**Streamlined Labeling of Carotid Artery Calcifications in CTA Scans**

**Introduction**

We require vast amounts of manually labeled calcifications to train advanced machine learning classifiers for carotid artery plaque detection and phenotyping high-risk calcifications for ischemic stroke patients. We developed *CTOOL*, a web-based software for streamlined calcium labeling with minimal user interaction.

**Method**

We designed and implemented *CTOOL* with radiologists to allow single-click plaque annotation. We perform 3D region growing based on a user-selected CT Hounsfield Unit (HU) intensity with a configurable tolerance threshold to include neighboring voxels. Visualization was set to window/level of 130/1500 HU. We selected 64 retrospective neck CTA dataset of ischemic stroke from the Penn Stroke Registry. For expert validation, we randomly selected 7 CTA scans from this data collection and divided them into a training set (N=2) and a testing set (N=5). A radiologist performed calcification annotations with *CTOOL* vs. manual segmentation with 3D Slicer. We time the experiment and measure accuracy as Jaccard index against fully-manual annotations with a multiple radiologist-consensus across a 4cm segment of the carotid bifurcation. We then recruited N=6 participants (avg. age 30.67yrs, 4 female, IRB approved) for a between-subjects user study without prior experience with either annotation software to compare speed across observers. We randomly assigned the participants and asked them to annotate carotid plaque in a single CTA scan after a brief training period of 5 minutes.

**Result**

Plaque annotations with *CTOOL* were faster than with 3D Slicer (expert w/ *CTOOL* 376.6±113.52s vs 631.2±325.88s, novice w/ *CTOOL* 126.59±21.57s vs 366.09±16.77s, t4=-12.40, p<0.0001). Annotation accuracy between both softwares was comparable (expert Jaccard w/ *CTOOL* 0.537±0.077 vs 0.464±0.238, novice Jaccard w/ *CTOOL* 0.481±0.070 vs 0.496±0.060). However, novice annotations will require expert validation or proofreading. All participants completed the NASA-TLX questionnaire to reveal lower mental, physical, and temporal demand with our software (expert w/ *CTOOL* 12.67 vs 16.334, novice w/ *CTOOL* 28.33±30.880 vs 33.33±14.727).

**Conclusion**

Our streamlined plaque labeling software allows 2.89x faster annotations (1.68x for experts) with comparable accuracy to manual segmentation.

Chart, waterfall chart

Description automatically generated