Interactive Dimensionality Reduction Methods for Visualization

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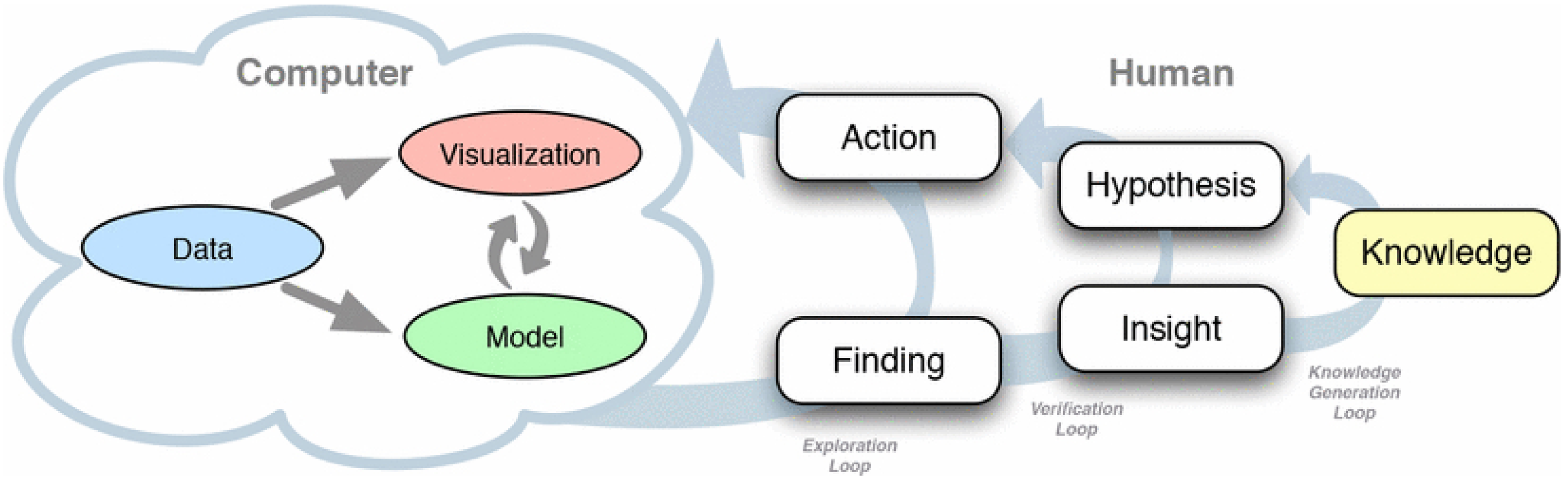
Dimensionality Reduction (DR) methods in an Interactive Context

DR method is an unsupervised learning technique to reduce the dimensionality of a dataset while preserving some of its important characteristics. The reduced data (called the *embedding*) can be used for visualization.

Problems: (1) The algorithm can make errors but we cannot correct them without interacting directly with the system. (2) Sometimes, it is hard to interpret the visualization results.

Research Questions: (1) How to integrate human knowledge into DR methods? (2) How to transform cognitive feedbacks from users to parametric constraints that can be used in DR methods?



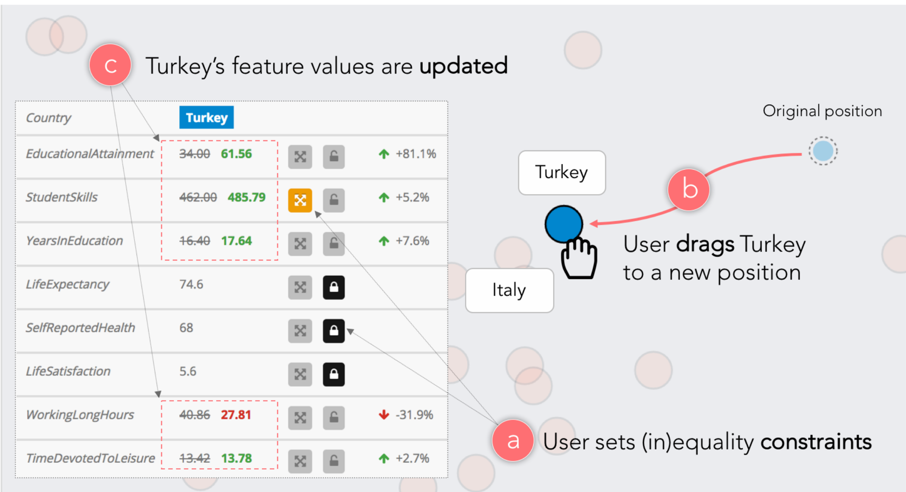
Visual analytics with Human-in-the-loop [3]

