

## 1. Introduction

“EEG is a non-invasive neuroimaging technique used to record the electrical activity of the brain via electrodes placed on the scalp” [1] Modern analysis techniques such as **Neurophysiological Biomarker Toolbox (NBT)** compute **biomarkers** per subject. These biomarkers are displayed using **topomaps** that interpolate per-electrode values on a 2D head. The current pipeline **rasterises** the image (Matplotlib + MNE-Python), which causes latency with larger batches, and artefacts on different resolutions.

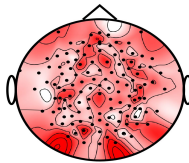


Figure 1: Topomap rendered via rasterization

**Knowledge gap:** the raster pipeline is unprofiled, and a direct vector (SVG) pipeline is uncharacterised in NBT.

## 2. Research Question

**RQ3:** How do raster-based and direct vector/SVG topomap pipelines compare in computational complexity, latency scaling, and visual/numerical fidelity across montage sizes and frequency-band grids?

**SQ3.1** — What is the performance profile of the Raster pipeline

**SQ3.2** — What is the performance profile of the Vector pipeline

**SQ3.3** — What is the server-side performance comparison

**SQ3.4** — What is the client-side performance comparison

## 3. Results

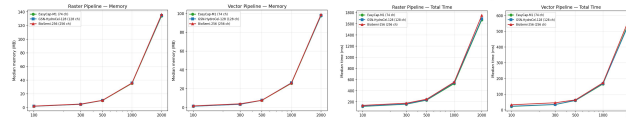


Figure 2: Vector and raster Pipelines memory impact per resolution across montage sizes

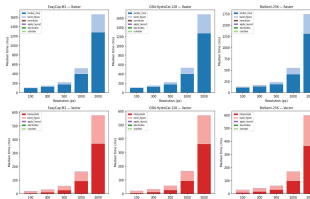


Figure 4: vector and raster Pipelines per stage latency per resolution across montage sizes

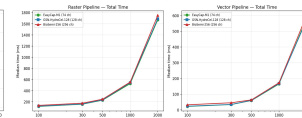


Figure 3: Raster and Vector pipelines, Latency per resolution across montage sizes

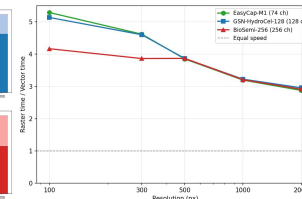


Figure 5: Vector latency speedup per resolution across montage sizes

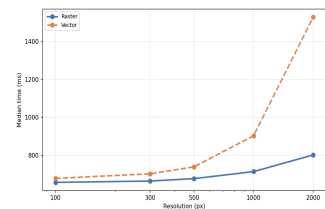


Figure 6: Client-side Latency per resolution for Raster and Vector

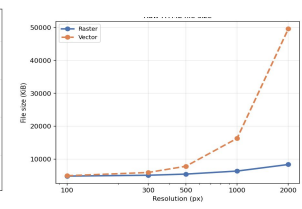


Figure 7: memory of the html output for raster and vector

## 5. Conclusion

- Removing rasterization from the pipeline yields 2.88 ×–5.29× speedup decreasing with resolution.
- Memory improvement is a constant ~1.36× ratio since both pipelines allocate  $O(R^2)$  grids while raster adds a pixel buffer.
- Vector rendering offloads work to the browser, having a client side latency ratio of 1.03× and 0.50× and a memory ratio of 0.96× and 0.14× with increasing costs at higher resolutions.
- Montage size has negligible impact at high resolutions.
- Promising alternative to the Raster pipeline with server benefits but client drawbacks.
- A hybrid approach recommendation — vector by default, raster fallback for weak clients.
- Testing with real life, and more varied data, and different implementations for raster and vector pipelines are recommended for expanding this research in the future.

## 5. References

[1] Mushtaq et al. “One hundred years of EEG for brain and behaviour research”. In: *Nature Human Behaviour* 8.8 (2024), pp. 1437–1443. doi: 10.1038/s41562-024-01941-5.