAN DATA

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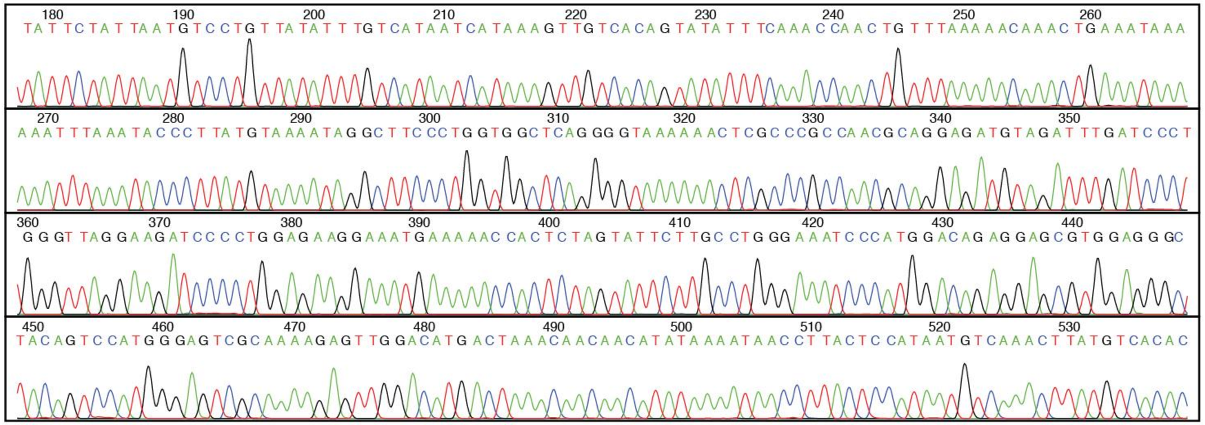
INTRODUCTION:

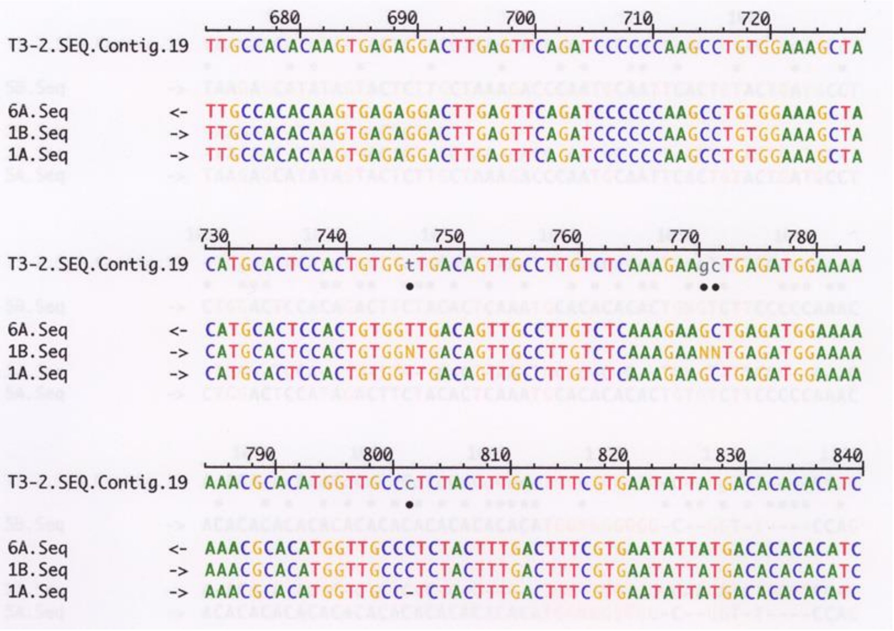
- This topic will discuss about categorical sequence data analysis.
- In the sequence data, the position of each consecutive states gives an interpretation in term of age, date, elapsed time or distance from the beginning of the sequence.
- Generally, this type of data refers to observations of a particular individuals or entities over a some period of time.
- The main objective is to analyze the behavior of the sequence of states for a particular entities.



DNA sequence data from an automated sequencing machine

INTRODUCTION:

- For this topic, our discussion will focus on the sequence analysis for life trajectory data.
- However, most of the concepts and techniques for sequential analysis can be applied in various domain areas such as; biology, quality control, text data, log-web data, and etc.



