Understanding Visual Scanning Behavior in Driving: A Review and a New Perspective Using Statistical Pattern-Based Approach

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1. Background

- Areas of Interest (AOIs) can be suboptimal for dynamic driving tasks.
- Scan paths provide more detailed strategies used by drivers.

2. Literature Review

- Measures provide an overview of a driver's visual attention but often do not provide a temporal dimension to the analysis.

Terms	Definitions
Direction of gaze	The AOI to which the eyes are directed. (1, 2)
Dwell time	The sum of all consecutive fixations and saccades within the AOI between transitions to other AOIs. (3)
Glance/Glance duration	The maintaining of visual gaze within an AOI, bounded by the perimeter of the AOI; comprised of at least one fixation and a transition to or from the AOI. (1, 4)
Glance frequency	The number of glances to an AOI within a sample interval where each glance is separated by at least one glance to a different AOI. (5, 4, 6, 7)
Glance location probability	The probability that the eyes are fixated at an AOI (or set of related AOIs) during a sample interval. (8)
Link value probability	The probability of a glance transition between two different locations.(8)
Total Eyes Off Road Time	The summation of all glance durations to all AOIs other than the road scene ahead during a sample interval. (7)
Total glance time	The summation of all glance durations to an AOI (or set of related AOIs) during a sample interval. (9)
Transition time	The duration of a transition. (1)

- Scan Path Analysis:
  - *Discrete Representation-based Methods*: Simplify scan paths by transforming the fixation sequences into string-based representations to achieve better computational efficiency. (10, 11, 12, 13)
  - *Continuous Representation-based Methods*: Directly leverage fixation locations to find an optimal mapping to match the closest neighboring fixations between two scan paths. (14, 15)

