DROPLETS: A Marker Design for visually enhancing Local Cluster Associations

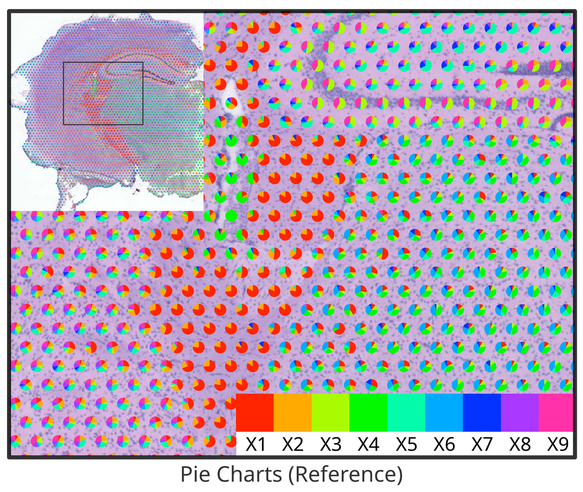
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Challenge Outline

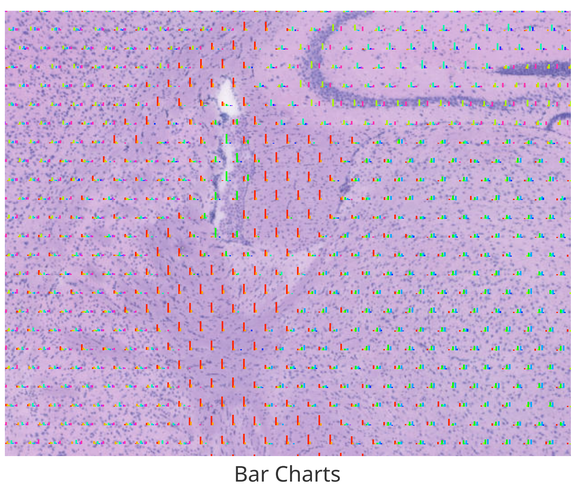
The STDeconvolve technique accurately recovers cell-type proportions in multi-cellular spatial transcriptomic tissue profiling. Visualizing this data presents challenges, as traditional methods like pie charts, bar charts, and treemaps have limitations in conveying locality and scaling with many components. These visualizations often suffer from spatial disarray, making it difficult to spot homogeneous regions. With the words of Tufte [2]: *"[...] the only worse design than a pie chart is several of them, for then the viewer is asked to compare quantities located in spatial disarray both within and between pies [...]."*

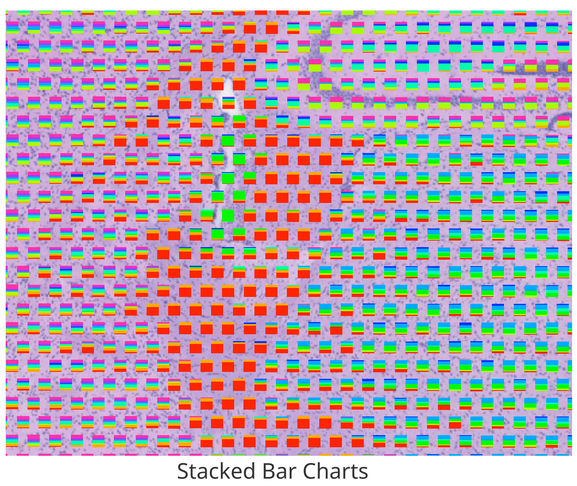
Key requirements for an improved visualization include optimal use of available space, high transparency to show underlying H&E images, and component markers reflecting association to local clusters. Current solutions fall short in addressing these needs effectively.

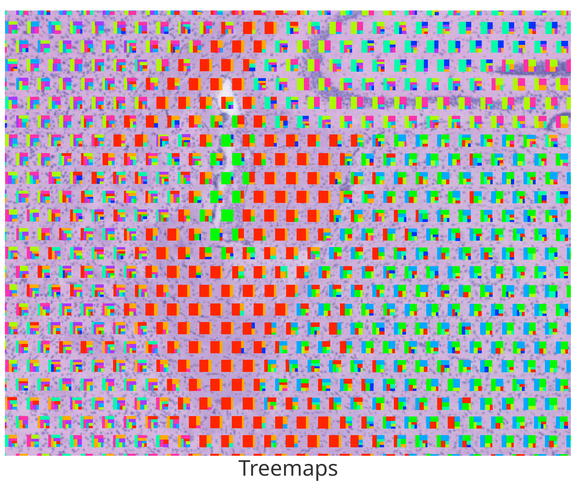
We intend a design which optimally uses the available space, being as translucent as possible (so that the underlying H&E image can be perceived), while still conveying the proportional information. Additionally the component markers should visually reflect their association to local clusters.



