

Fully automated artifact reduction method for time-resolved cone-beam CT angiography

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Acknowledgement

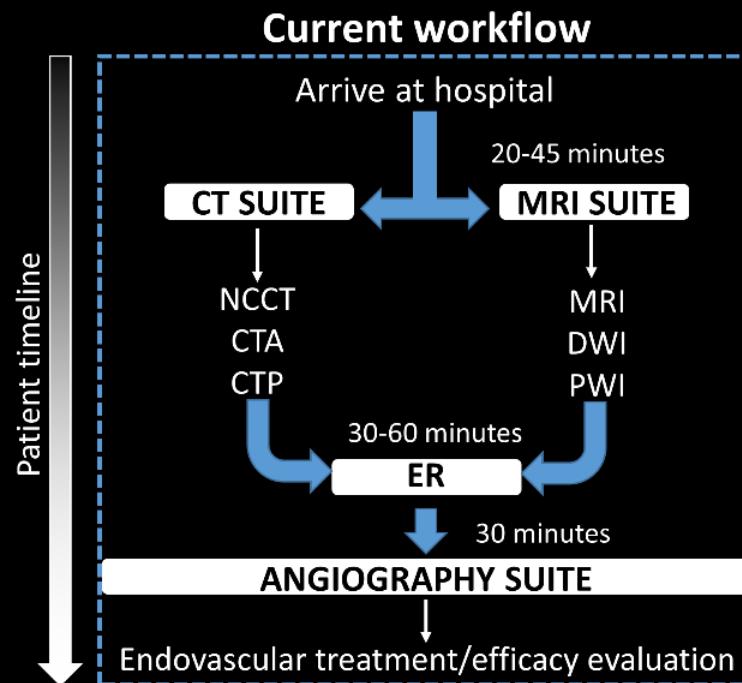
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Motivation: one-stop-shop (OSS) protocol

- Large Vessel Occlusion (LVO) stroke patients benefit from multi-modal imaging.
- Despite the benefits of performing this multi-modal imaging, the time needed to perform this imaging process results in significant delays to patient treatment¹.

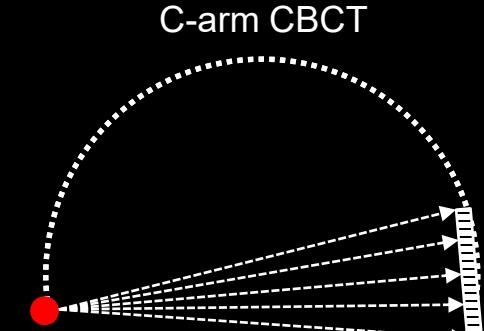
- The desire to save time has motivated the one-stop-shop imaging paradigm for acute stroke imaging².



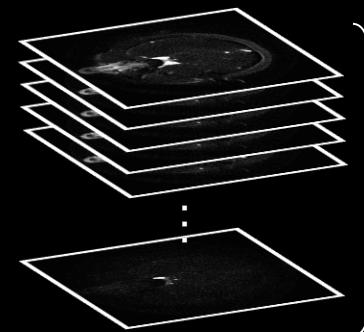
potentially save at least
one hour per patient!



Introduction: one-stop-shop (OSS) protocol



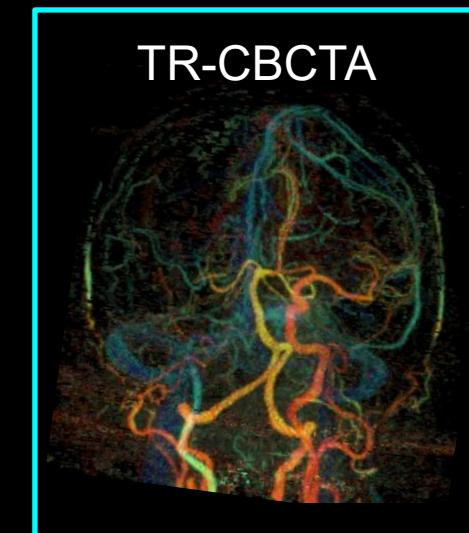
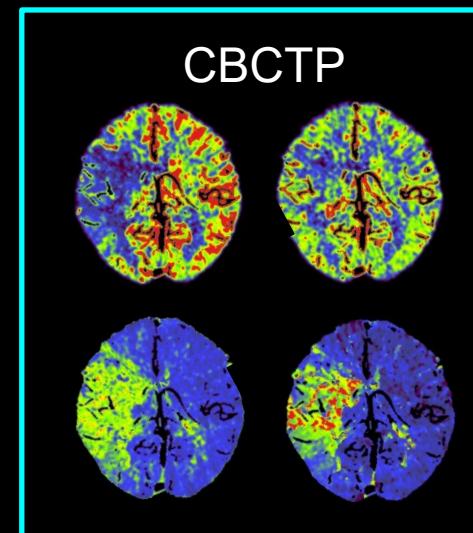
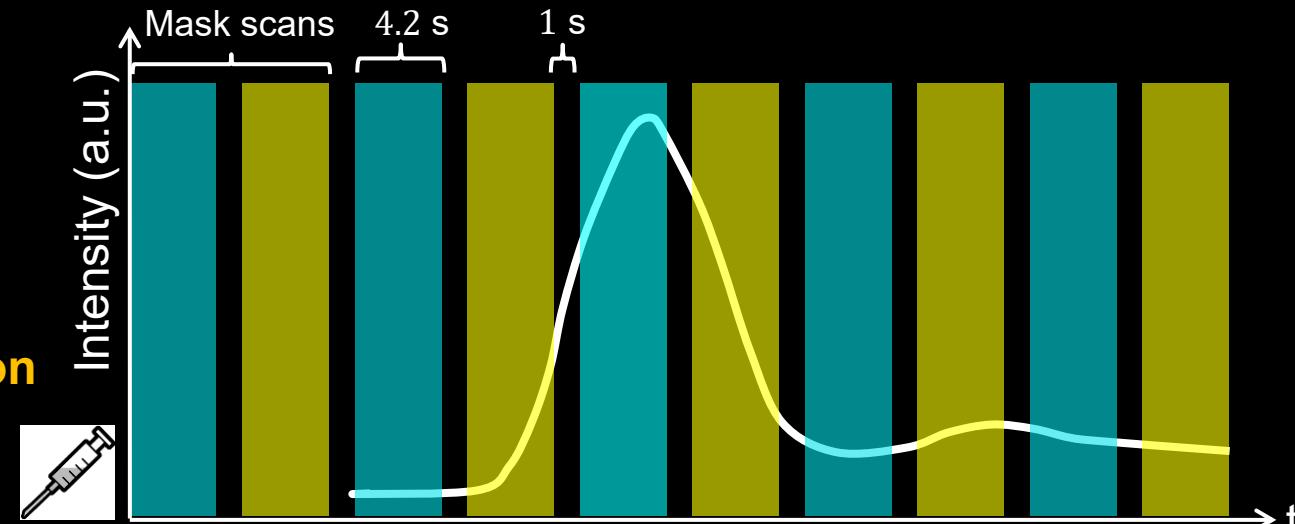
eSMART-
RECON¹