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                          680       690       700       710       720
T3-2.SEQ.Contig.19    TTGCCACACAAGTGAGAGGACTTGAGTTCAGATCCCCCCAAGCCTGTGGAAAGCTA

6A.Seq             <- TTGCCACACAAGTGAGAGGACTTGAGTTCAGATCCCCCCAAGCCTGTGGAAAGCTA
1B.Seq             -> TTGCCACACAAGTGAGAGGACTTGAGTTCAGATCCCCCCAAGCCTGTGGAAAGCTA
1A.Seq             -> TTGCCACACAAGTGAGAGGACTTGAGTTCAGATCCCCCCAAGCCTGTGGAAAGCTA

                      730       740       750       760       770       780
T3-2.SEQ.Contig.19    CATGCACTCCACTGTGGtTGACAGTTGCCTTGTCTCAAAGAAgcTGAGATGGAAAA
                                       •                           ••
6A.Seq             <- CATGCACTCCACTGTGGTTGACAGTTGCCTTGTCTCAAAGAAGCTGAGATGGAAAA
1B.Seq             -> CATGCACTCCACTGTGGNTGACAGTTGCCTTGTCTCAAAGAANNTGAGATGGAAAA
1A.Seq             -> CATGCACTCCACTGTGGTTGACAGTTGCCTTGTCTCAAAGAAGCTGAGATGGAAAA

                            790       800       810       820       830       840
T3-2.SEQ.Contig.19    AAACGCACATGGTTGCCcTCTACTTTGACTTTCGTGAATATTATGACACACACATC
                                       •
6A.Seq             <- AAACGCACATGGTTGCCCTCTACTTTGACTTTCGTGAATATTATGACACACACATC
1B.Seq             -> AAACGCACATGGTTGCCCTCTACTTTGACTTTCGTGAATATTATGACACACACATC
1A.Seq             -> AAACGCACATGGTTGCC-TCTACTTTGACTTTCGTGAATATTATGACACACACATC
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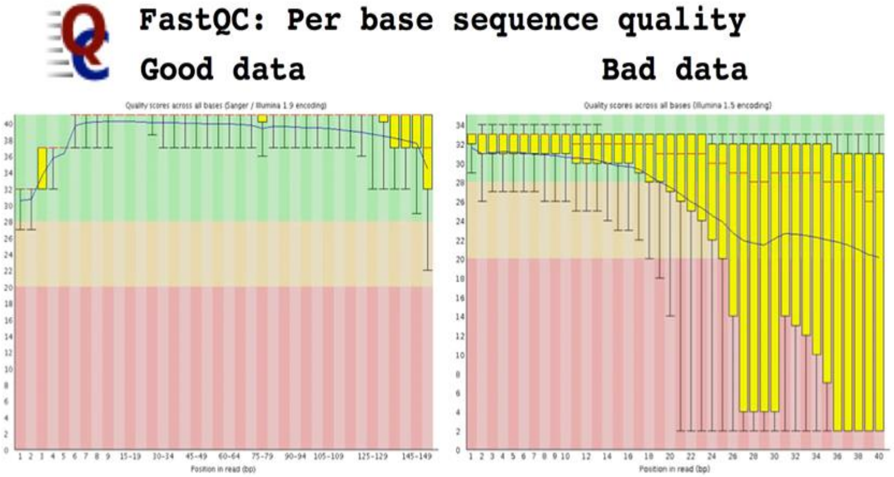


SEQUENCES DATA:

- Sequences are complex objects, and it require specialized data mining techniques to analyze this kind of data.

- Among the interesting questions related to the sequence type data:

i) What are the characteristics of a sequence data?.

ii) What are the indicators that can be used to measure sequence data?.

iii) What are the appropriate plots to visualize a sequence data?.

iv) How can we compare the similarity between several sequences data?.

- Using data mining tools, the information that we can extract:

i) Information about the behavior of sequences data.

ii) A groups of sequences that indicate a similar pattern (typologies of sequences data).

iii) The relationship of sequences data with some related covariates.

STATE SEQUENCES:

- Sequence of state is an important concept used to analyze the trajectory of life.
- Example: occupational histories, patient level history, cohabitation life courses and etc.

- Example: Based on state sequence data of cohabitation life courses, we can determine:

i) The characteristics of social norm of a life courses.

ii) The standard trajectories of a life course.

iii) The departures behaviors from the standards trajectories.

iv) The evolution patterns of a life course over time.

v) The characteristics of cohabitation life correspond to a factor of sex, social origin, cultural, and etc.

STATE SEQUENCES:

- The analysis of state sequence will summarize and categorizing the sequential patterns into some particular groups that having similar properties.

- The sequential analysis techniques:

i) Statistical summary indicators.

ii) Visualization.

iii) Grouping.

iv) Comparing sequences.

- The obtained groups and summary indicators provide an information for further analysis involving various inferential statistical methods.

STATISTICAL SUMMARY INDICATORS:

- Among the important statistical summary indicators are:

i) Mean time spent in each state.

ii) Mean time spent in each state by groups.

