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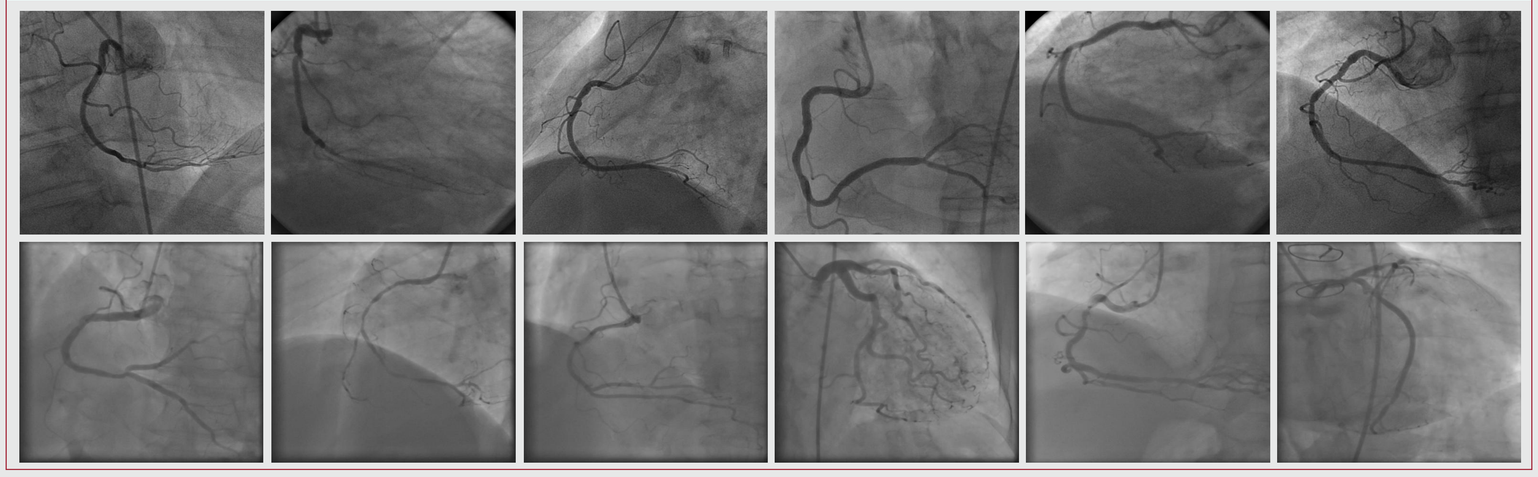
Accurate and robust fully-automatic QCA: Method and numerical validation

Abstract

The **Quantitative Coronary Angiography (QCA)** is a methodology used to evaluate the arterial diseases and, in particular, the degree of stenosis. In this paper we propose **AQCA**, a fully automatic method for vessel segmentation based on graph cut theory. **Vesselness**, **geodesic paths** and a new **multi-scale edgeness map** are used to compute a globally optimal artery segmentation. We evaluate the method performance in a rigorous numerical way on two datasets. Moreover, the method can discriminate between arteries and catheter with an accuracy of 96.4%.

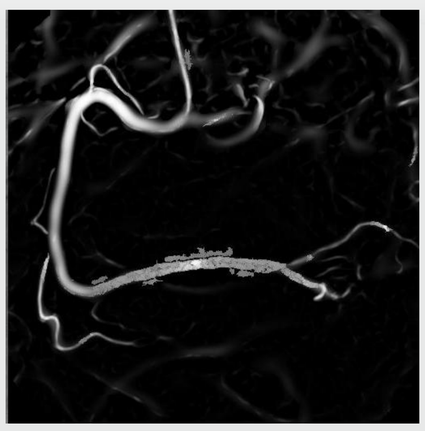
X-ray angiography images



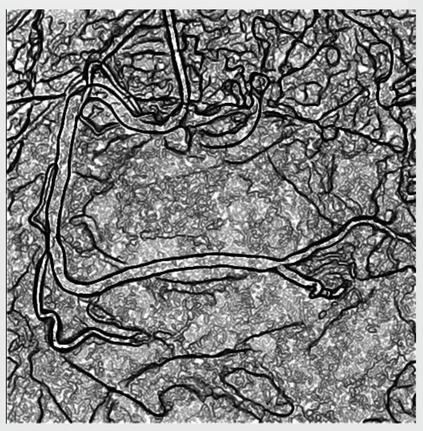
1. Automatic Vessel Segmentation

Graph-cuts Energy Minimization Framework [3]