1. Li et al, IEEE TMI (2019)

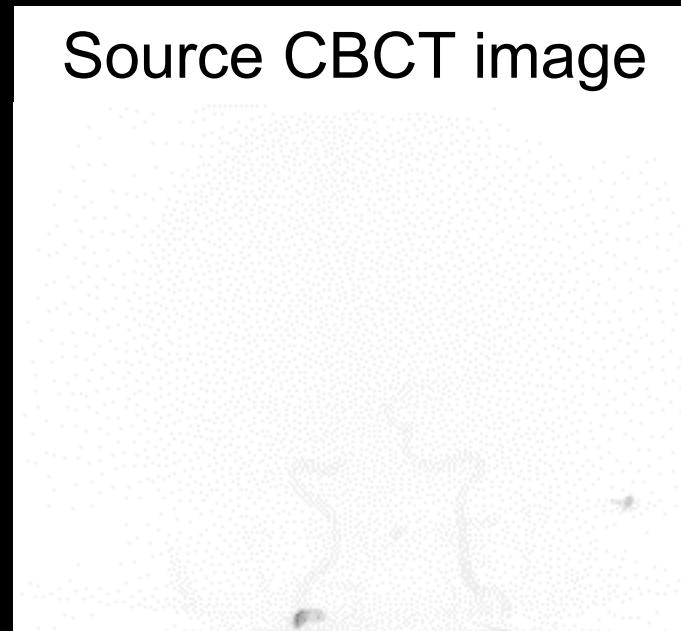
256x256x200
x 40 frames

IV
Injection



Introduction: the benefit of TR-CBCTA

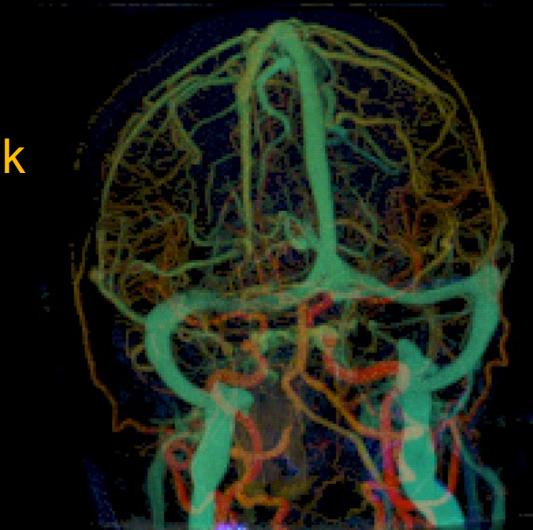
- Besides collateral analysis, color-coded time-of-arrival maps¹ can be derived from TR-CBCTA and provide complementary information of various vasculature phases.



Time @ intensity reaches 30% peak



Time-of-arrival map



Early arrival

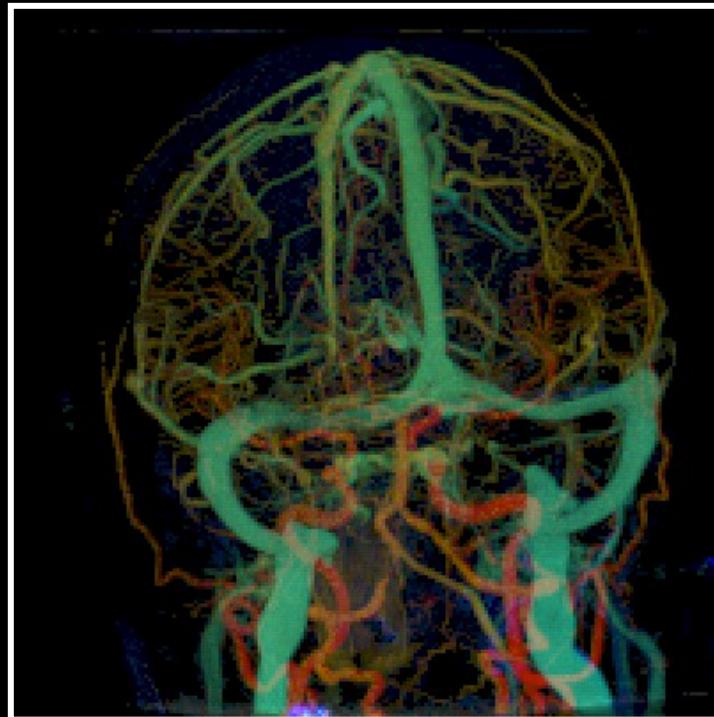


Late arrival

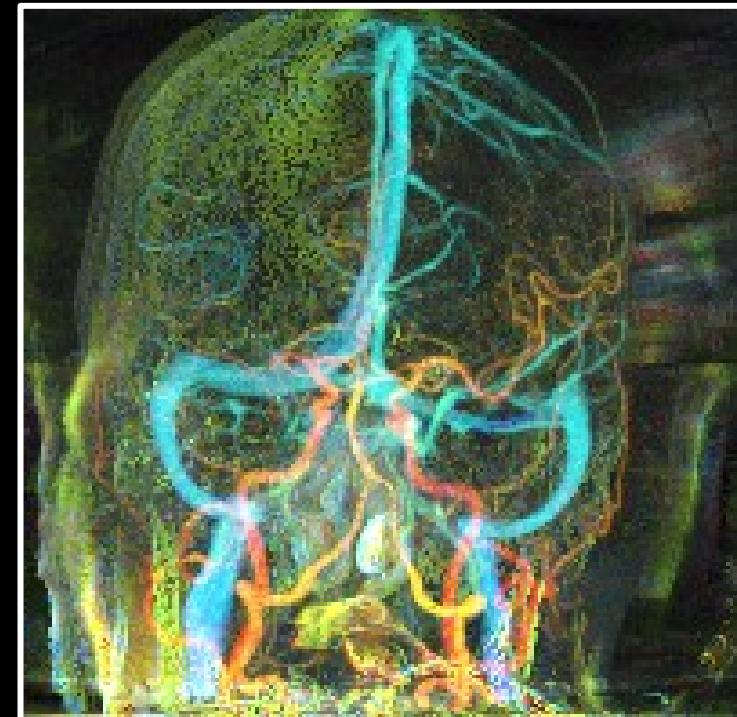


The technical limitation

- Time-resolved cone-beam CT angiography (TR-CBCTA) acquired in the angiography suite often presents **mis-registration** and **residual bone artifacts** due to patient motion and gantry instability.