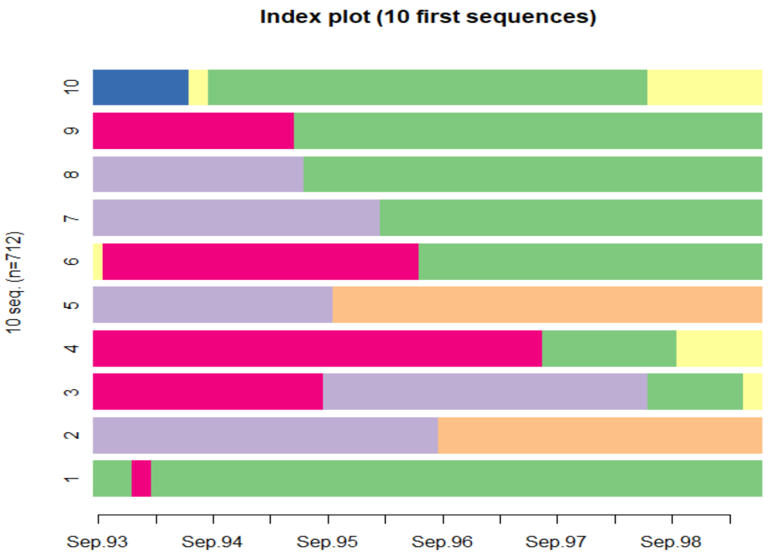
iii) Number of transitions.

iv) Transition rates.

v) Time varying transition states.

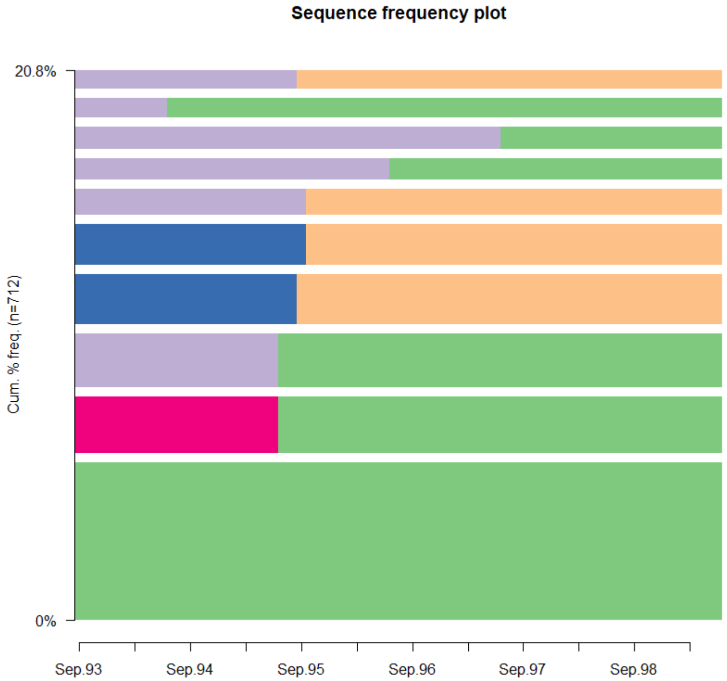
VISUALIZATION: SEQUENCE INDEX PLOT

- A sequence index plot can be used to visualize behaviors of state sequences.
- The plot represented by horizontally stacked boxes which are colored according to the state.
- The horizontal bar width represents a proportional of each frequency.
- Each bar with a different color and length displays information about individual longitudinal changes from one state to another.



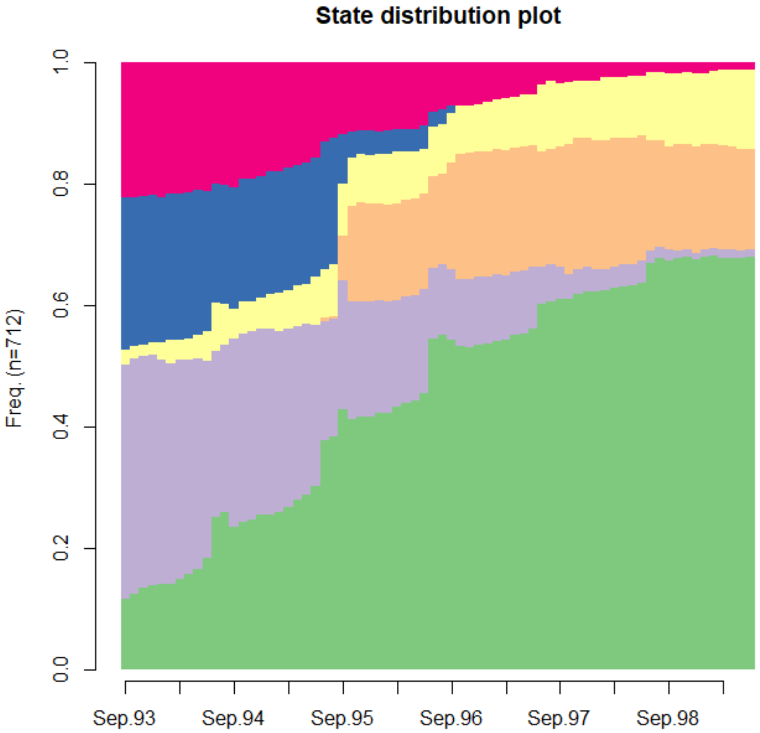
VISUALIZATION: SEQUENCE FREQUENCY PLOT

- Sequence frequency refers to the number and percentage of frequencies arranged in descending order.
- A sequence frequency plot provides a graphical display of the frequency of a sequence with the width of the bar proportional to its frequency.



