

Explorative Analysis of Dynamic Force Networks in 2D Photoelastic Disks Ensembles Supplementary Material

Farhan Rasheed¹, Abrar Naseer³, Talha Bin Masood¹, Tejas G. Murthy³, Vijay Natarajan²,
and Ingrid Hotz¹

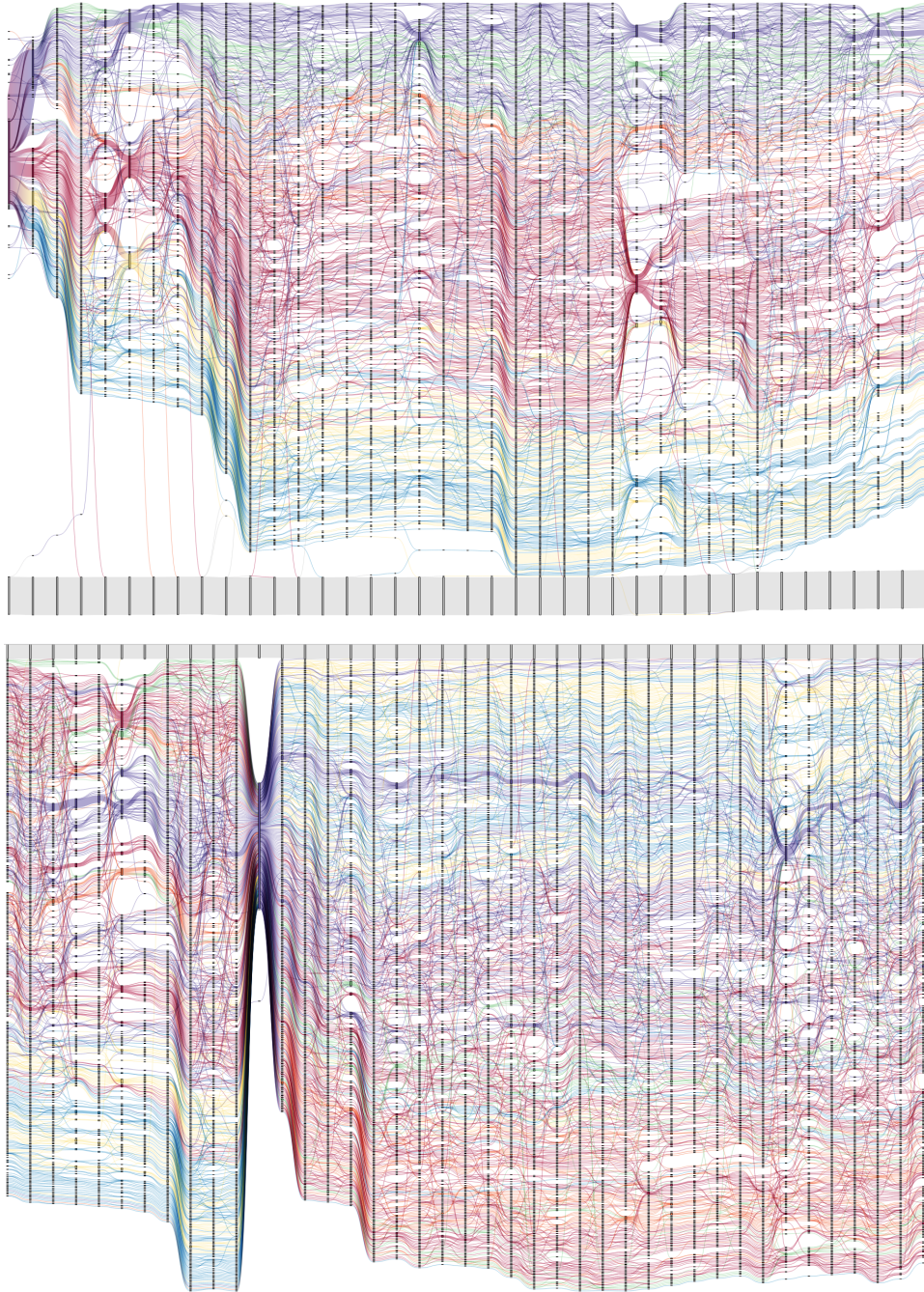
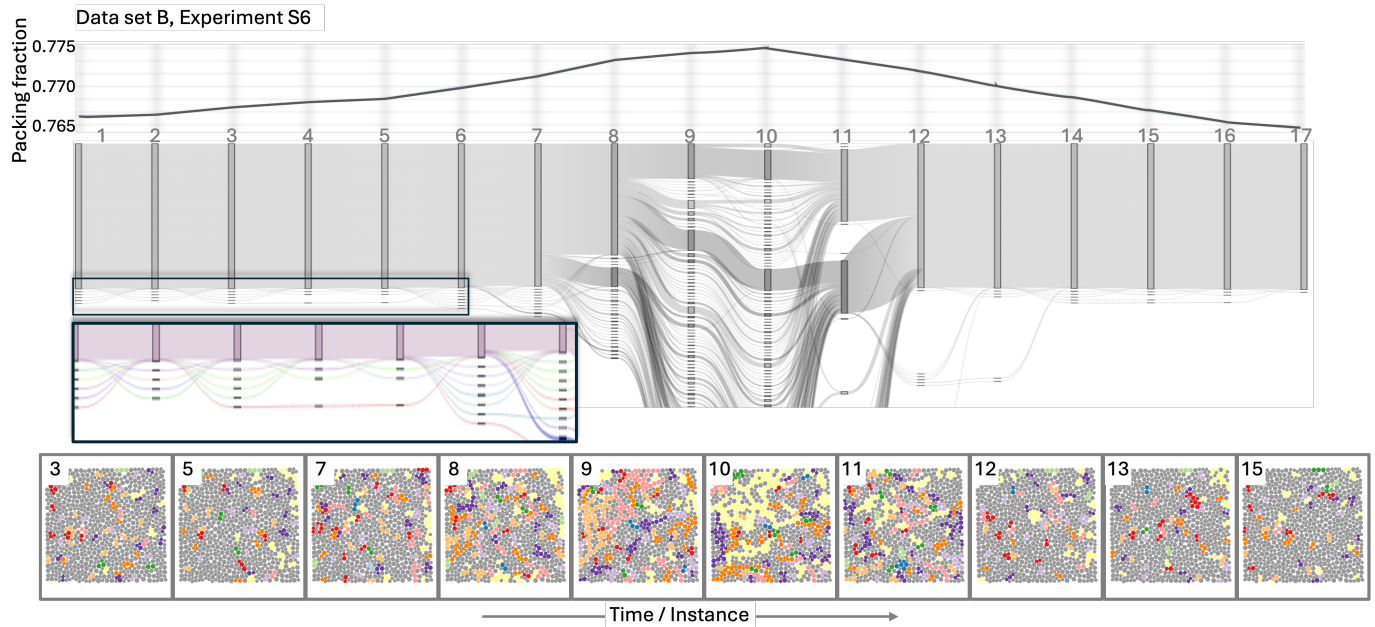
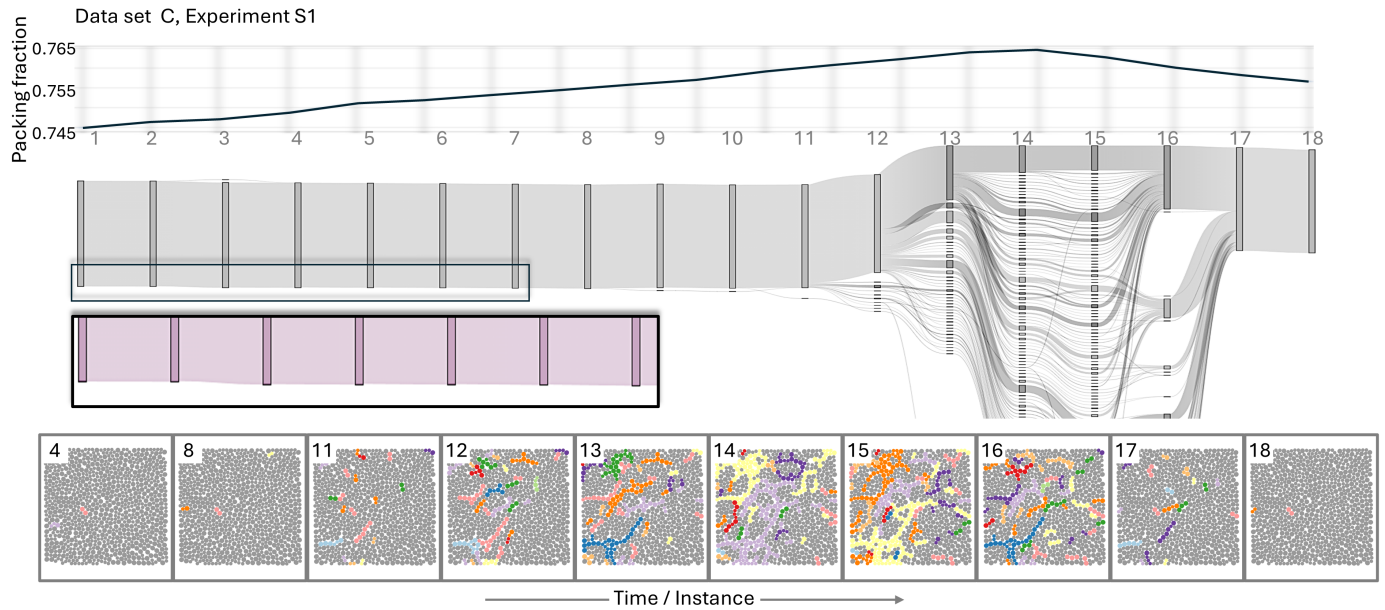