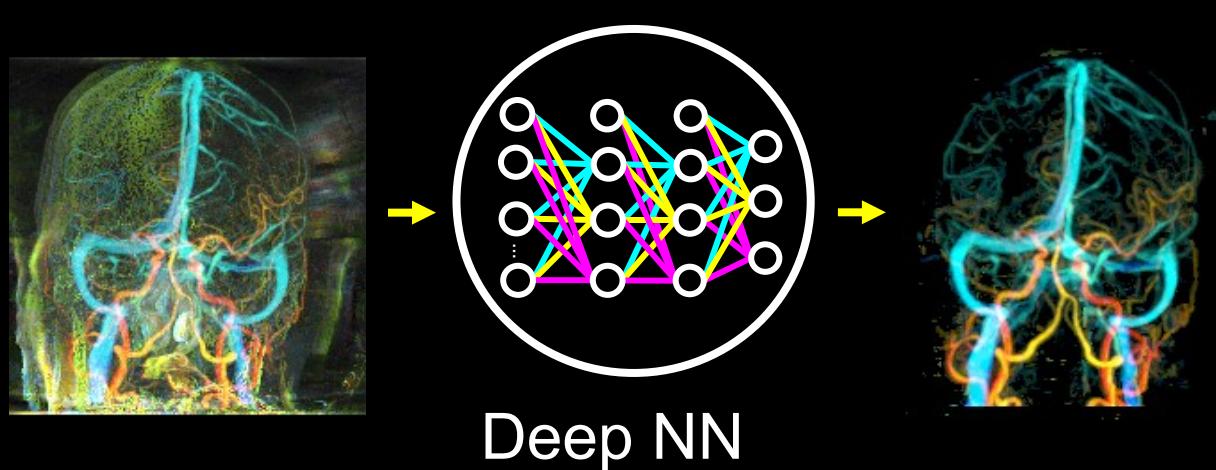
Ideally (very few)



In reality (majority)



Conventional supervised deep learning method



- Implementation details¹
 - Network architecture: U-Net
 - Input: 256 x 256 (axial image)
x 40 frames, TR-CBCTA
via eSMART-RECON²
 - Training target: 256x256 hand-labeled vasculature map
 - Output: 256x256 Probability map
 - Training data: 50 patient cases,
5-fold cross-validation

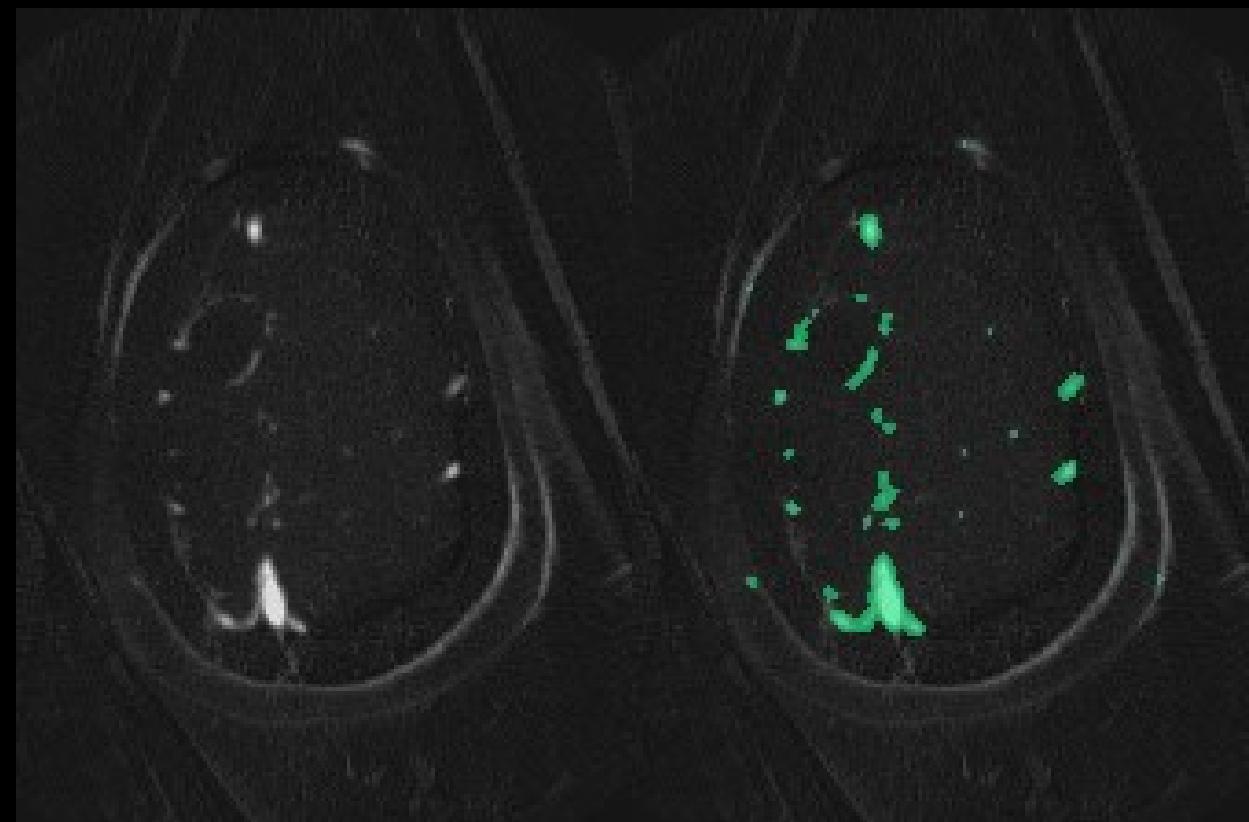


Laborious hand annotation process

- Vasculature is hand-labeled in Temporal-MIP images for each patient.
 - >200k labeled voxels/patient
- Need special medical domain knowledge.