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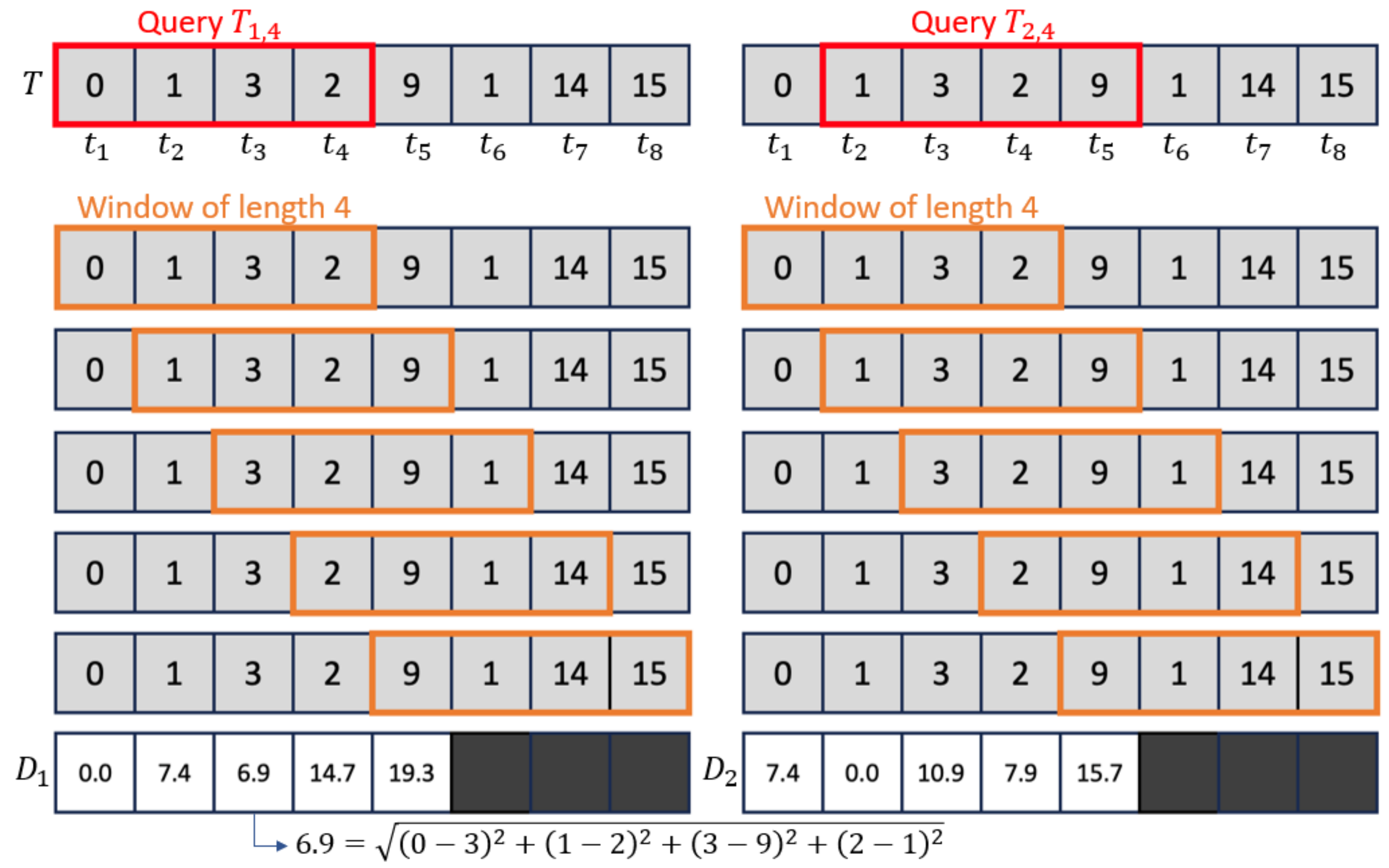
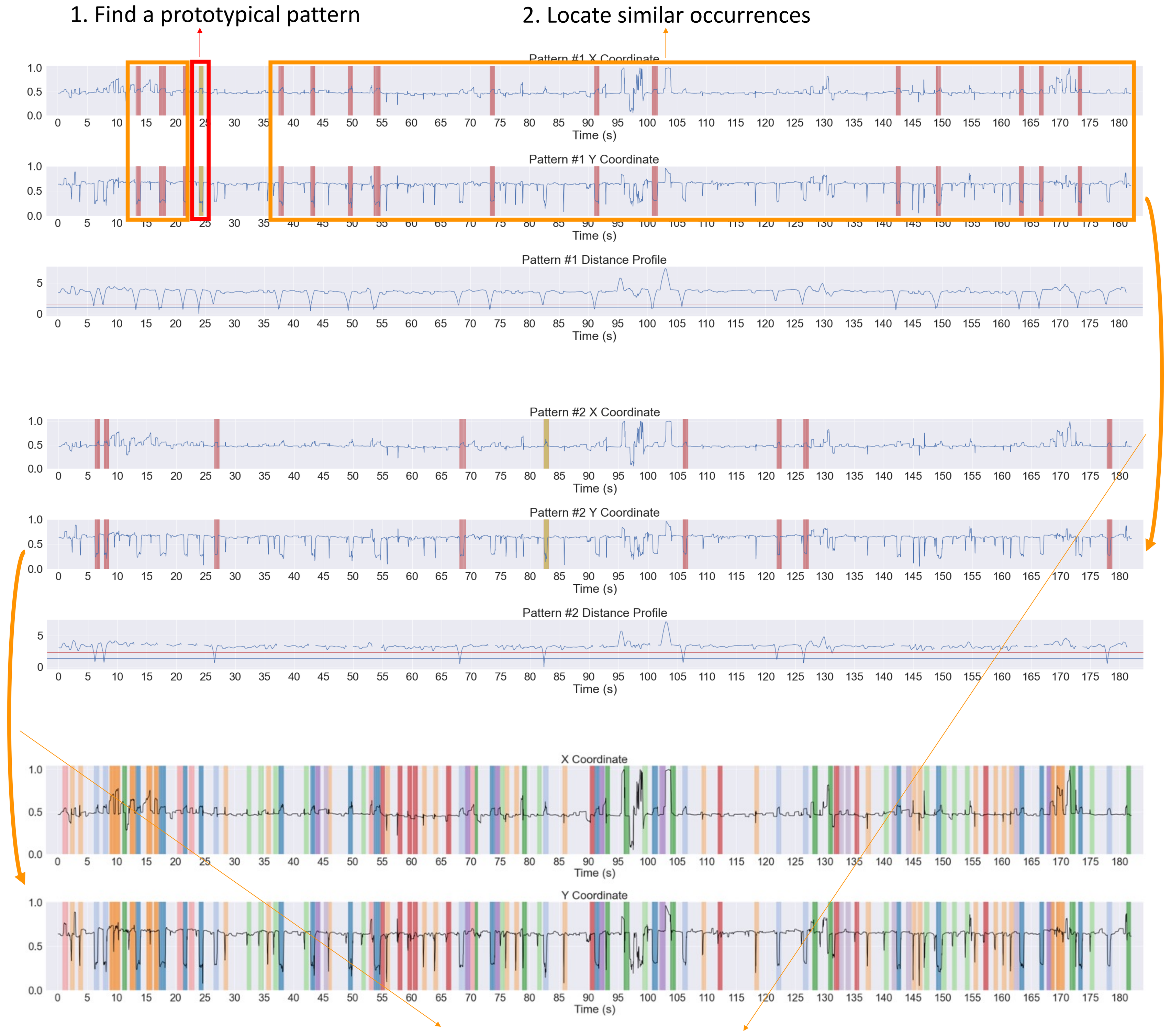
3. Methodology