Fig. 1. Evolution diagrams for dataset A1 (bottom) and A2 (top) at zero level.



(a) Dataset B, Experiment S6



(b) Dataset C, Experiment S1

Fig. 2. Overview visualization of two selected experiments. The first row illustrates the evolution of the packing fraction over time. Below, the evolution diagram at filtration level zero is displayed. A close-up view highlights details from the initial time steps. The bottom row depicts the development of connected components at the median force as the filtration level. Each component is assigned a randomly generated color.

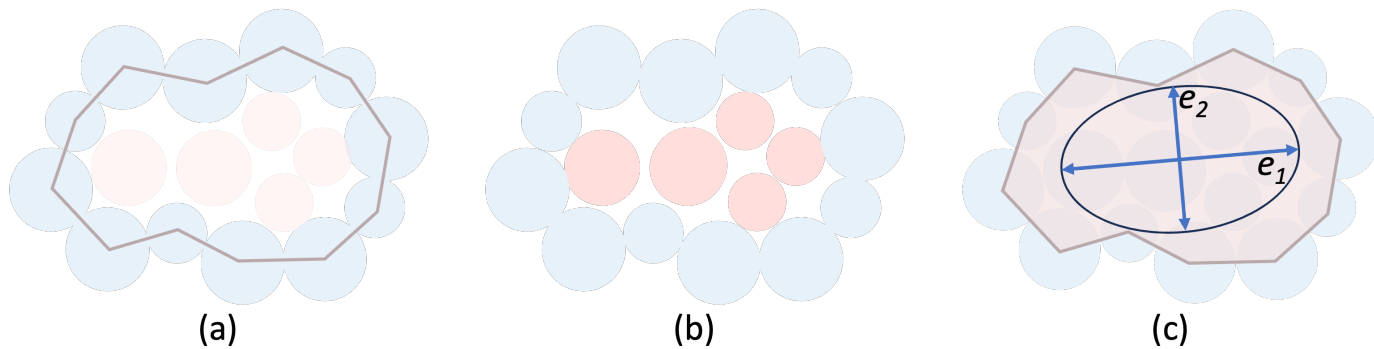


Fig. 3. Property aggregation over cycles. (a) iteration over the boundary, (b) iteration over the interior, (c) fabric tensor represented as an ellipse highlighting its eigenvectors.

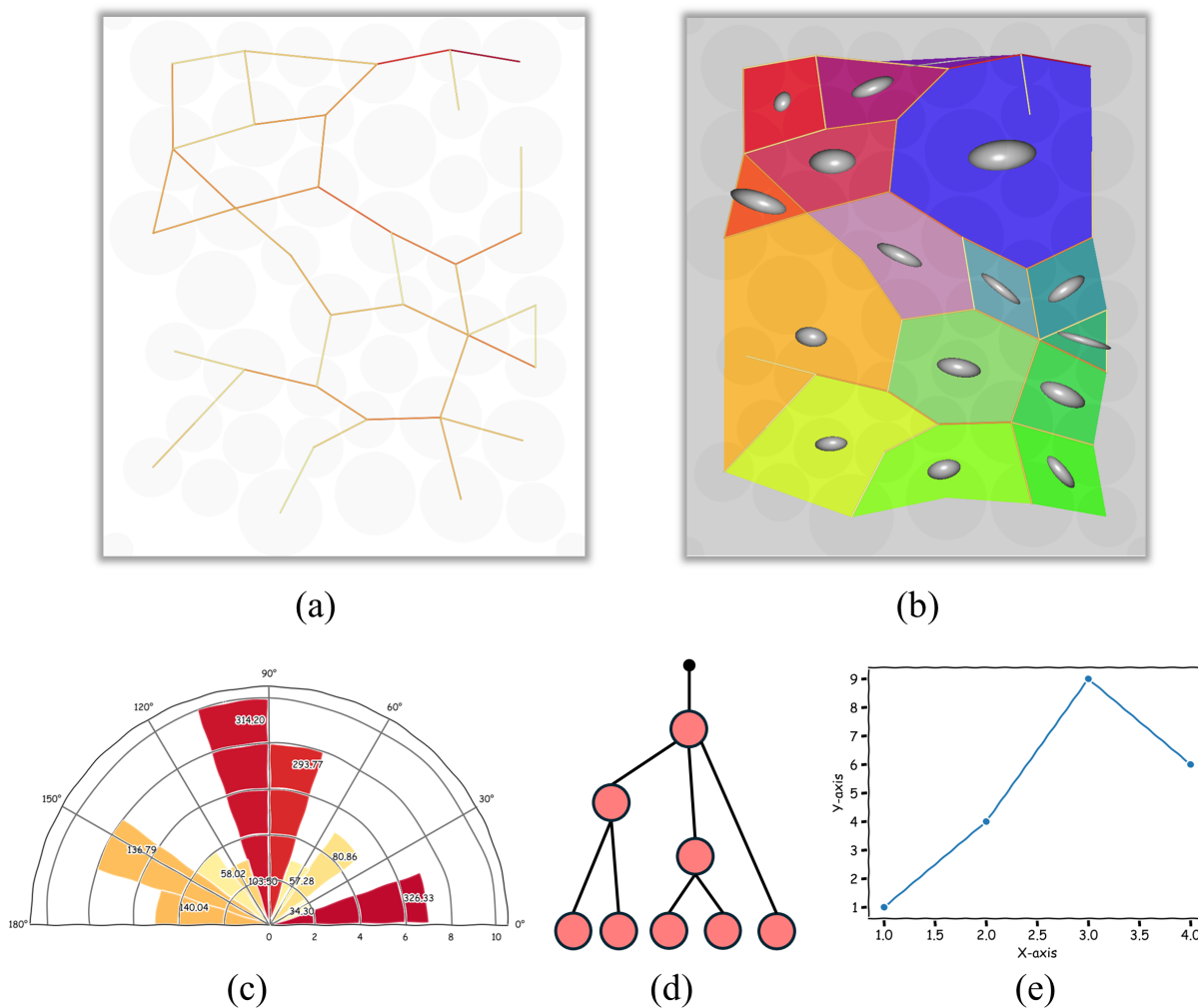


Fig. 4. VisPhoD Level 2 - Single Experiment Instance. (a) Force network visualization. (b) Partitioning of the domain, overlaid with glyphs representing fabric tensor. (c) Polar plots illustrating cycle or edge orientations, colors encode statistical properties of the cycles. (d) Hierarchical tree representation of cycles across filtration levels. (e) Line plot displaying key properties across filtration levels, including the number of cycles, number of n -cycles, average anisotropy, and other relevant metrics.