Temporal-MIP CTA

Labels

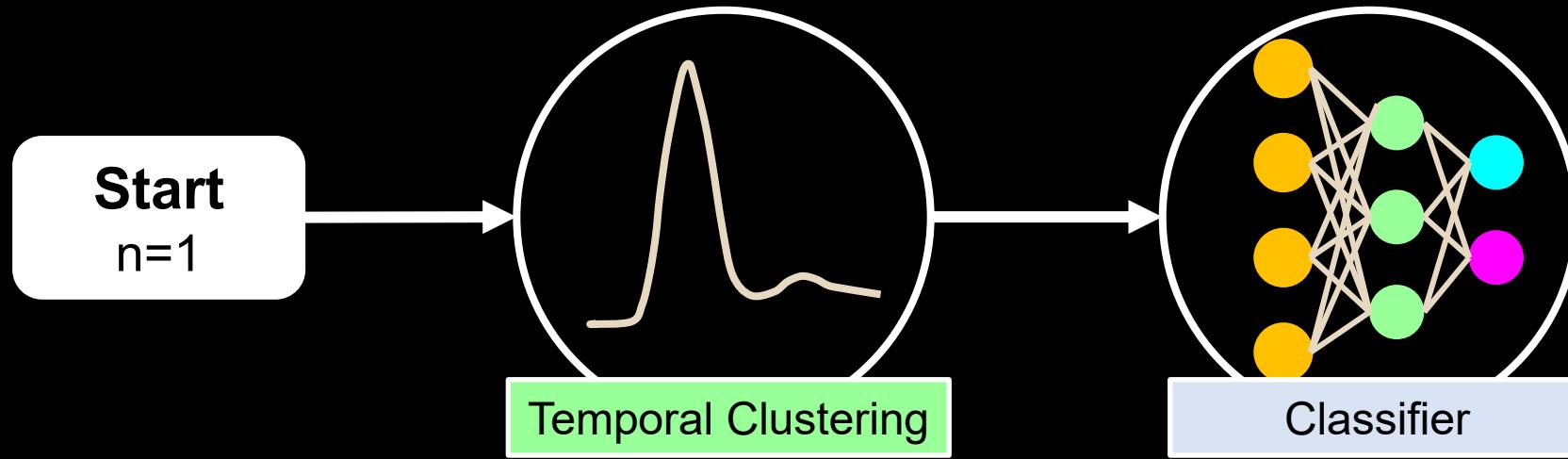




Objective

- To develop a **fully-automated** machine learning method to effectively reduce artifacts in TR-CBCTA in angiography suites.

Method: hybrid artifact reduction framework



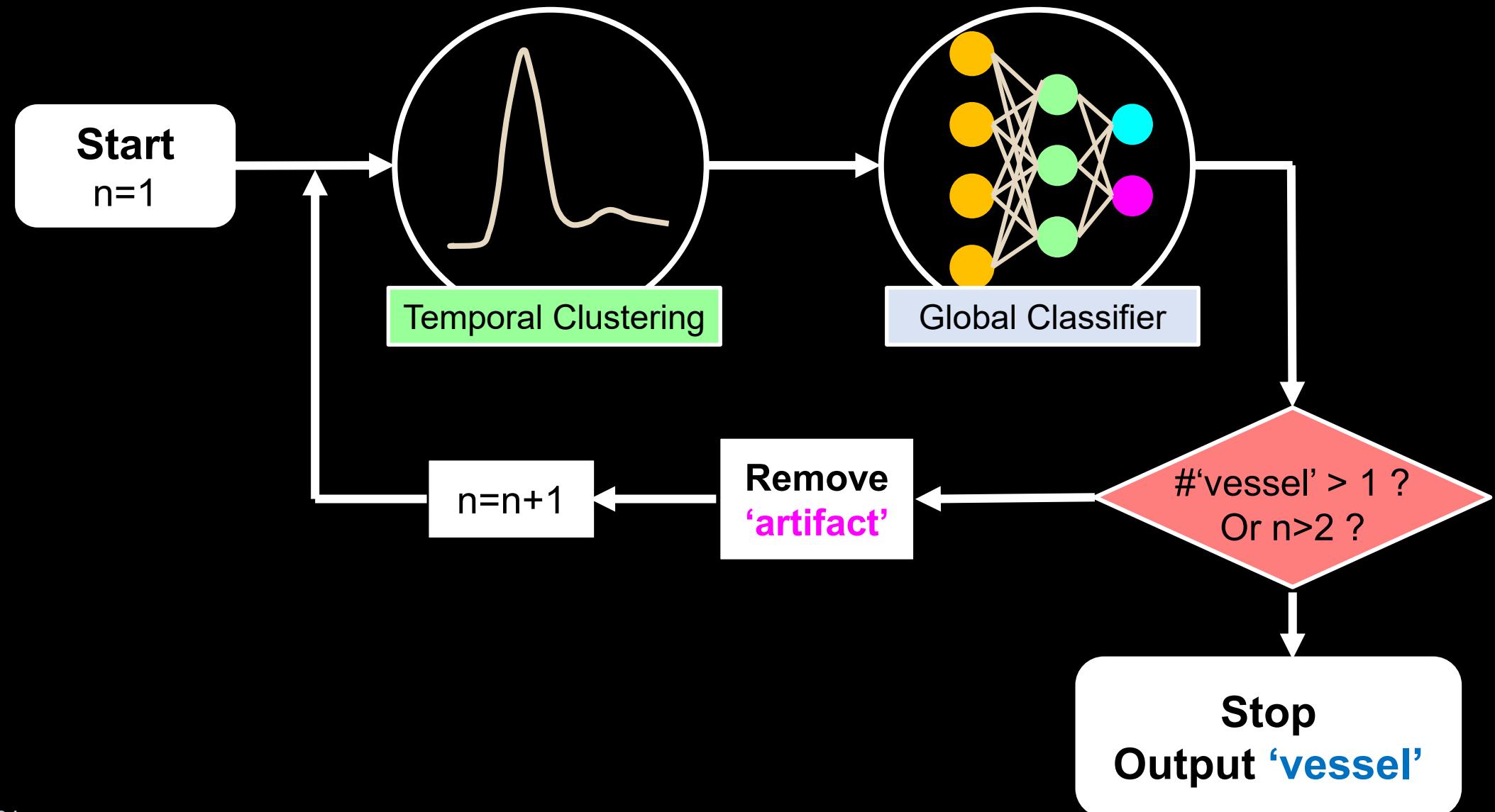
Input: SMART-RECON
Denoised CTA^{1,2}
Volume dim: 256x256x200
Time points: 40

