# t-SNE based Transfer Functions for Multi-attribute Volume Rendering

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## INTRODUCTION

- Current transfer functions **struggle to remain user-friendly as the dimensionality of the dataset surpasses 10 - 20 dimensions.**
- New techniques are required for **identifying, visualizing, and analyzing interesting interactions between voxels**

## PROPOSAL

- Make use of **neighbourhood-preserving (non-linear) dimensionality reduction in the transfer function**
- **Scales easily with any number of dimensions and is simple to work with (see Figure 1)**
- Selecting **clusters will visualize the spatial structures of similar points** in the volume

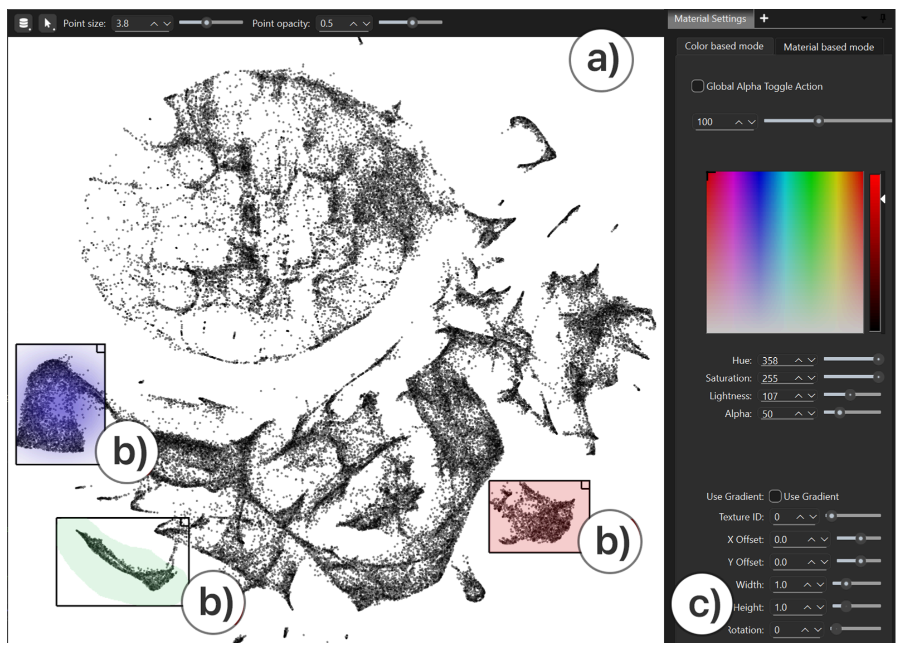
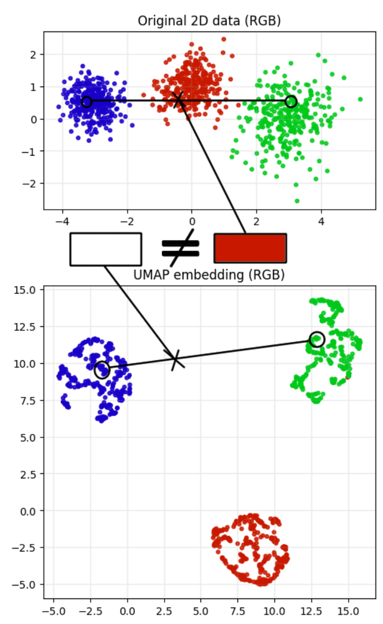
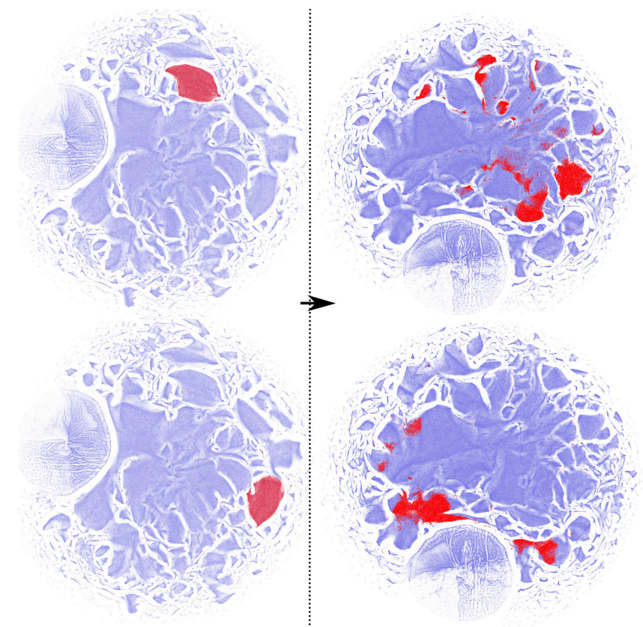