Different approaches for integrating user constraints and Concrete Examples

Interactive feedbacks from users or experts can be seen as constraints for the DR methods.
Several kinds of constraints at different levels: **Instance-level [A]**, **group-level [B]**, **feature-level [C]**, **dataset-level [D]**.

Feature exploration ([A], [C])

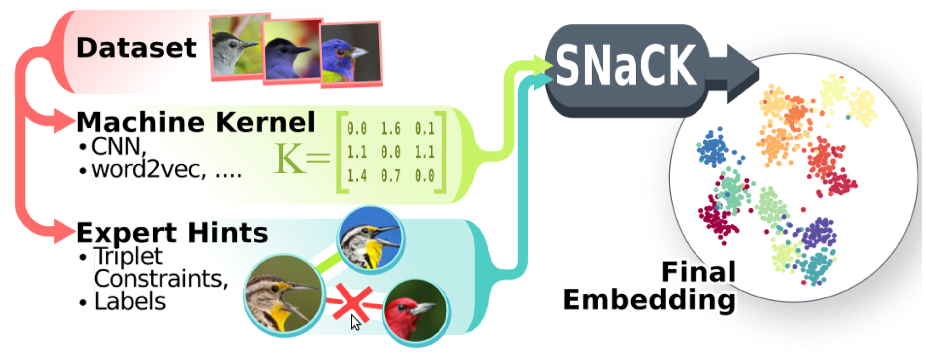
Understanding which features determine the position of point in the visualization [1].



Triplet constraints ([A], [B])

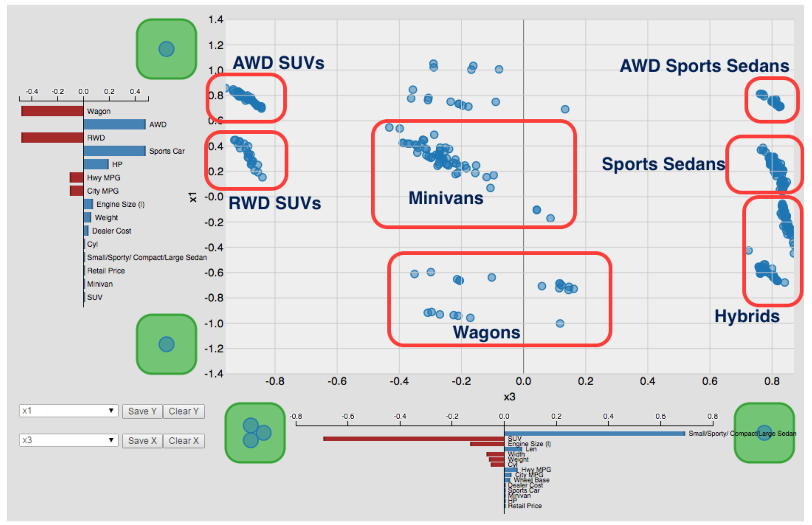
`Triplet` (i, j, k): object i seems more similar to object j than i does to object k.

t-STE can help experts interactively explore and label datasets [4].