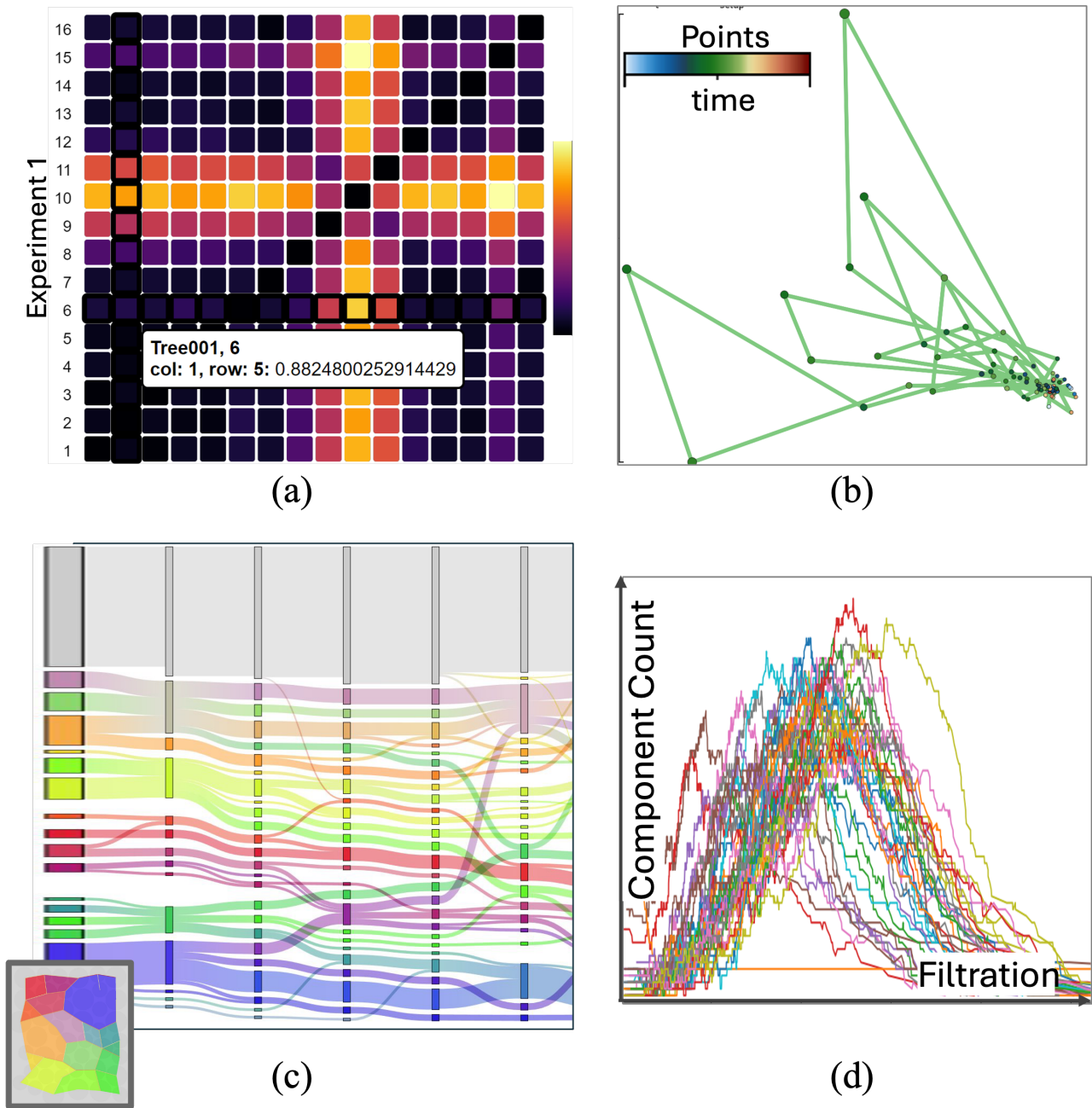


Fig. 5. VisPhoD Level 2: (a) Heatmap of the distance matrix, brighter colors indicate greater distances. (b) Multi-Dimensional Scaling (MDS) projection of the distance matrix, with lines connecting adjacent time points. (c) Evolution diagram illustrating cycle development over time. Columns represent 1d projection of the segmentations (for initial time step also showing the 2D segmentation). Links indicate spatial overlap between segments in consecutive time steps, colors encode the spatial location of each segment's center. (d) Line plot comparing aggregated parameters over time.