**Figure 1:** The transfer function widget interface. a) t-SNE embedding, b) TF widgets and c) various widget settings

## PROPOSAL PROBLEMS

1. The use of **linear interpolation will result in incorrect results** in the transfer function space (see Figure 2).
2. The size of the visualized **dataset is now limited by what the used dimensionality reduction algorithm** is able to handle.
3. The **larger the used dataset, the worse the results are in the embedded space**, as neighbourhood-preserving dimensionality reduction algorithms struggle on larger datasets (see Figure 3).
4. The user is **unable to directly see the underlying values** of the points in the transfer function



**<- Figure 2:** Displacement in the embedding will result in incorrect colors

**-> Figure 3:** Shows how a cluster is distributed in different instances of the same dataset

## VISUALIZATION

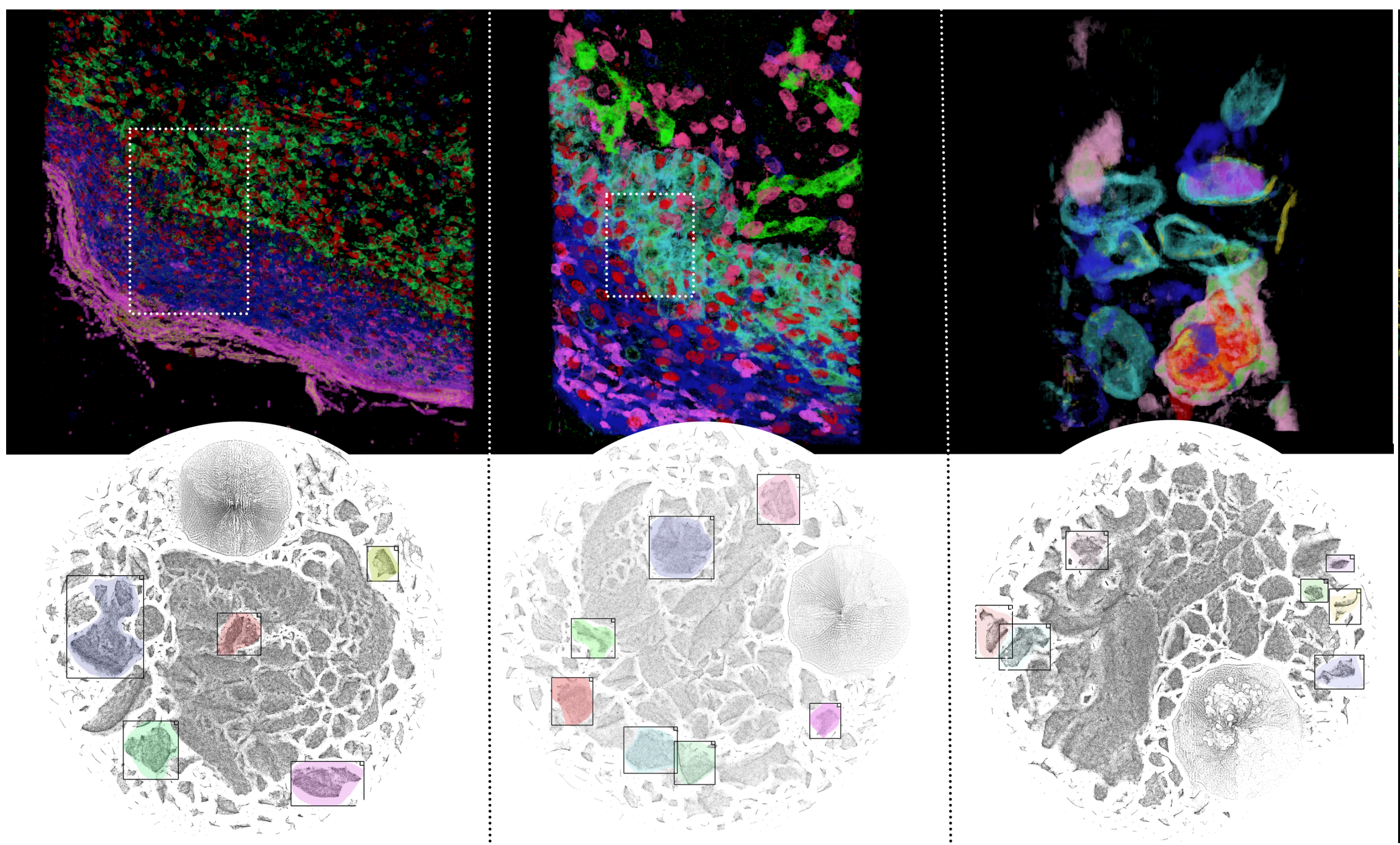


**Figure 4:** Volume renderings of various challenge dataset ROIs at different levels of detail using t-SNE based transfer functions.