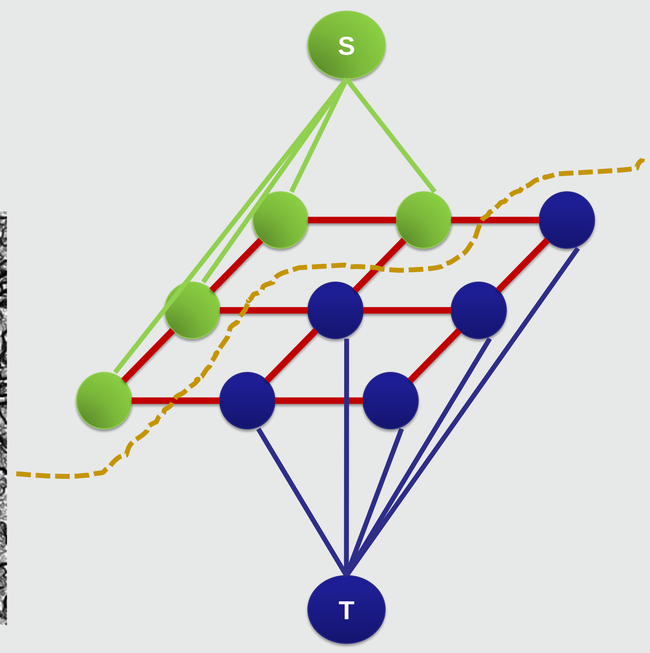
$$\mathbf{E}(\underline{\alpha},\mathbf{k},\underline{\theta},\mathbf{z}) = U(\underline{\alpha},\mathbf{k},\underline{\theta},\mathbf{z}) + V(\underline{\alpha},\mathbf{z})$$