Method: K-Means clustering
Input: 40-D temporal curves
Output: 4 clusters
Format: volumetric mask

Method: Supervised Learning
Input: 256x256x200 clustering masks
Target: manual labeling, 'vessel', 'artifact'
Output: prediction score (threshold=0.5)

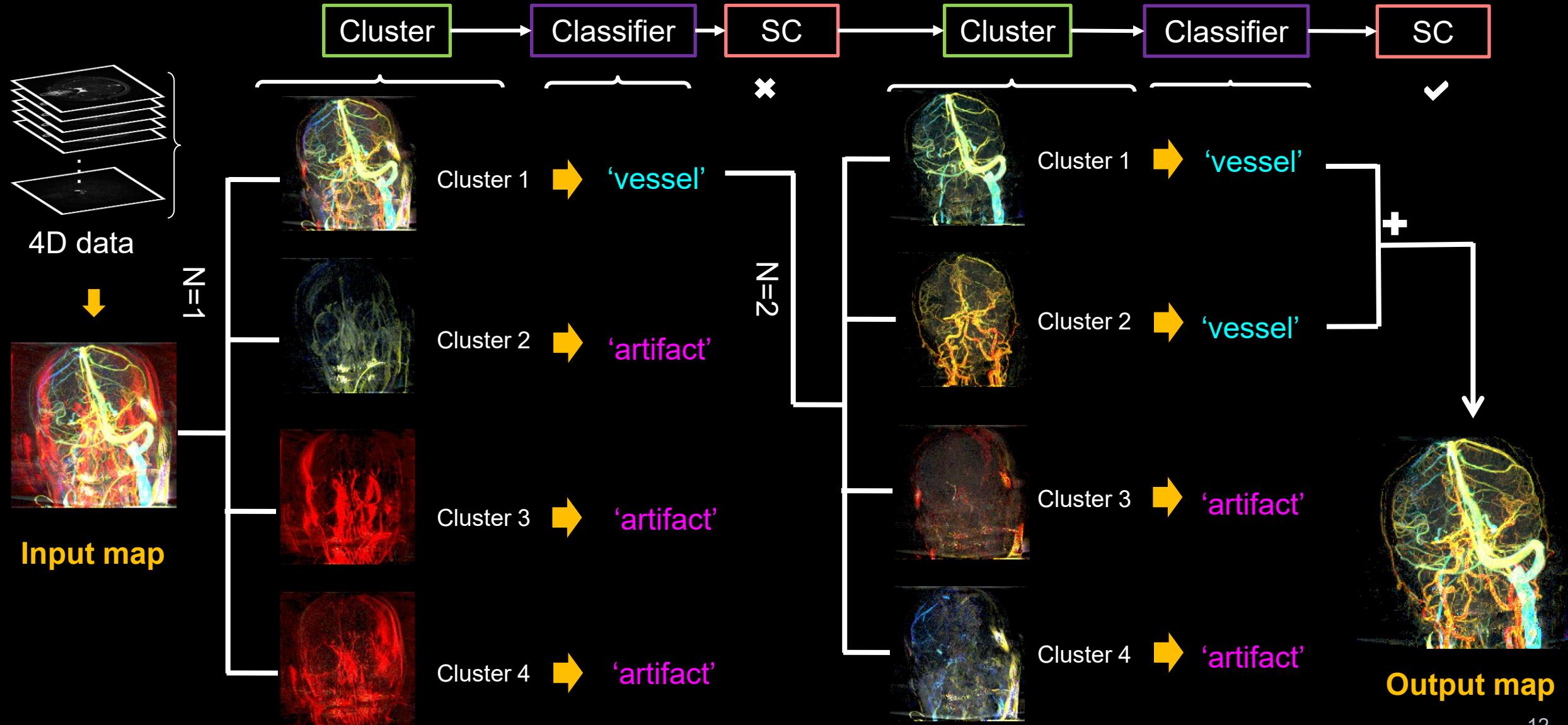