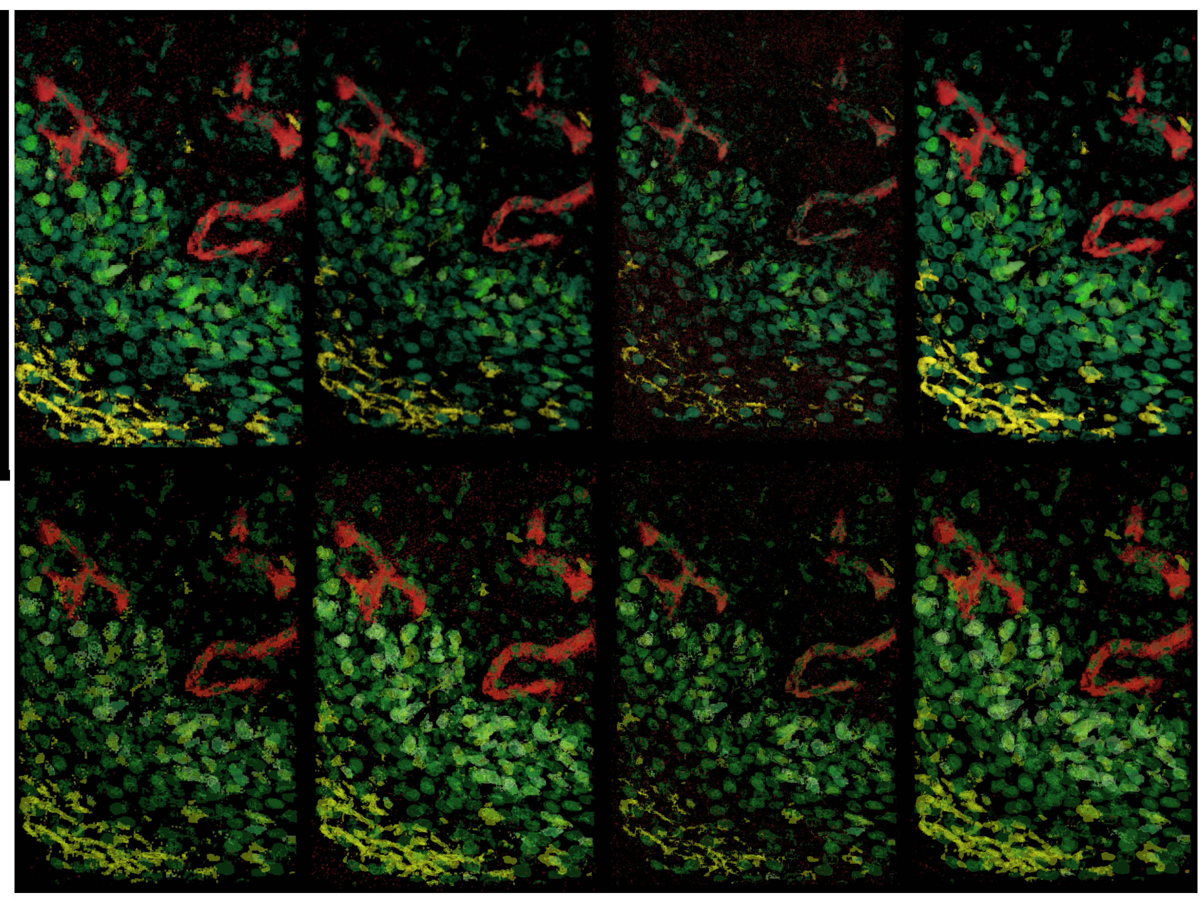


**Figure 5:** Comparison of all proposed render modes

- We have proposed **an interpolation pipeline that fixes the first problem of our proposal (see Figure 4)**
- That interpolation pipeline **takes dozens of seconds to minutes the render a single frame**
- **We only render the final image with the slow interpolation pipeline** and swap it out with one of the other real-time methods (see Figure 5)

- Further **analysis of the underlying data (issue 4) of the user's selection can be done using other existing tools, such as a heatmap.** Since our application is implemented as a plugin in the existing ManiVault Studio framework [1]

## CONCLUSION

- Developed a **volume rendering pipeline for multi-attribute data using 2D transfer functions derived from t-SNE** that scales well with high-dimensional data.
- Our **interpolation approximation pipeline improves accuracy**
- Proposed a **hybrid strategy: fast rendering during interaction, refined by the NN-based pipeline once computation completes**.

## FUTURE WORK

- **Explore hierarchical dimensionality reduction** to address the challenges of extremely large datasets.
- **Re-enable features depending on sample output, like early ray termination,** that are currently not possible due to it being a CPU-GPU pipeline.

ManiVault Studio [1]

CONTANCT INFORMATION
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