Pie Charts (Reference)


Bar Charts


Stacked Bar Charts

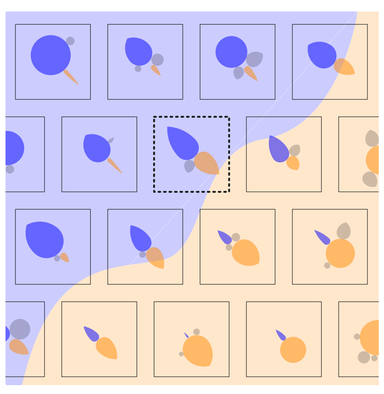

Treemaps

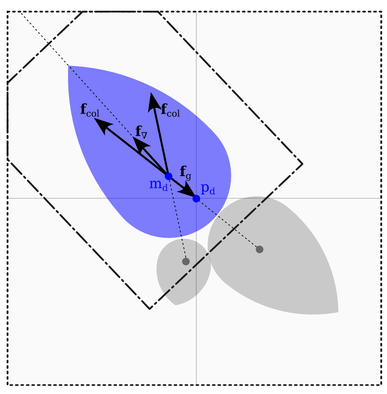
Proposed Design

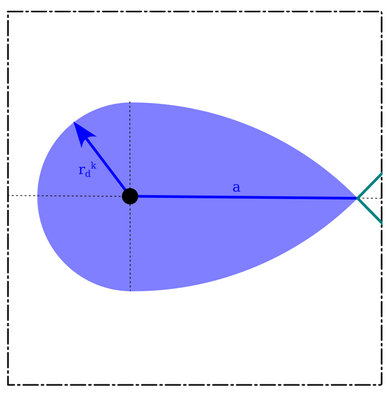
The essential idea of our proposed design is to visualize the different cell-type contributions as separated, yet tightly-packed, smooth shapes which reflect both a component's contribution and their belonging to local accumulations. To this end, a circular base shape is equipped with a protruding spike (tail) pointing towards the center of an associated local cluster, with the length of this spike reflecting the size of the respective cluster.

This is in accordance with the Gestalt principles of Continuity and Common Fate. Continuity states that viewers group elements that seem to follow a continuous path – in our case towards a local accumulation. Common Fate refers to viewers' tendency to group elements which seem to move in a common direction.

This marker design emphasizes latent borders of regions with similar cell-type contributions and facilitates the recognition of – otherwise undetectable – coherent regions. Regarding the positioning of the individual components within an ST pixel, we arrange them such that they appear to be "drawn towards" their belonging local cluster centers by employing a simple force model. This ensures both that component markers are closer to their respective clusters and that their tails are unlikely to obfuscate other markers, while still maintaining a tight packing.