Method: artifact reduction framework





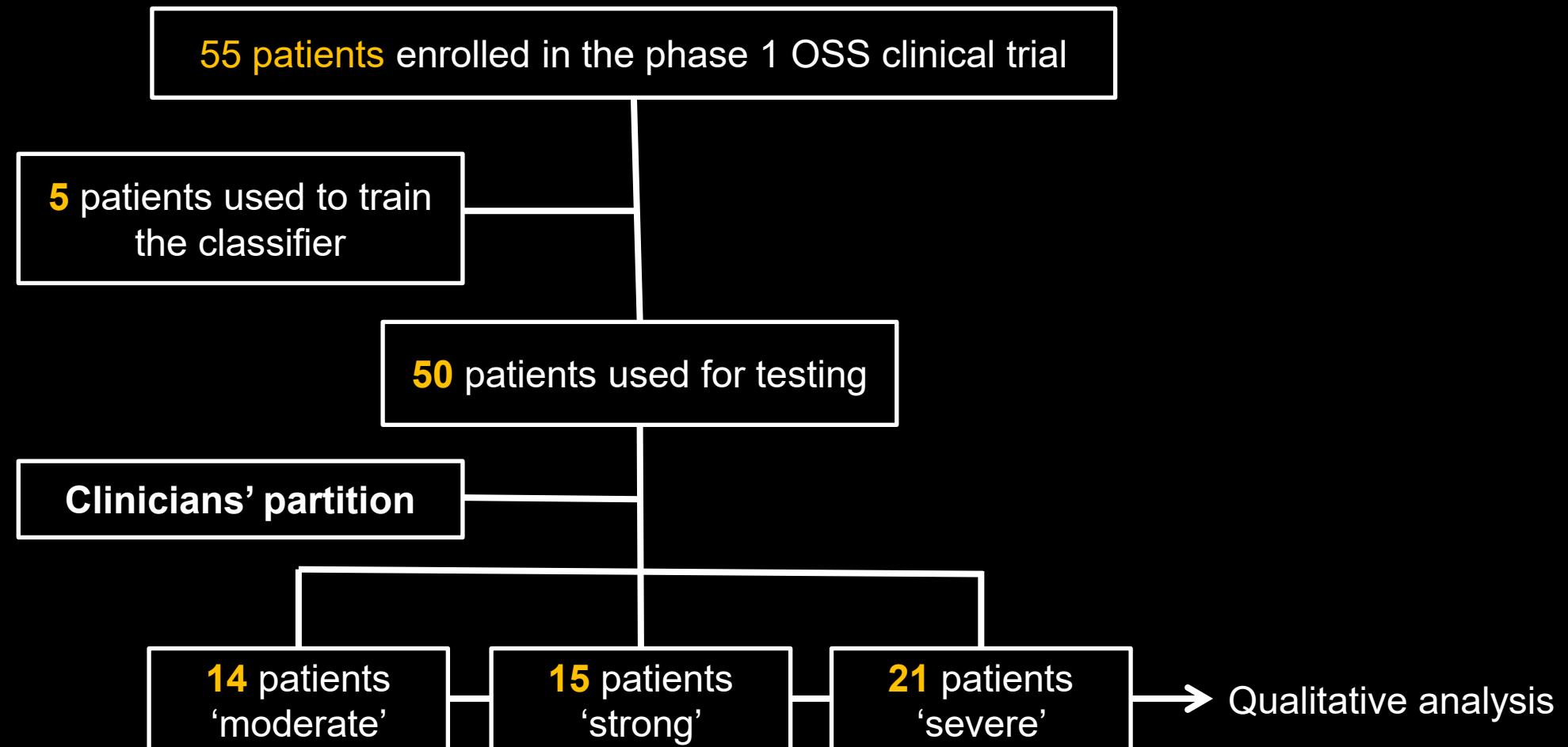
An example of working pipeline





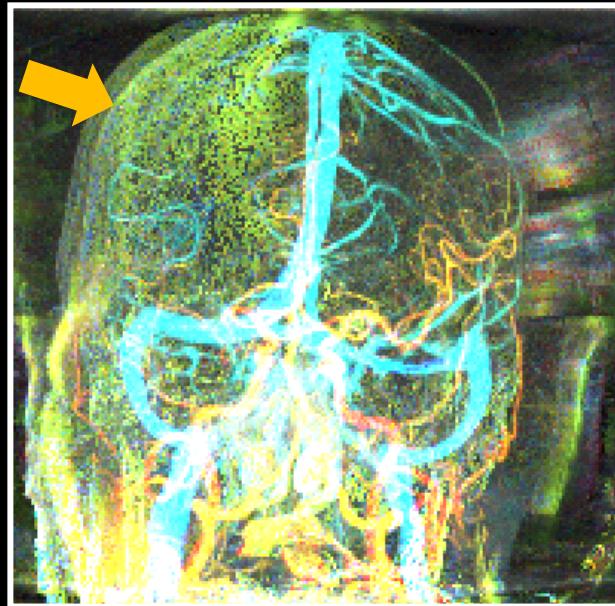
Methods: study schema

- IRB approved and HIPAA compliant study

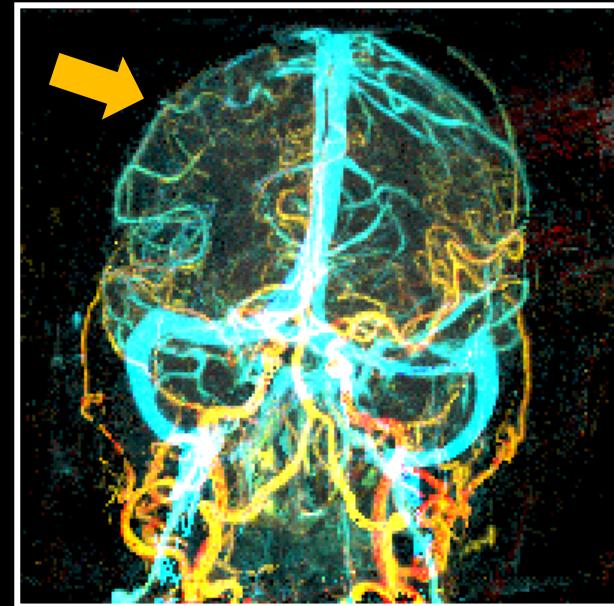