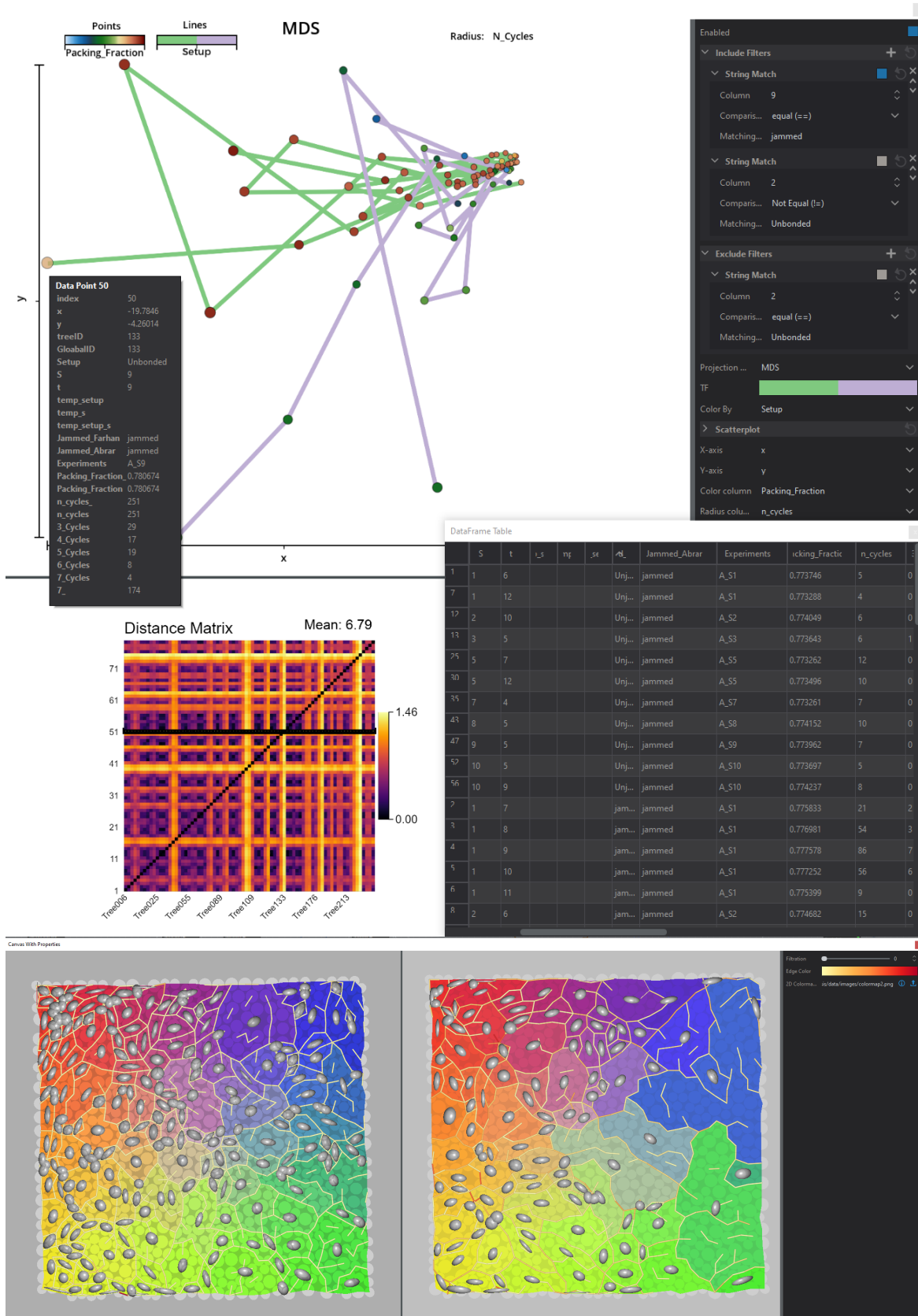


Fig. 6. VisPhoD Level 3: Top row: Joint distance matrix projection for two datasets using MDS. Lines, colored by dataset, connect adjacent time points, colored according to their packing fraction. Hovering over points reveals details of the corresponding time step. The interaction panel on the right allows for adjustments to the representation. Middle row: Joint heat map representing the distance matrix. The interaction panel supports filtering. Bottom row: Side-by-side comparison of the segmentations for two selected time points.

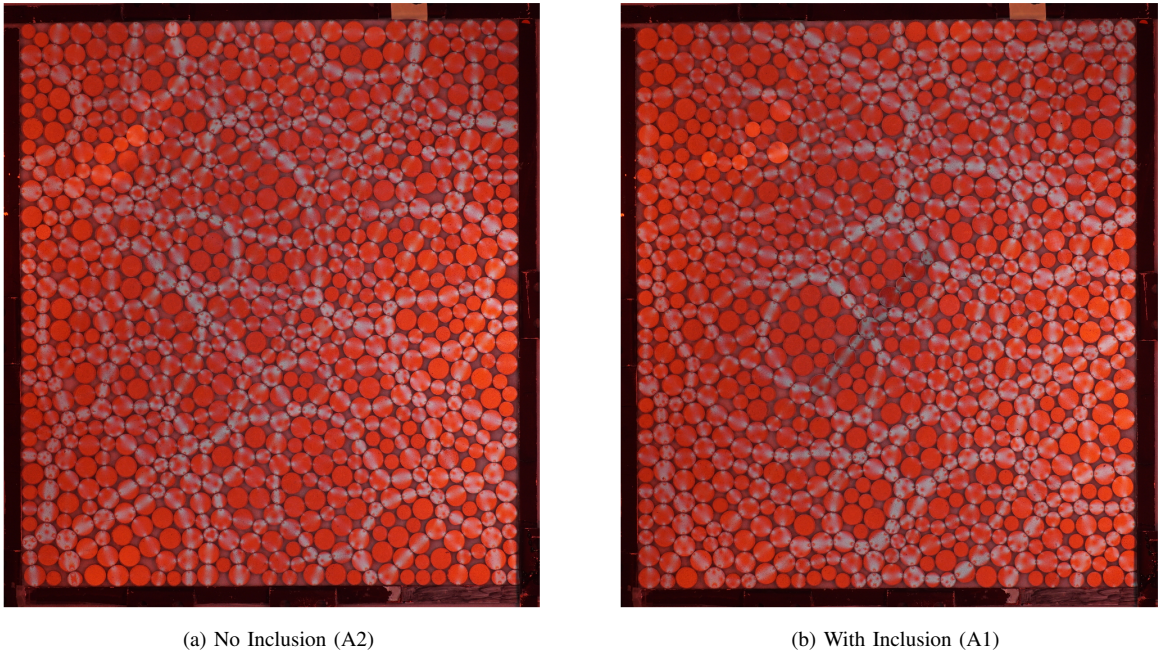


Fig. 7. Dataset A: An instance of dataset A (a) without inclusion and (b) with inclusion having disks with relatively dark color.

