Automatic Detection of Significant and Subtle Lesions from Coronary CT Angiography

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I. Introduction

• Coronary Artery Disease (CAD) is the leading cause of death worldwide for both men and women.
• CCTA has shown high accuracy for detection of coronary artery stenosis & atherosclerotic plaque.
• Current clinical assessment of CCTA is based on visual analysis: time consuming and observer-variable.
• A few studies on automatic lesion detection (≥50%).
• There has been no reported attempt to automatically detect less-stenosed (25–49% stenosis) lesions, which have been shown to contribute to cardiovascular events.

II. Goals

• To develop and validate an automated algorithm for detecting nonobstructive (25–49% stenosis) and obstructive (≥25% stenosis) arterial lesions from coronary CTA.

III. Methods

• The algorithm needs two points as input, at the ostium of the RCA and the LM coronary artery, and secondly, the placing of a standard circular region of interest in the aorta at the level of the LM ostium, to obtain scan-specific attenuation range for luminal contrast. Following these steps, the process is automated.

- Centerline extraction by 3D Thinning and Graph Theory
- Classification of 3 Main Arteries by Dijkstra’s Shortest Path and Anatomical Knowledge
- Vessel Linearization
- Lumen Segmentation by Scan-specific Threshold Levels for Lumen and Plaque
- Expected Normal Luminal Diameter Calculation by Automated Piecewise Least Squares Line Fitting
- Lesion Location Detection by Calculating Stenosis in Multiple Steps

• Centerline extraction and classification of 3 main arteries (LAD, LCX and RCA) by 3D Thinning + Dijkstra’s shortest path + anatomical knowledge.

• The vessels are subsequently converted to a linearized 2D representation, which are stacked up cross-sectional planes perpendicular to the centerline.
• Computed the attenuation range for lumen and plaque automatically from the image histogram of the normal blood pool. Then, Lumen is segmented by local recursive region-growing in the linearized volume.

IV. Results

• 42 patients data (57% male, a mean age of 60±12.
• 252 coronary artery segments (proximal/mid).
• An expert observer identified 21 patients with 45 lesions (≥25% stenosis). 21normal patients had no luminal stenosis or plaque.

<table>
<thead>
<tr>
<th>Lesions by Experts (≥25% stenosis)</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
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<tbody>
<tr>
<td>LAD 24</td>
<td>92%</td>
<td>75%</td>
<td>80%</td>
</tr>
<tr>
<td>LCX 10</td>
<td>100%</td>
<td>76%</td>
<td>79%</td>
</tr>
<tr>
<td>RCA 11</td>
<td>100%</td>
<td>82%</td>
<td>75%</td>
</tr>
<tr>
<td>Total 45</td>
<td>96%</td>
<td>78%</td>
<td>80%</td>
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<th>Breakdown of detected false positives lesions.</th>
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<td>Lesion presence and location detection.</td>
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V. Conclusions

• We developed a novel automated algorithm for detection and localization of significant (≥50%) and non-significant (25–49%) arterial lesions from CCTA, which performed with high sensitivity compared to an expert reader.

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