Results I: a case with strong artifacts

Original

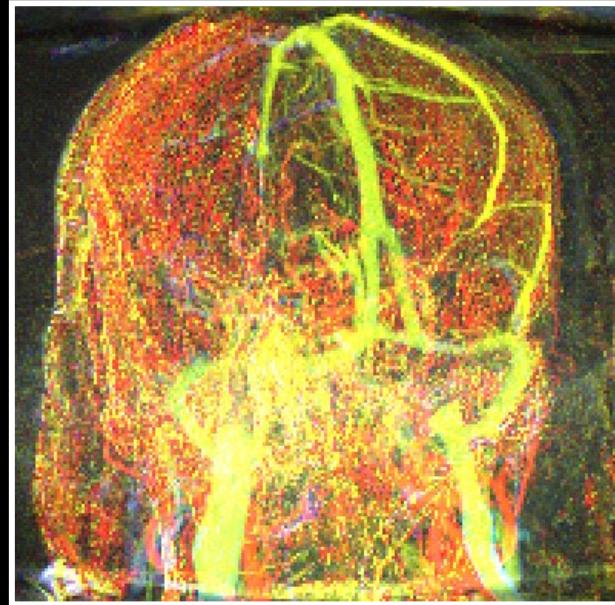


Proposed

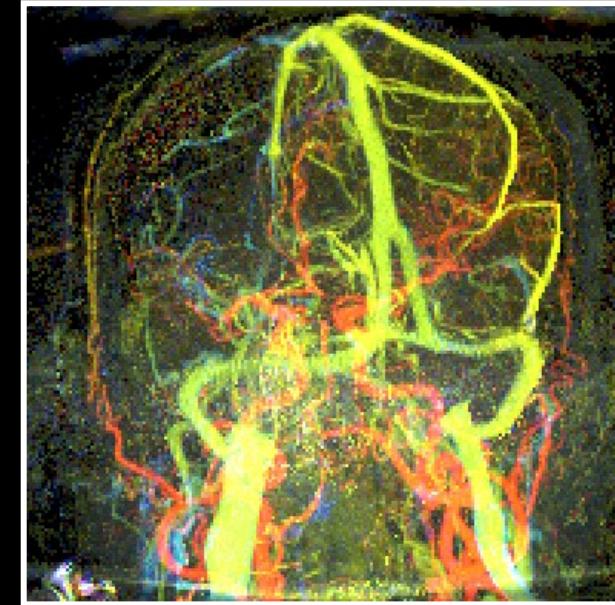


Results II: a case with strong artifacts

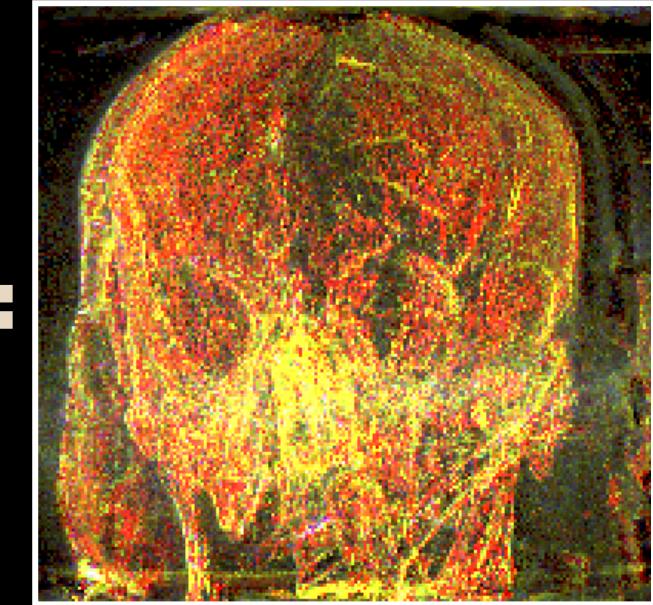
Original



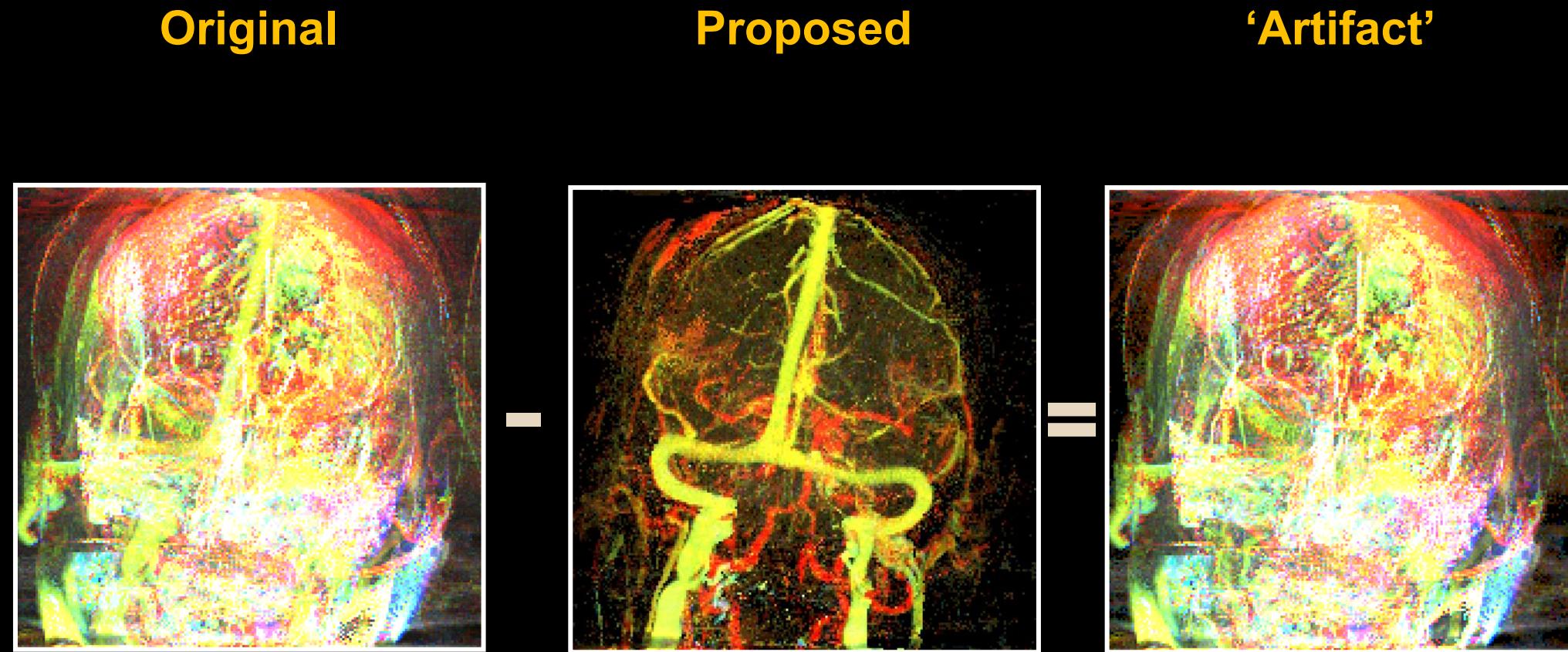
Proposed



'Artifact'