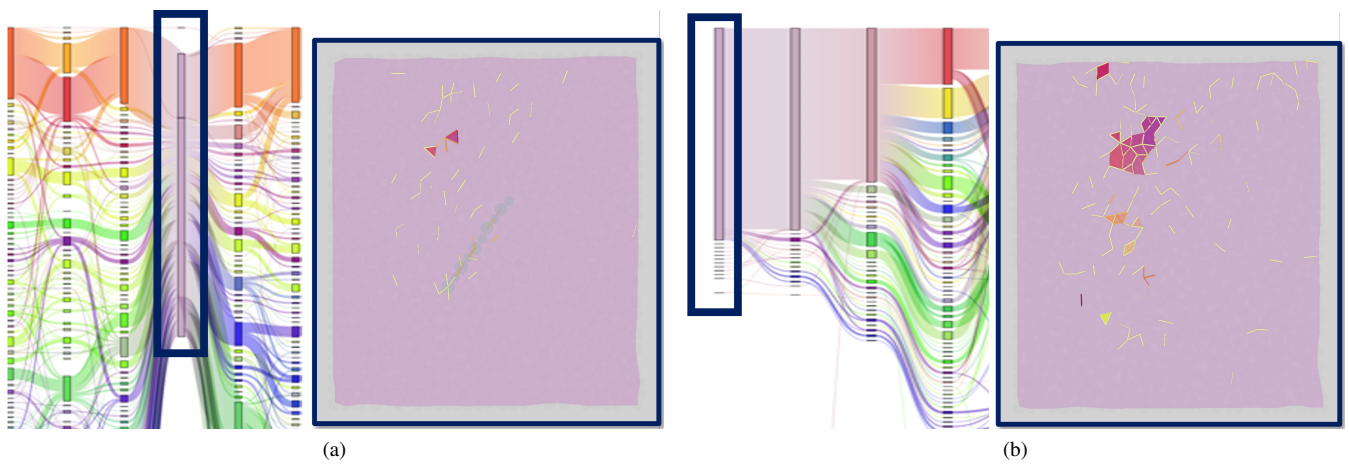


Fig. 8. A closeup of two selected time-steps from the evolution diagram and the corresponding rendering of the cycle-based segmentation view of (a) A1 at time point 12 and (b) A2 at time point 1.

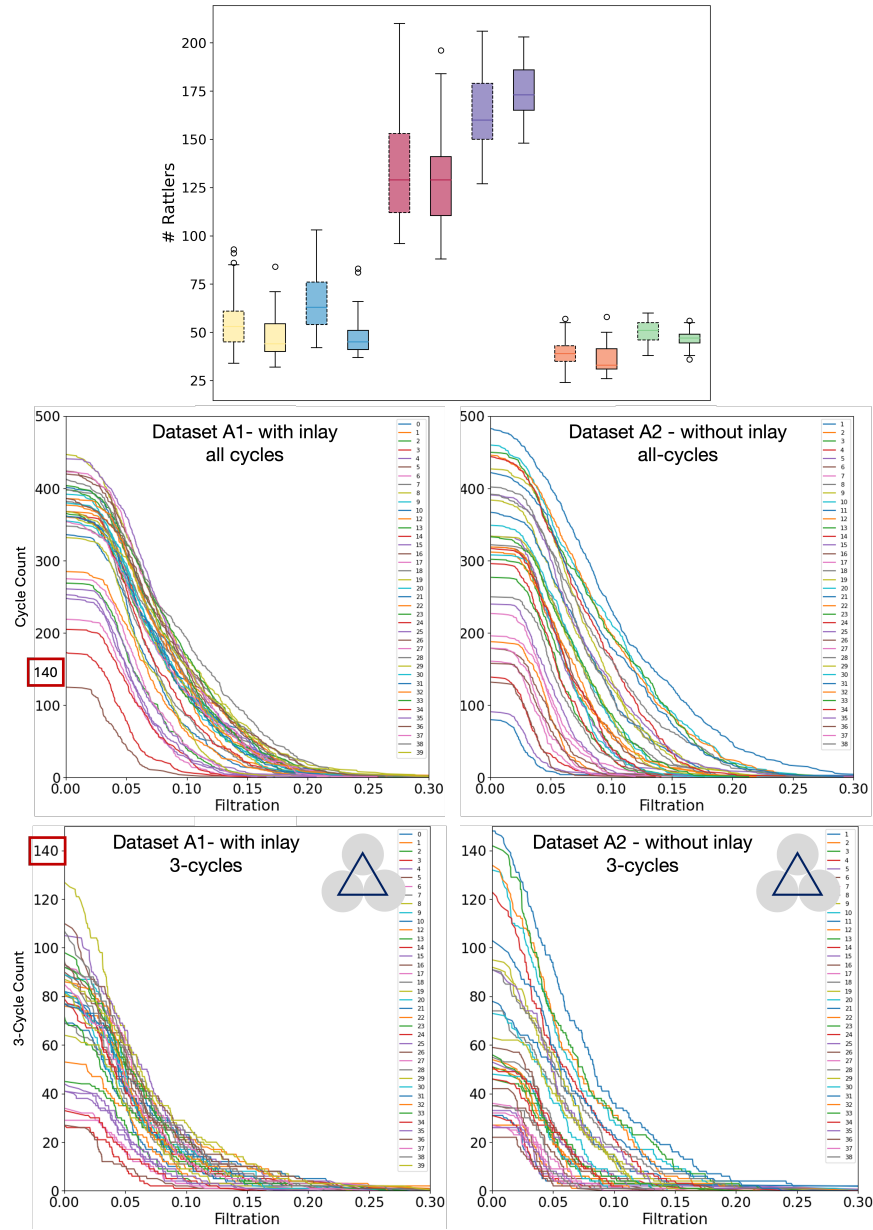


Fig. 10. Statistical plots give the quantitative view of the experiments. (a) Box plot showing the statistical summary of the rattlers at a median level over the entire experiment. The distribution of rattlers in the purple region in A2 is significantly less than the corresponding region in A1 with p-value 0.005 (they are different 0.01) by *Mann-Whitney U test*. The color corresponds to the regions in ??(b) the boxes with dashed outlines belong to experiment A2 with solid outlines to A1. The line plots show the development of the number of 3-cycles across filtration for (b) A1 and (c) A2. Each line shows a time point in the experiment.