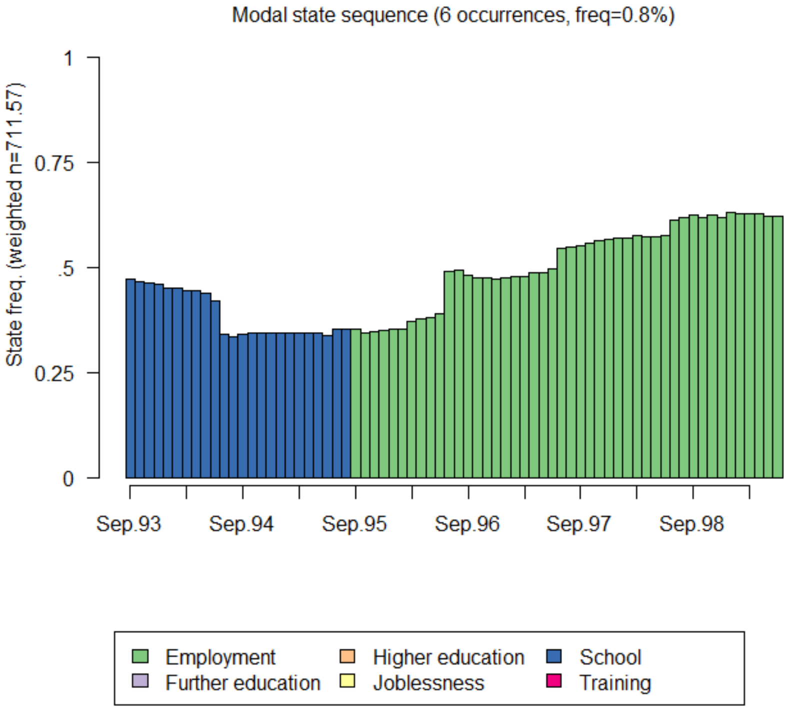
VISUALIZATION: STATE DISTRIBUTION PLOT

- This plot displays the general pattern of the whole set of trajectories in sequence data.
- It provides aggregated views for transversal characteristics of sequences data.



VISUALIZATION: MODAL STATE PLOT

- This plot provides information about the sequence made by the most frequent state at each position.
- It also shows a number of occurrences of the modal state sequence.



SEQUENCE CHARACTERISTICS BY ENTROPY INDEX:

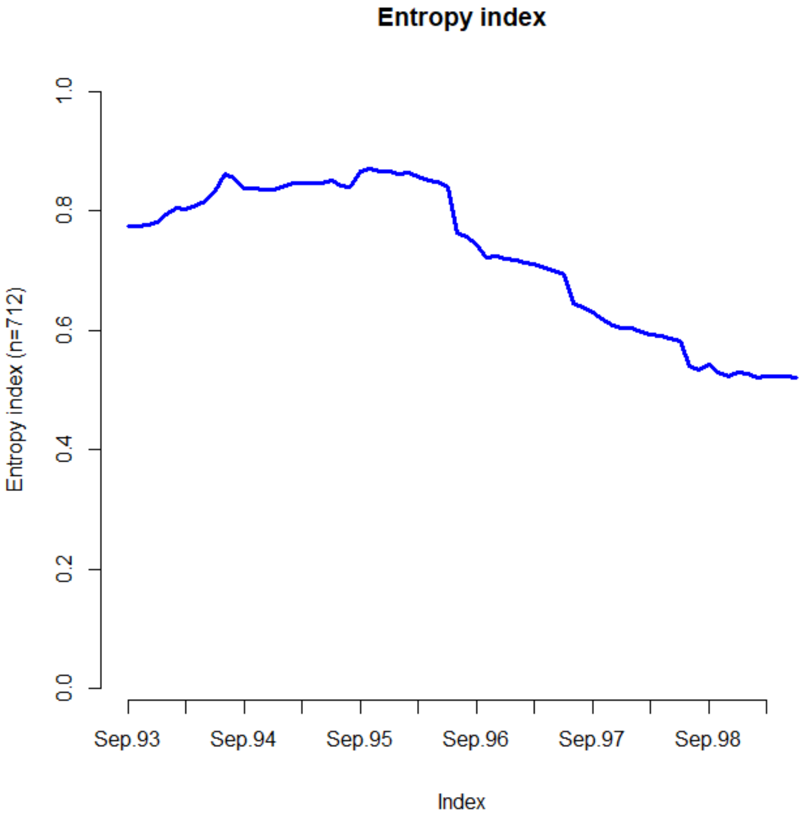
- The entropy provides a measure of the diversity of states.
- Entropy index for sequences data can be determine as follow:

$$h(p_1, \ldots, p_a) = -\sum_{i=1}^{a} p_i \log(p_i)$$

- where *p*$_i$ is the proportion of cases/entities in state-*i*, *a* is the size of a sequence data.
- If the value of entropy=0, indicates that all cases are in the same state (variation is 0).
- If the value of entropy is high, indicates that the same proportion of cases are found in each state (variation is high).

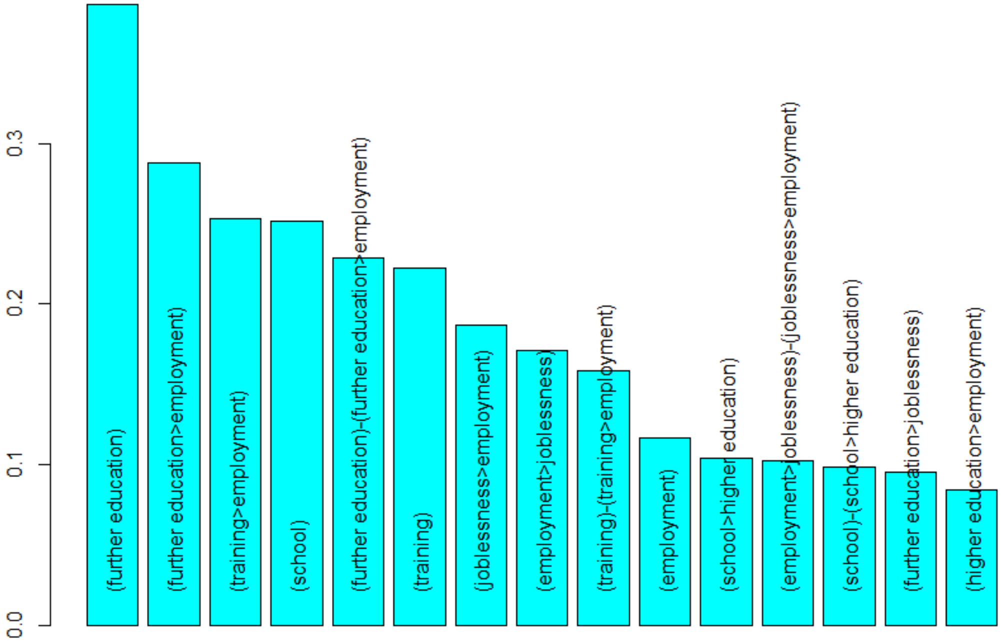
VISUALIZATION: TRANSVERSAL ENTROPIES

- The plot of transversal entropies displays information on the variation of states in the sequence data shown against the time factor.



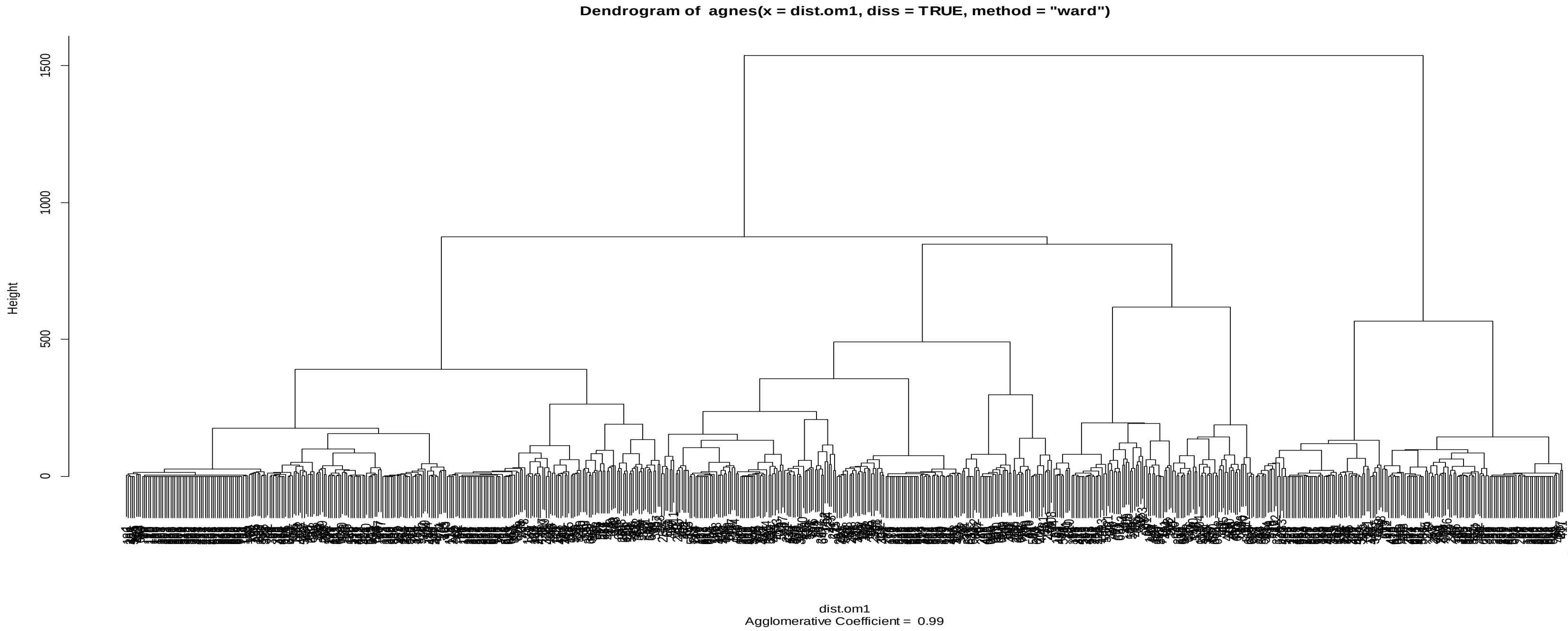
EVENT SEQUENCE ANALYSIS:

- Event sequence analysis is a method to define events, the logical relationship between events and how each event expands with other events.
- Instead of focusing on sequences of states, we can look at sequences of transitions or events.

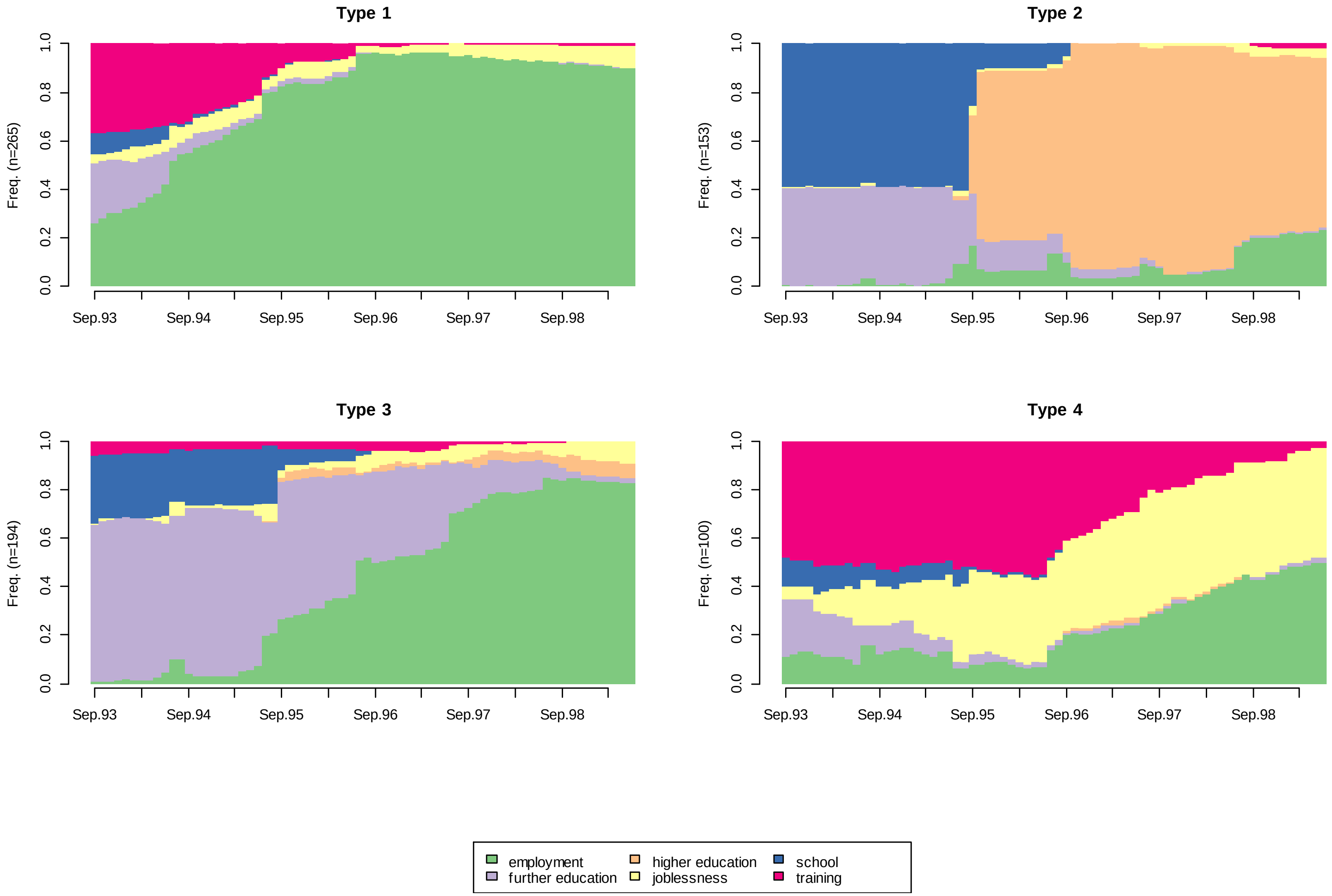


CATEGORIZING PATTERNS:

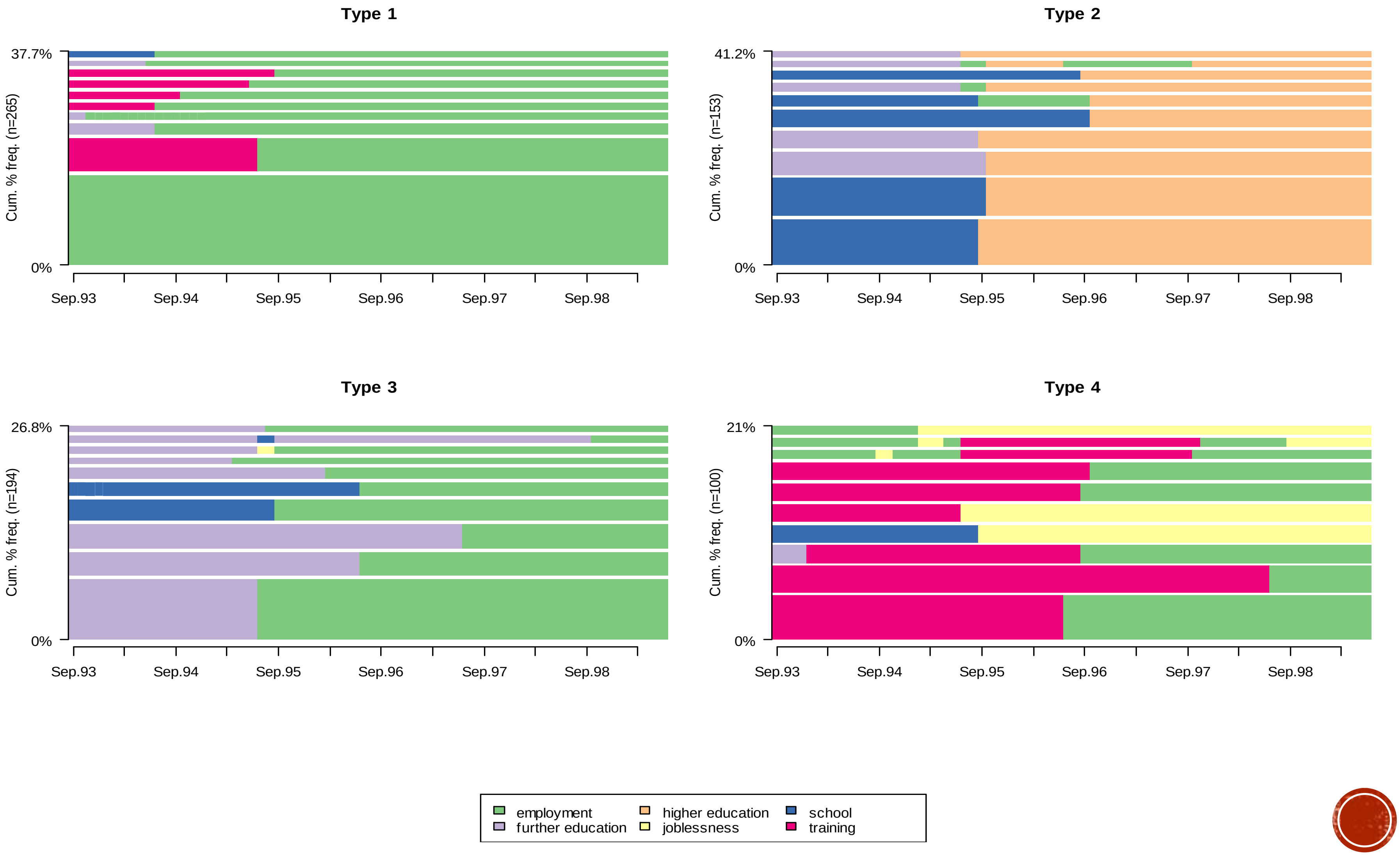
- Categorizing patterns provide information about a typology of a sequences.
- It can be done by measuring similarity between a pairwise distances between a sequences.
- This techniques are based on the algorithm of optimal matching.
- Each cluster of a groups entities indicate similar trajectories characteristics.