Unary potential



Boundary potential



2. Centerline extraction

Segmentation → Distance transform → Non-maximum suppression → Ridge transversal

3. Caliber estimation

LoG filtering: scale space

$$\sigma^2 \mathrm{LoG}(x, y; \sigma)$$

Minimum at $\sigma = w/2$

4. Catheter detection

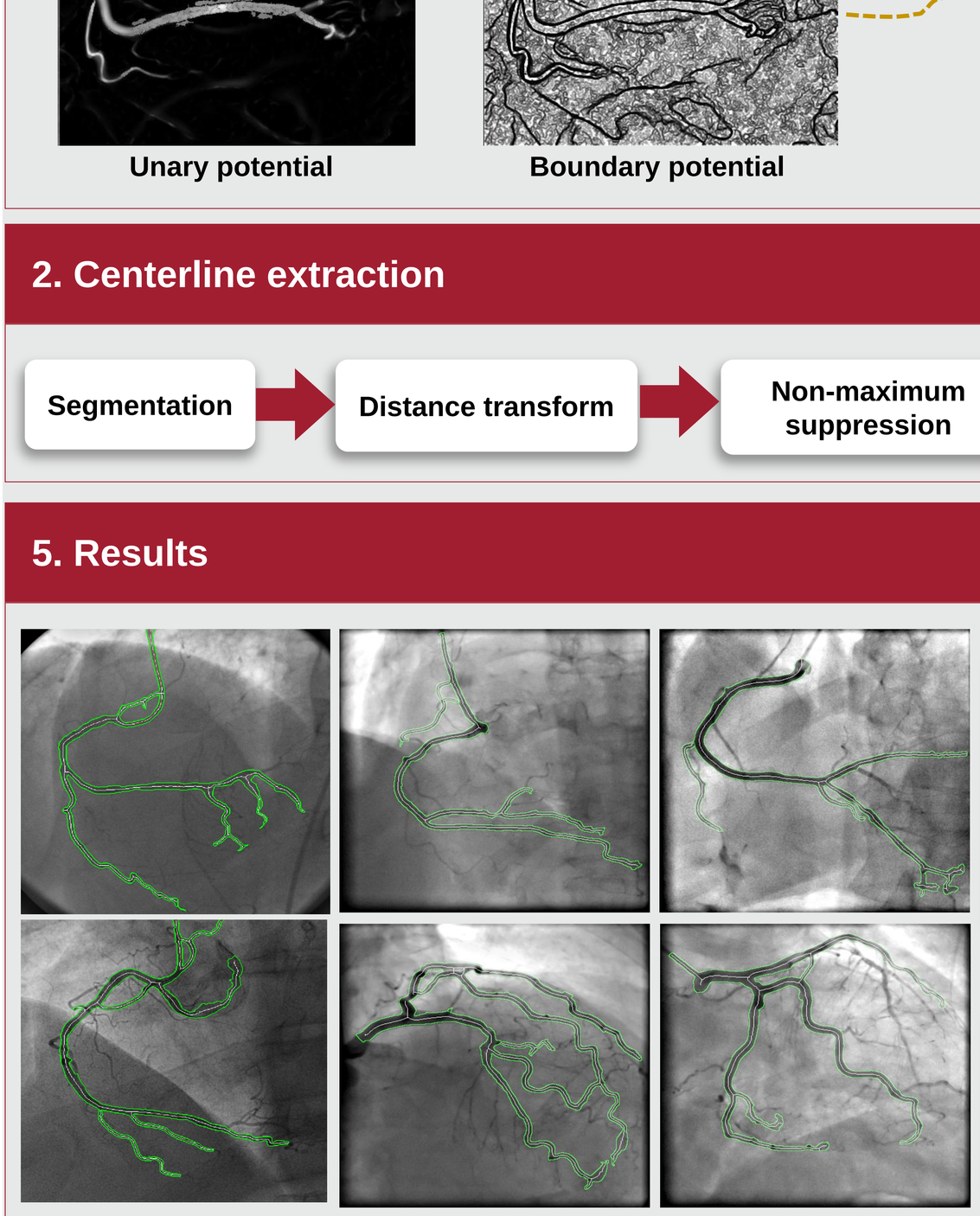
Feature Extraction

Position **x**, Curvature **K(x)**, Angular direction **α(x)**, Caliber **C(x)**

Bayesian Classifier

$$p(\mathbf{x}|c)$$
$$p(\log(\epsilon + K(\mathbf{x}))|c)$$
$$p(\alpha(\mathbf{x})|c)$$
$$p(C(\mathbf{x}|c))$$

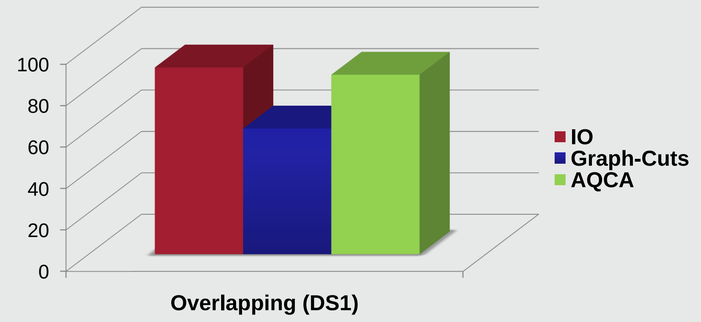
5. Results



Asbsolute and signed caliber error in DS2 (in mm)

	$\lvert \Delta D_c \rvert$	ΔD_c
IO	0.18±0.24	-0.001±0.3
GC	0.84±0.74	0.096±1.12
AQCA	0.49±0.55	-0.1±0.73

Catheter detection	%
Sensitivity	70.9
Precision	90.1
Accuracy	96.4



- **Robust:** The method has been tuned on DS1, providing excellent results on DS2**.**
- **Extensible:** we show an application to QCA but could be easily extended to images containing other tubular structures.
- **Future lines:** high order potential to deal with bifurcations and crossings.

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Acknowledgements

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