



The Rest of the Fish: Light-Sheet Microscopy Imputation with Transformers

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Whole-brain light-sheet microscopy in larval zebrafish enables volumetric imaging of neural activity across the entire brain at relatively low frame rates, or of partial brain regions at higher temporal resolutions. However, the fast dynamics of modern calcium indicators, which operate on millisecond timescales, are often undersampled—leading to significant loss of temporal detail. Slower indicators, meanwhile, obscure brief but important neural events.

To address this challenge, we propose a transformer-based model that leverages the intrinsic correlations in neural activity to impute missing data—both temporally and spatially.

Our model interpolates missing timepoints between sparsely acquired full-brain volumes and in-paints omitted planes in high-speed partial volumes, effectively reconstructing a high-resolution recording across space and time.

We employ a BERT-style masked-token transformer, trained to recover masked frames and planes. This architecture offers several key advantages:

- Temporal flexibility via learned positional encodings, enabling irregular sampling and the omission of nuisance frames (e.g., flyback planes);
- Insights can be derived through attention maps, which highlight influential regions in the imputation process;
- Bidirectional inference, allowing both forward and backward context;
- Scalable inference, as the model accommodates variable token lengths to adapt to hardware constraints.

The imputed data can then be used to recover, for example, fluorescence of identified ROIs.

We hope to extend the model to include a deep Gaussian process layer, allowing the user to have full posterior estimates of activity alongside the ability to regularise the smoothness of the fit [2].

Ultimately, this framework could enable experimenters to achieve high-framerate, whole-brain imaging with only modest adjustments to current sampling protocols.

zebrafish, light-sheet microscopy, imputation, transformer