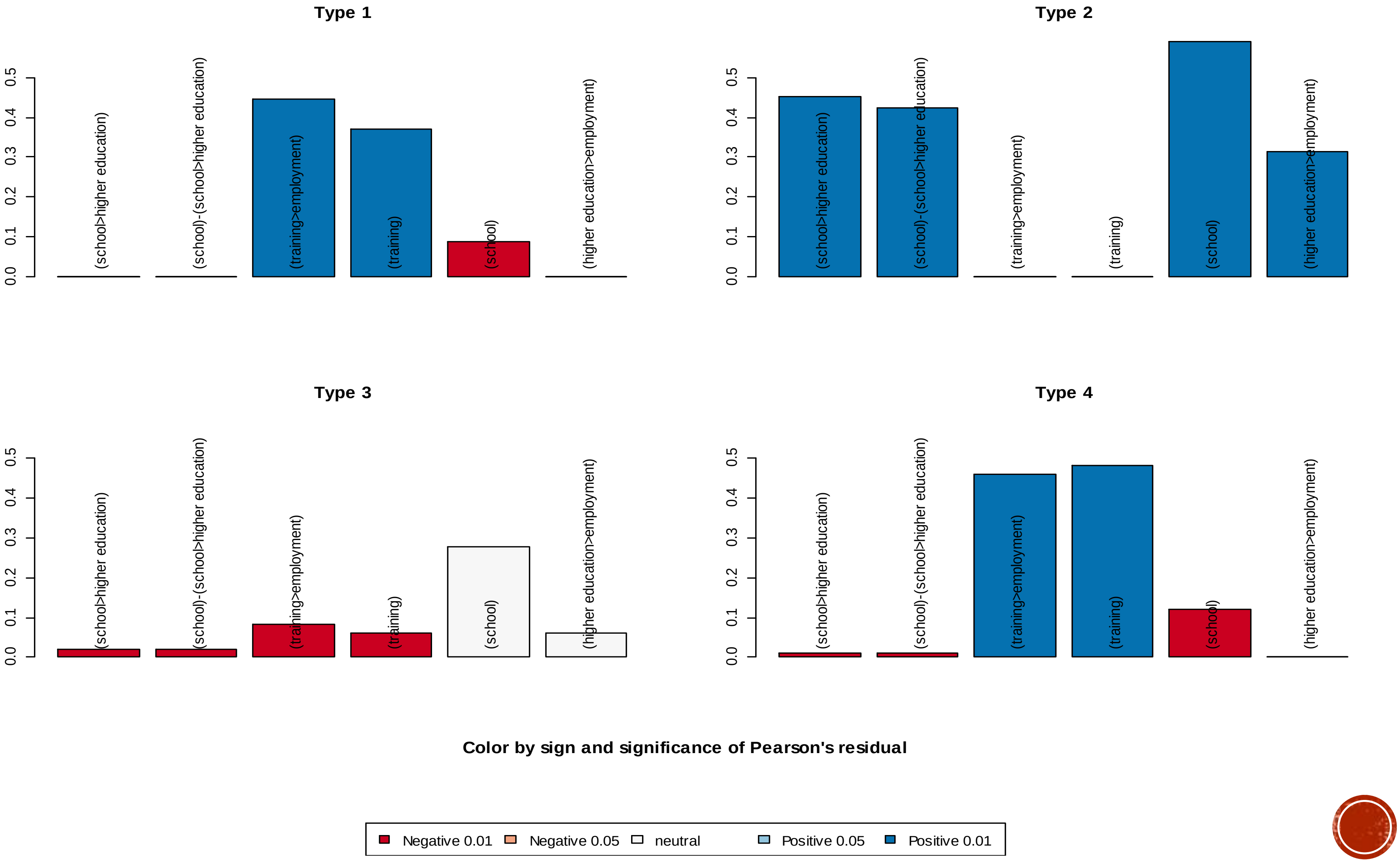
CATEGORIZING PATTERNS: STATE DISTRIBUTION



CATEGORIZING PATTERNS: SEQUENCE FREQUENCIES



CATEGORIZING PATTERNS: DISCRIMINATING TRANSITIONS



SEQUENCES ANALYSIS: OTHER APPROACHES

- There are a lot of approaches that can be used to deal with state sequences data.

- Some of them are:

i) Correspondence analysis of the states.

ii) Markov modeling.

iii) Event sequences analysis.

iv) Survival analysis.

v) Longitudinal analysis.

vi) Discrete panel data analysis.

vii) And etc.

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- Melnykov, V. (2016). ClickClust: An R Package for Model-Based Clustering of Categorical Sequences. *Journal of Statistical Software*, 74(9), 1–34

NEXT TOPIC:

Mining Text Data