- *Visual Scanning Patterns*: unique and representative visual scanning behaviors.
- *Distance Profile (16)*: a vector of the Euclidean distances between the ith query subsequence and each subsequence in the entire time series. **If the sum of the values in the distance profile of a given query subsequence is large, the subsequence is unique.**

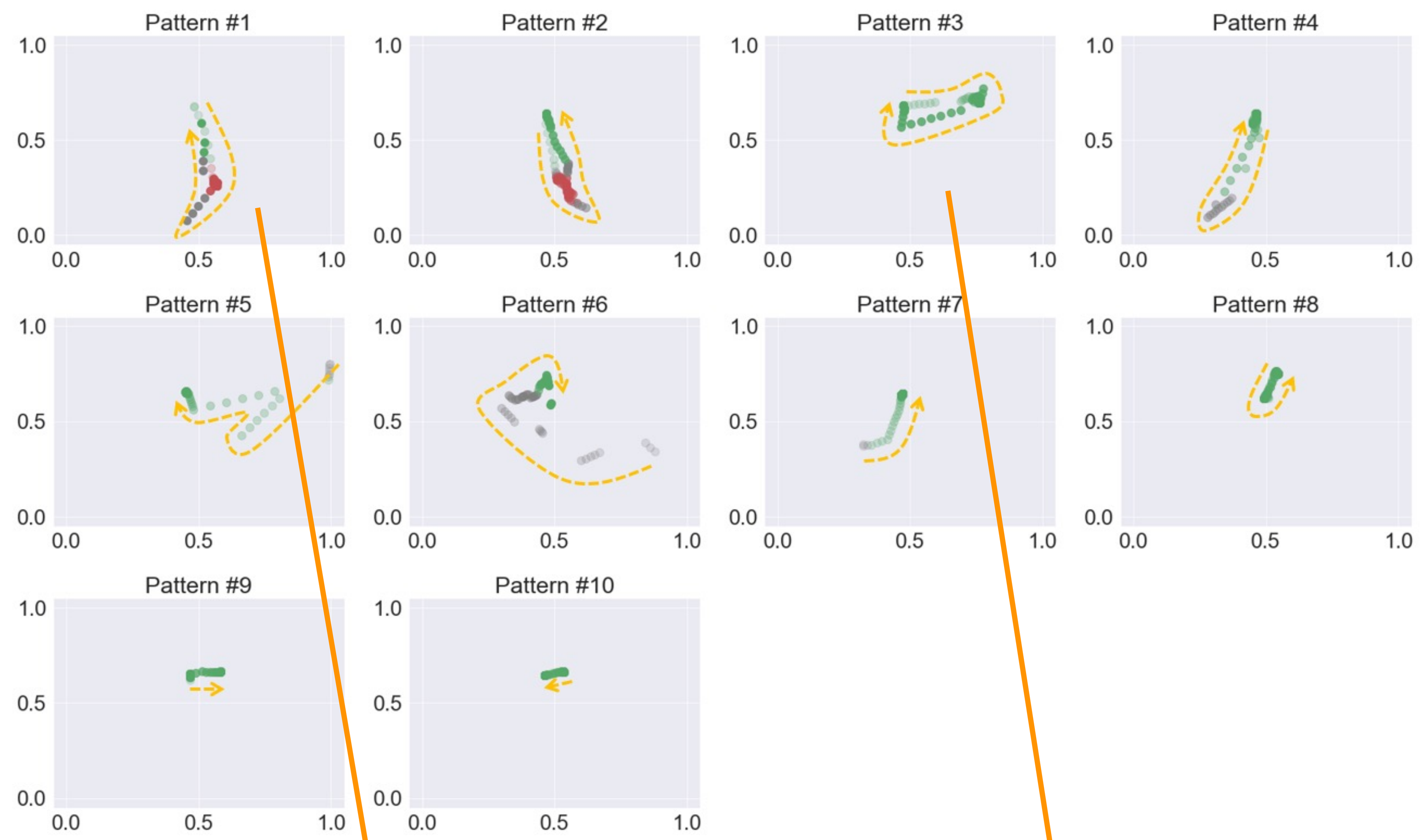


- *Visual Scanning Pattern Analysis*:

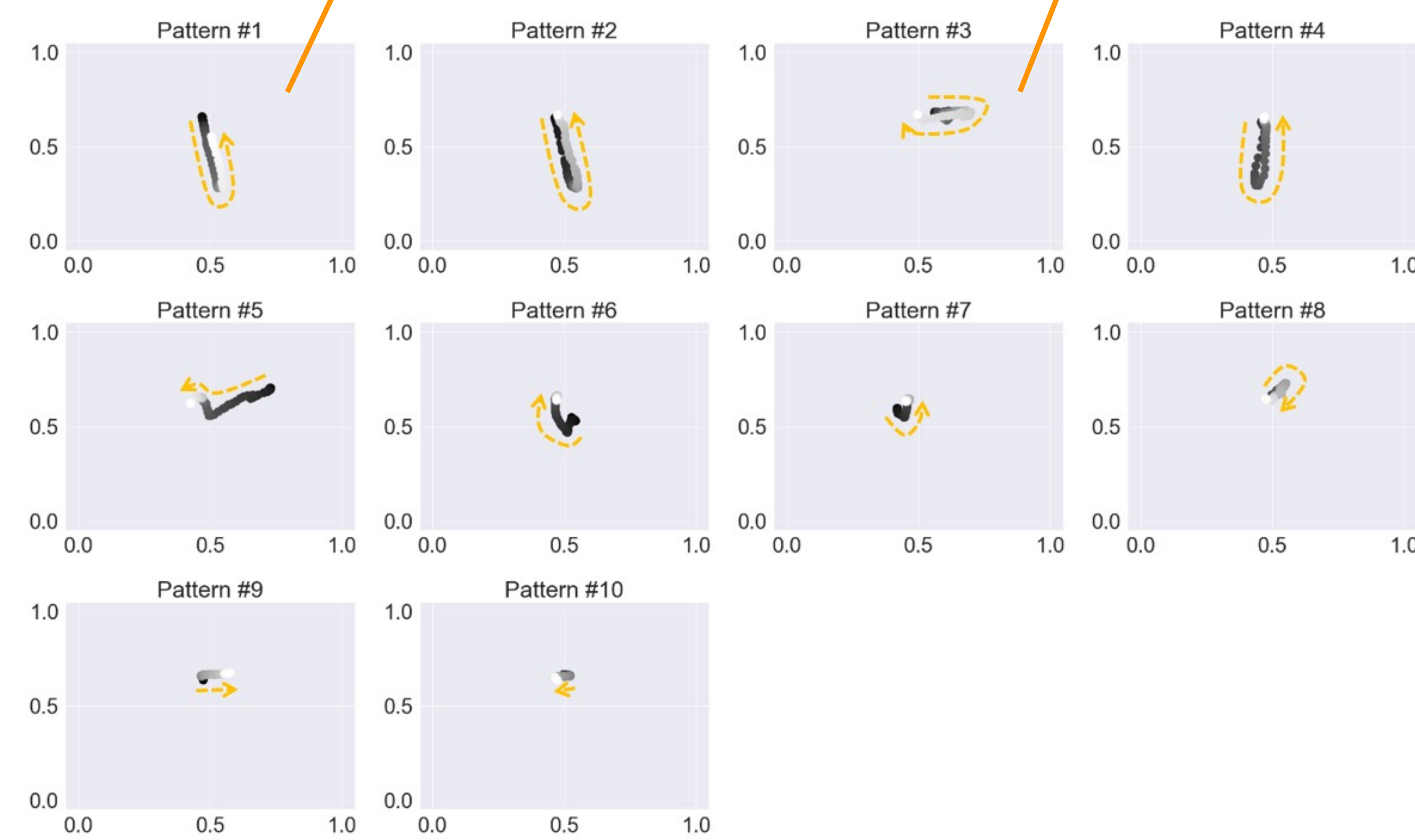


4. Visualization

Scan paths of the identified 10 prototypical patterns



The average scan paths of the identified 10 patterns



5. Conclusion

By directly analyzing the scan path, this new method reveals the overall trends, semantics, and intricate differences in eye movement, surpassing the AOI-based feature extraction method. The study elaborates on the visualization of the obtained patterns and the scan paths of corresponding prototypical and average patterns and presents derived insights into driving behaviors.