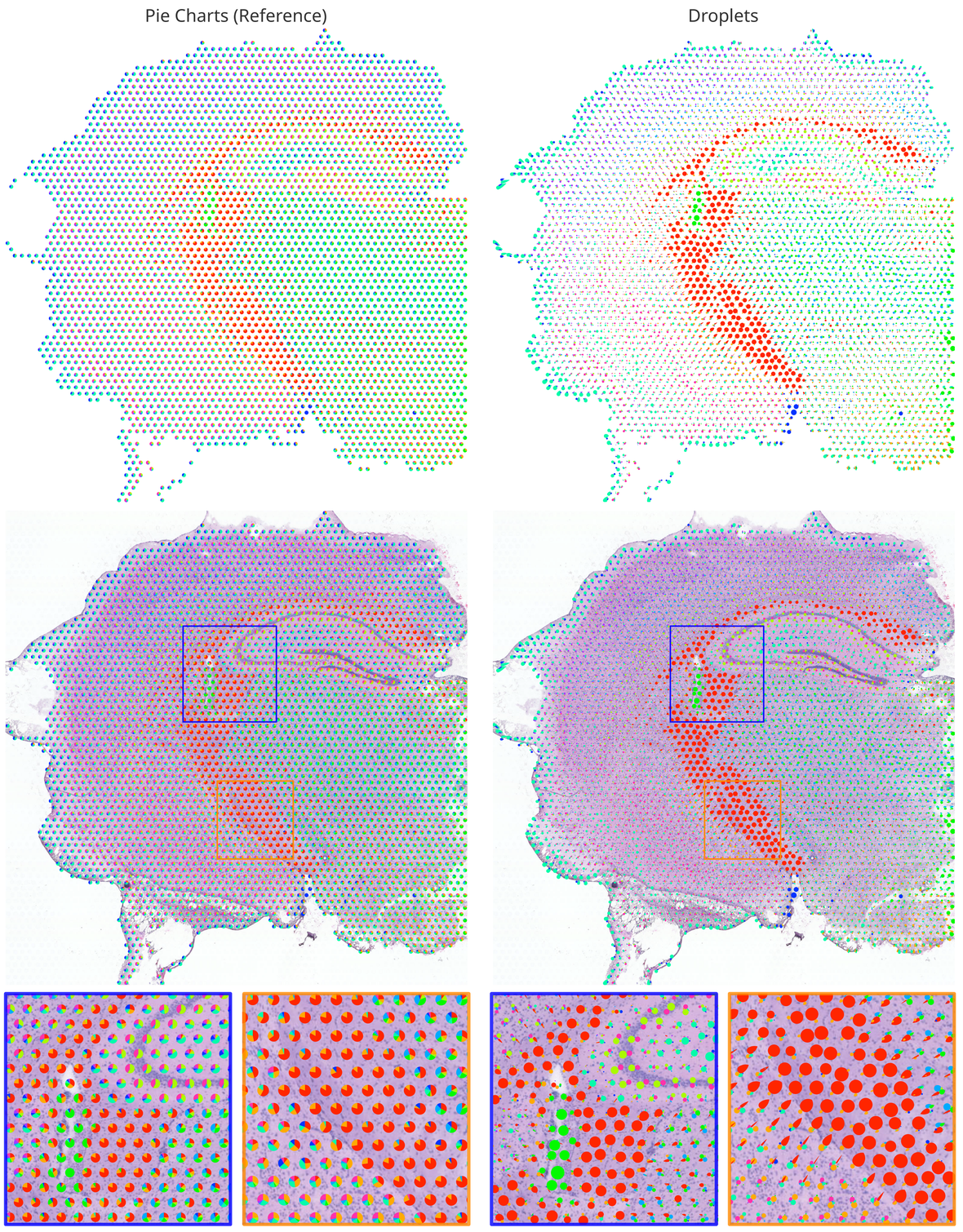






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Results and Evaluation



For evaluation we implement our proposed design in Python and apply it to the provided tissue sample. We visually compare it to the baseline design with pie charts as shown above.

From the macro perspective in the first and second row, it is already apparent that our proposed design reveals several fine-grained intensity structures which are latent in the pie charts layout, such as the turquoise X5 cell-types, present all around the border, or the violet and pink marblings of the X8/X9 cell-types to the top and left borders of the tissue sample.

A closer inspection of a region where homogenous cell-type compositions border each other (close-up with blue outline), clearly demonstrates the advantage of our design. This part of the tissue reveals a coherent region dominated by the red X1 cell type, which encases a cluster of the green X4 cell type.

To the top and right we observe an area dominated by the X5 cell type which is intersected with a streak, composed in equal parts of X3 and X9 cell type, which also correlates with darker marbling in the H&E image. Even though this can also be derived from the pie chart visualization, our proposed design conveys this information more efficiently with less visual disturbance.

Since the ST pixels in this closeup are mostly characterised by secluded regions of a dominant cell-type, the markers in this area exhibit very short tails or none at all. In other cases, where a dominant cluster has offshoots into neighboring regions – such as the X1 cell type cluster in the orange close-up – the droplets' shape leads to more pronounced cluster outline, in accordance with the Common Faith Gestalt principle.

References

[1] B. F. Miller, F. Huang, L. Atta, A. Sahoo, and J. Fan. Reference-free cell type deconvolution of multi-cellular pixel-resolution spatially resolved transcriptomics data. *Nature communications*, 13(1):2339, 2022.

[2] E. R. Tufte and P. R. Graves-Morris. *The visual display of quantitative information*, vol. 2. Graphics press Cheshire, CT, 1983.