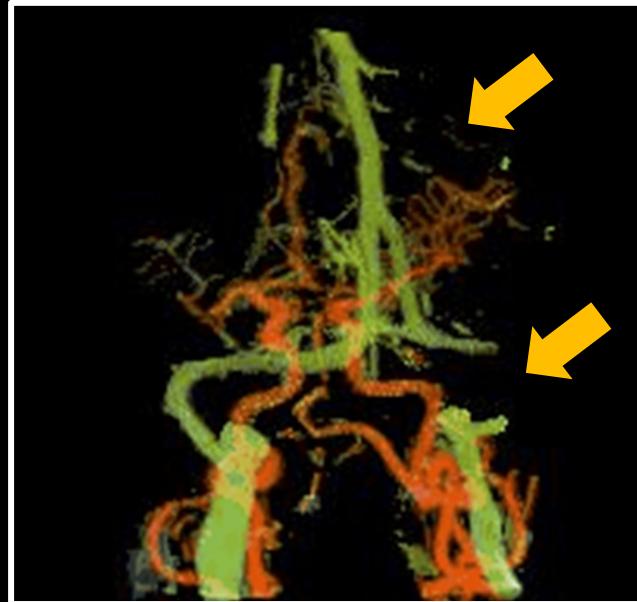


Results III: a case with severe artifacts

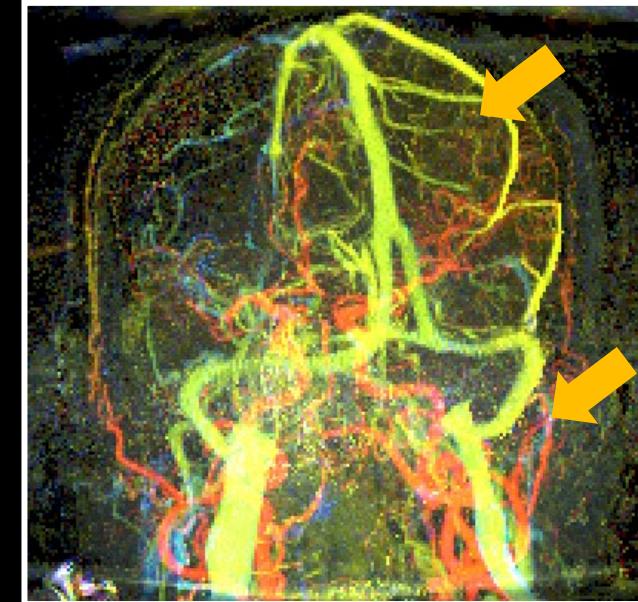


Robustness analysis: moderate artifacts

DeepNN¹



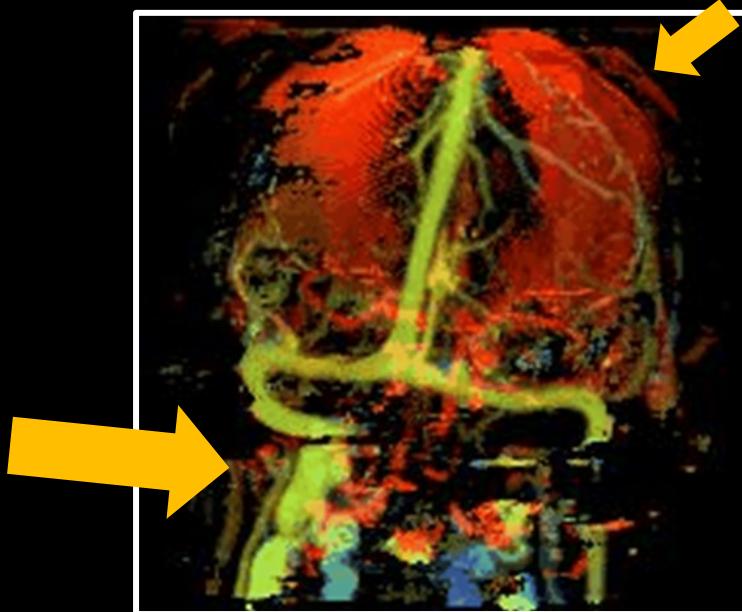
Proposed



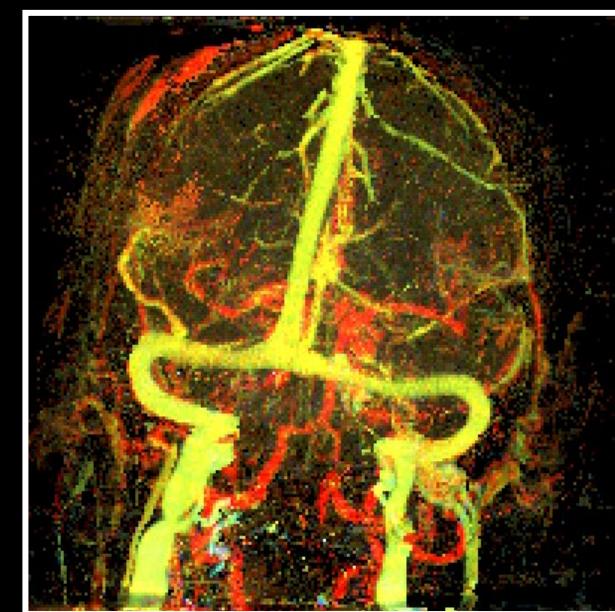
1. Juan et al; RSNA. (2019)

Robustness analysis: severe artifacts

DeepNN¹



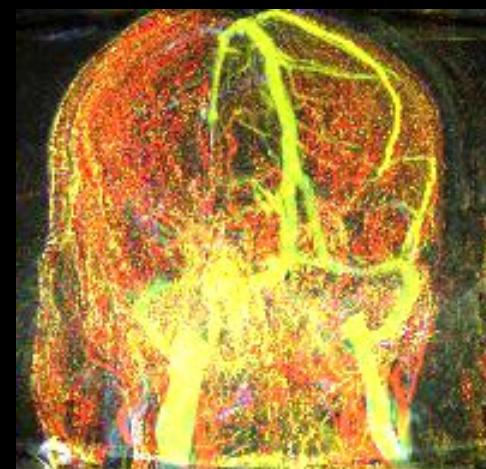
Proposed



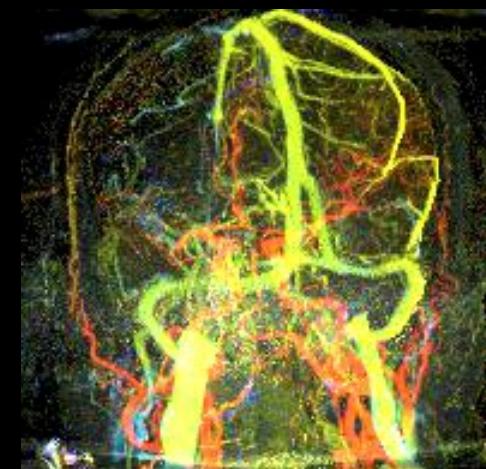
1. Juan et al; RSNA. (2019)

Conclusion

- Robust artifact reduction has been achieved for clinical cases in the test cohort regardless of their initial artifact levels.
- After artifact reduction, the visualization of TOA maps clearly shows different contrast enhanced phases of vessels.



Proposed





Acknowledgement

Thank You
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