Intracranial Aneurysm Detection using Spherical Representations
Youssef Assis, Liang Liao, Fabien Pierre, René Anxionnat, Erwan Kerrien

⚠ To cite this version:

Youssef Assis, Liang Liao, Fabien Pierre, René Anxionnat, Erwan Kerrien. Intracranial Aneurysm Detection using Spherical Representations. Colloque Français d’Intelligence Artificielle en Imagerie Biomédicale, Mar 2023, Paris, France. hal-04206825

HAL Id: hal-04206825
https://hal.univ-lorraine.fr/hal-04206825
Submitted on 14 Sep 2023
Intracranial Aneurysm Detection using Spherical Representations

Youssef Assis1, Liang Liao2,3, Fabien Pierre1, René Anxionnat2,3, Erwan Kerrien1

1 University of Lorraine, CNRS, INRIA, LORIA, F-54000 Nancy, France
2 Department of Diagnostic and Therapeutic Neuroradiology, University of Lorraine, Nancy, France
3 IADI, INSERM U1254, University of Lorraine, Nancy, France

Context & Contributions
• Context: Detection of unruptured intracranial aneurysms is a difficult problem.
• Goal: - Automate aneurysm detection. - Assist radiologists in their clinical routine.

Introduction
• Intracranial aneurysms: local dilatations of cerebral blood vessels (Figure 1, red arrows).
• Extremely difficult detection problem:
  - Data scarcity: - Small and private datasets. - 0 to 5 aneurysms per patient.
  - Class imbalance: very small structures (+10/1M voxels).
  - Data annotation: difficult and time-consuming.

Method
1. Datasets: TOF-MRA images

<table>
<thead>
<tr>
<th></th>
<th>Subjects</th>
<th>Aneurysms</th>
<th>Mean size</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHRU Nancy</td>
<td>132</td>
<td>206</td>
<td>3.97mm</td>
</tr>
<tr>
<td>CHUV Lausanne [1]</td>
<td>270</td>
<td>164</td>
<td>3.74mm</td>
</tr>
</tbody>
</table>

2. Data Sampling Strategy:
   a) Data annotation:
      - Approximate and fast: 2 points \(\rightarrow\) Sphere (Figure 1).
   b) Small patch-based approach:
      - 96 x 96 x 96 voxels.
      - Non-intersecting \(\rightarrow\) independent patches.
   c) Data selection and synthesis:
      - Negative patches (without aneurysm): Selection 40 patches per patient; Mostly centered on blood vessels.
      - Positive patches (with aneurysm): Synthesis 50 duplicates and deformation by random distortion.

3. Deep Neural Network Architecture:
   - 3D anchor-free adaptation of the YOLO [4] architecture.
   - Detection \(\rightarrow\) Sphere \((x, y, z, radius)\) + confidence score.

4. Evaluation:
   - Based on Intersection-over-Union metric (TP = IoU > 10%).
   - Average Precision (AP), Sensitivity, False positives per case.

Experimental Study
1. Preliminary study: CHRU Nancy
   • Ablation study confirms our data sampling strategy:
     - Data selection and synthesis.
     - Spherical representation \(\gg\) Box representation.
     - Anchor-free \(\gg\) Anchor-based.
   • Results (5-Fold cross validation):
     - Average Precision: 81.22%.
     - Sensitivity: 81.55% associated with 0.57 FP/case.

2. Validation with public dataset: CHUV Lausanne [1]
   - 5-Fold cross validation.
   - Very competitive results.
   - Reduced training and inference time.

<table>
<thead>
<tr>
<th></th>
<th>Average Precision (%)</th>
<th>Sensitivity (%)</th>
<th>FP/case</th>
<th>Training Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>nnDetection [2]</td>
<td>73.68</td>
<td>84.76</td>
<td>0.67</td>
<td>29 hours</td>
</tr>
<tr>
<td>nnUnet [3]</td>
<td>72.46</td>
<td>71.95</td>
<td>0.13</td>
<td>5 days</td>
</tr>
<tr>
<td>Ours</td>
<td>75.80</td>
<td>84.76</td>
<td>0.57</td>
<td>24 hours</td>
</tr>
</tbody>
</table>

Visual Results
• Combination of an efficient data sampling strategy with a 3D YOLO architecture for aneurysm detection.
• Can be easily adapted for small object detection problems.
• Perspectives: combine and improve the performance with recent training techniques from 2D object detection.

Conclusion & Perspectives

References