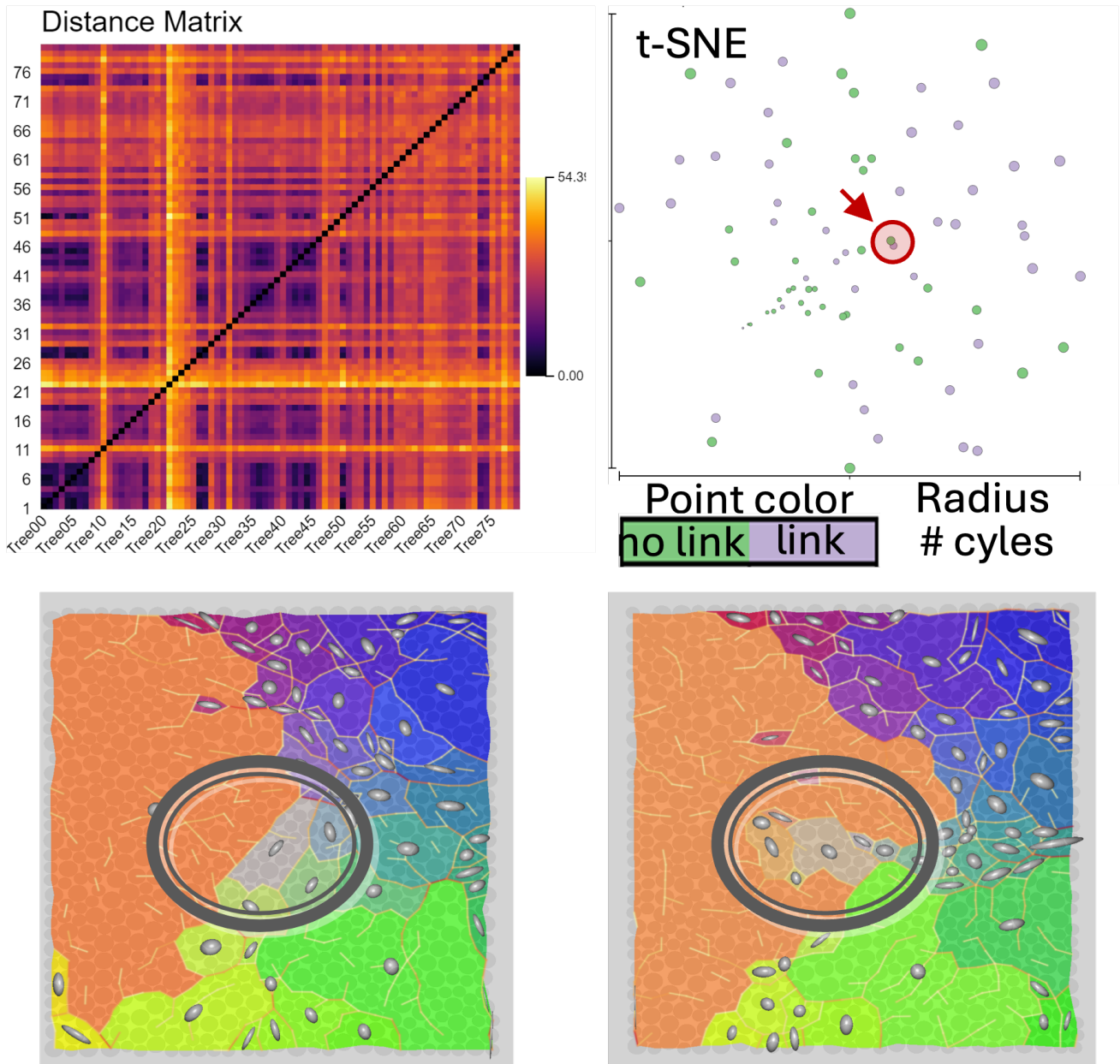


Fig. 11. Top: Distance matrix and t-SNE projection for both experiments *A1* and *A2*. Side-by-side visualization of segmentation for two instances selected in the t-SNE plot.