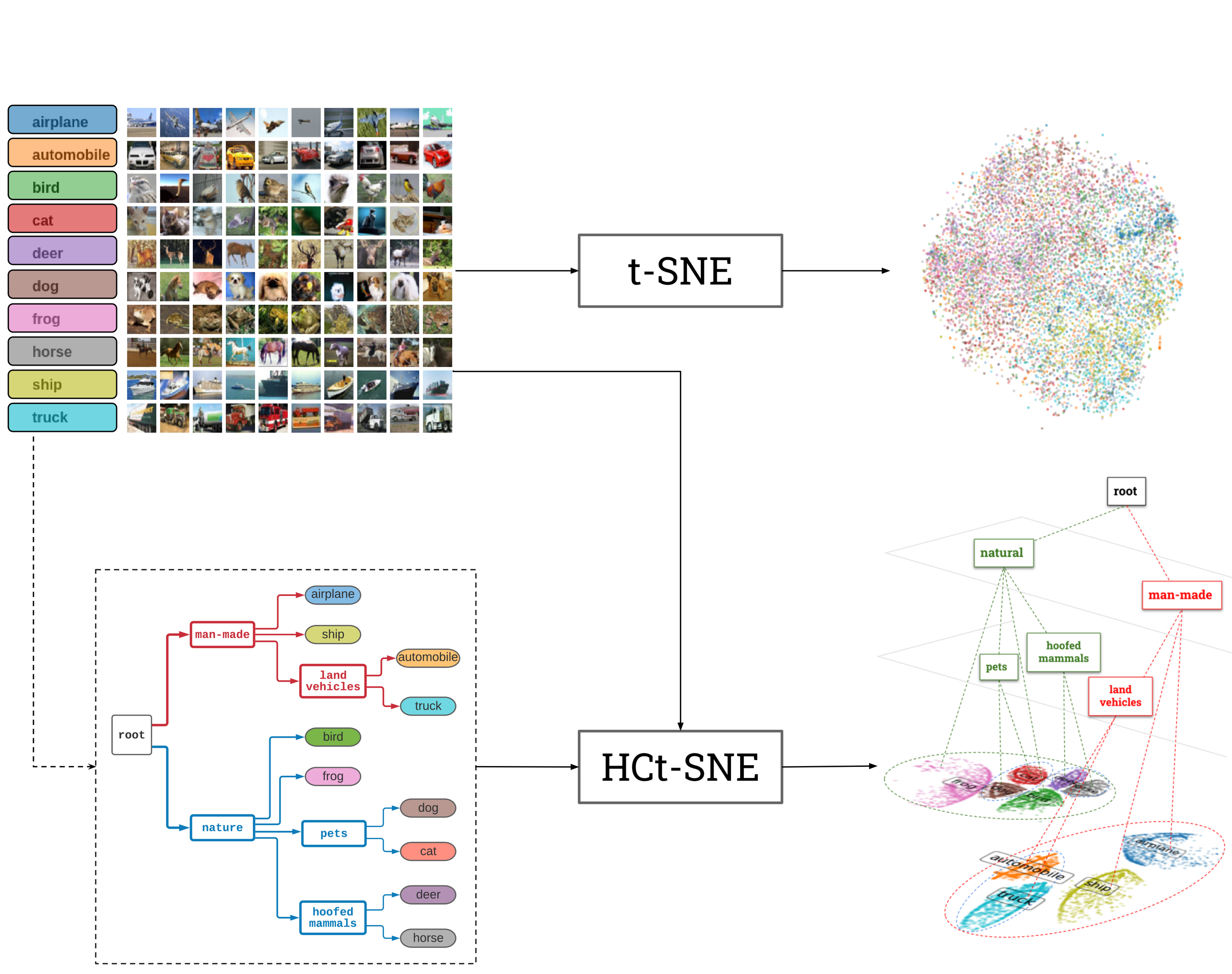
Example-based constraints ([C],[D])

Using examples to guide the algorithm to construct understandable axes [2].