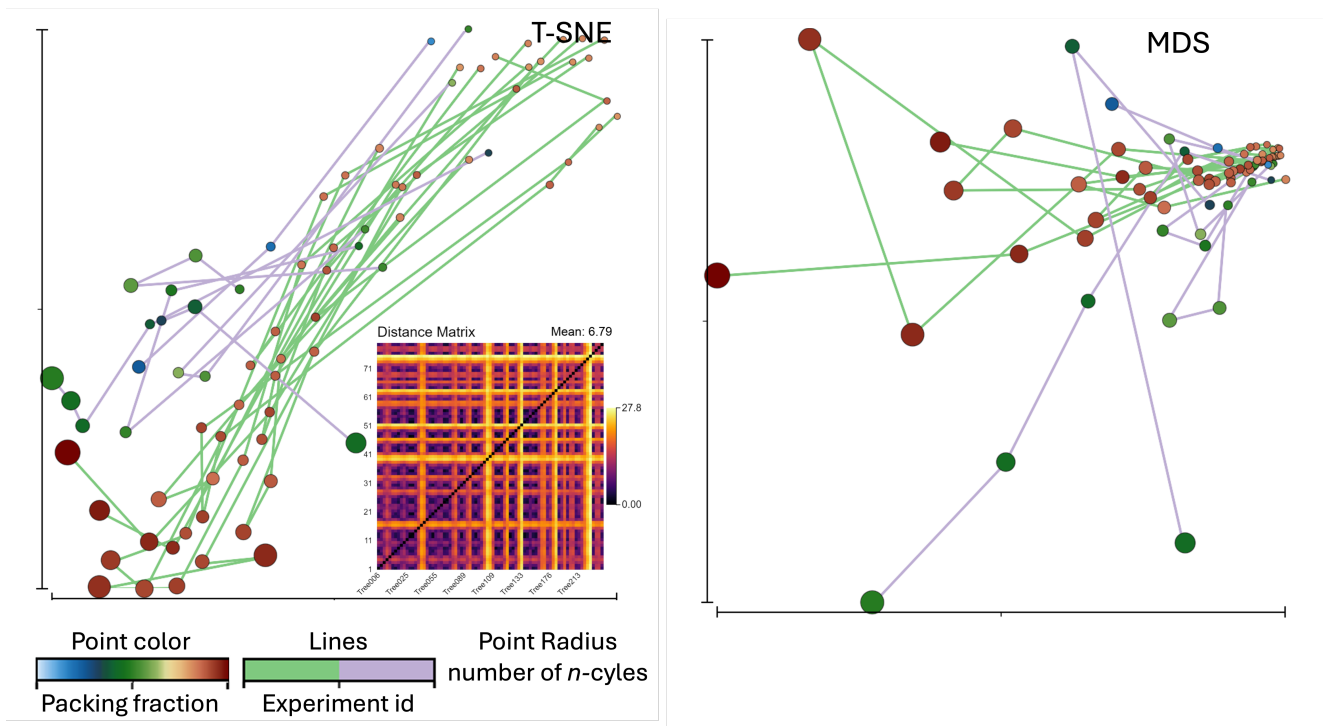
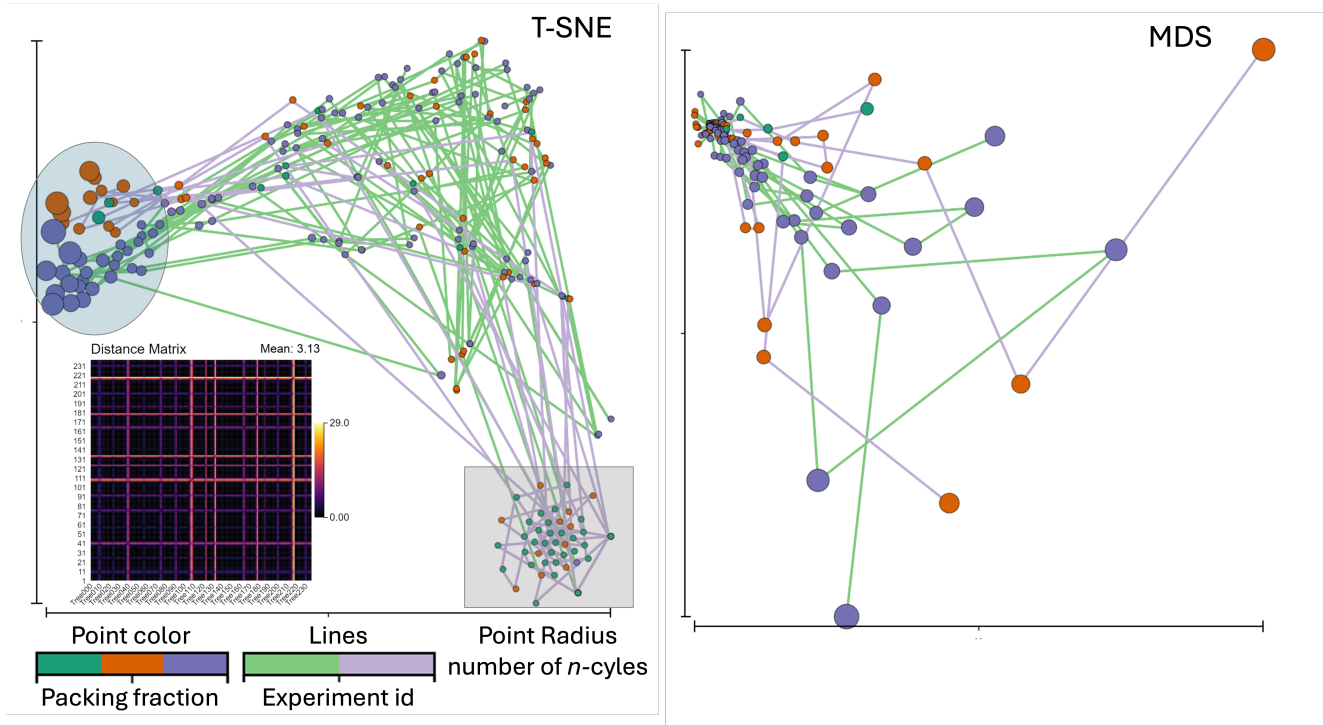


Fig. 13. Combined dimensionality reduction plots for data sets B&C. Dataset B is colored by green line while dataset C is color by purple.