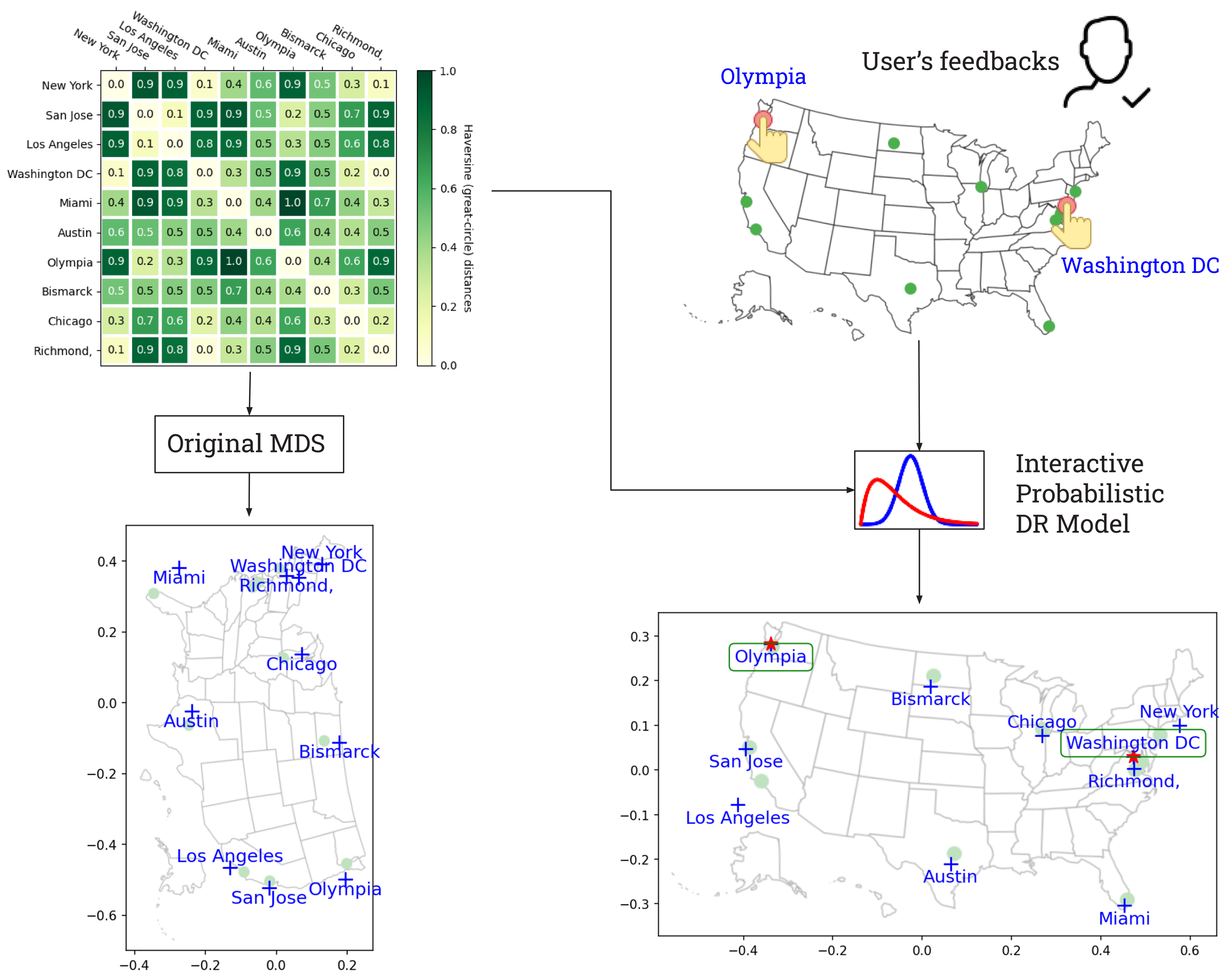
Proposed Interactive DR Methods for Visualization

Interactive *t*-SNE with Hierarchical Constraints (HC*t*-SNE) [5]



For complex datasets (like color images), *t*-SNE embeddings are not always useful due to the lack of clear (group) patterns.
⟶ HC*t*-SNE allows user defining a hierarchical structure in the form of a tree and integrates this hierarchy directly into the visualization.

Interactive Probabilistic MDS (iPMDS)[6]



MDS, a classical and widely used DR method, has an issue: the visualization can be in any arbitrary orientation.
⟶ iPMDS integrates the *fixed-position* constraints to correct the orientation and create understandable axes for the embedding.

References

[1] Marco Cavallo et al. "Exploring Dimensionality Reductions with Forward and Backward Projections". In: *arXiv:1707.04281* (2017).

[2] Hannah Kim et al. "InterAxis: Steering Scatterplot Axes via Observation-Level Interaction". In: *IEEE TVCG* (2016).

[3] Dominik Sacha et al. "Visual Interaction with Dimensionality Reduction: A Structured Literature Analysis". In: *IEEE TVCG* (2017).

[4] Laurens Van Der Maaten et al. "Stochastic triplet embedding". In: *Machine Learning for Signal Processing (MLSP)*. 2012.

[5] Viet Minh Vu et al. "HCt-SNE: Hierarchical Constraints with t-SNE". In: *Proc. IJCNN*. 2021.

[6] Viet Minh Vu et al. "iPMDS: Interactive Probabilistic Multidimensional Scaling". In: *Proc. IJCNN*. 2021.

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