Discrete Contour Extraction from Reference Curvature Function

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Abstract

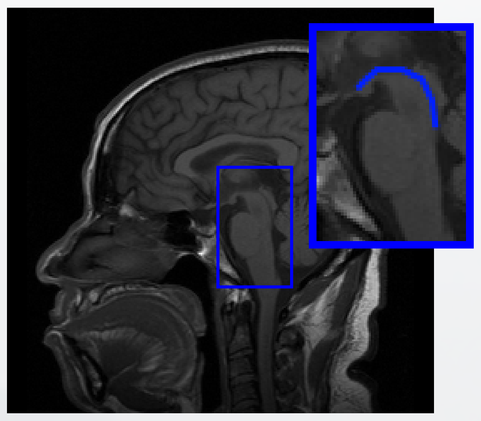
We propose to use a reference curvature function for extracting the frontier of a shape in a gray level image. The frontier extraction is done by using both geometric information represented by the reference curvature and gradient information contained in the source image. The application of this work is done in a medical application.

Keyword: segmentation, curvature, medical applications.

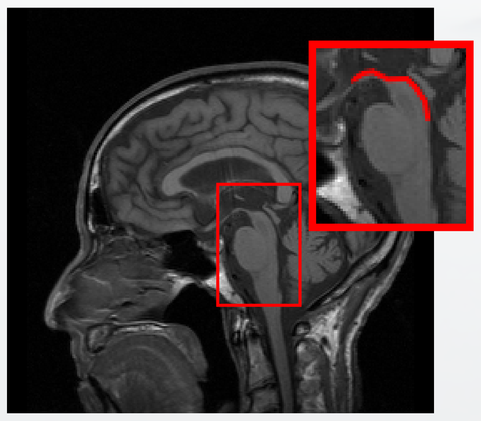
1 Introduction

Objective and main idea:
- Extract contours from a geometric description of the shape.
- Use curvature description with a robust estimator.
- Include information of image gradient in the contour extraction.

Medical Application:
- Application to the early diagnostic of a particular Parkinson's disease syndrome.
- Characterize the atrophy of the mid-brain part of the brain stem [4].
- Contour extraction and curvature measures on the brain stem.



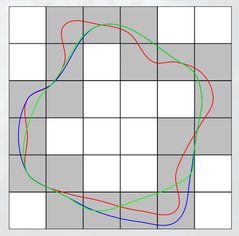
healthy patient

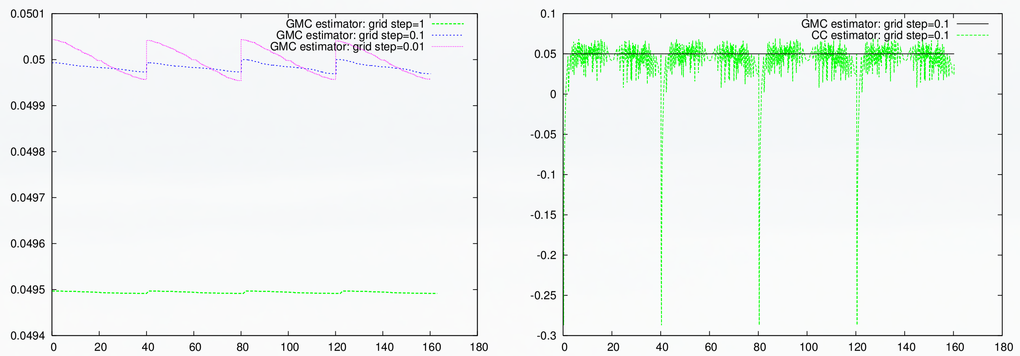


pathologic patient

2 Robust Curvature Estimator [2]

Principle:
- Take into account all possible shapes associated to a same discretisation.
- Precision even with low resolution shapes.
- Noise resistant with blurred segments [1].



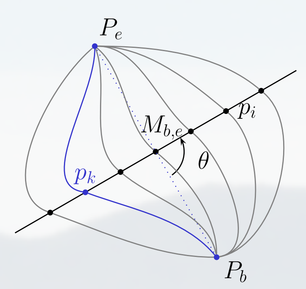


Circle of radius $R = 20$

3 Contour Selection from Curvature Information

3.1 Construction of the list of the potential contours

Construction of the contour between two points:
- Shortest path algorithm proposed by Mortensen *et al.* [3].
- Shortest path going from P_b to P_e is denoted by $S(P_b, P_e)$
- List of potential contours defined from each point p_k by : $S_k = \{S(P_b, p_k), S(p_k, P_e)\}$



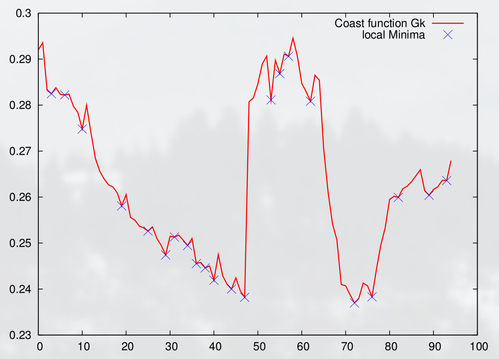
3.2 Selection through the possible candidates

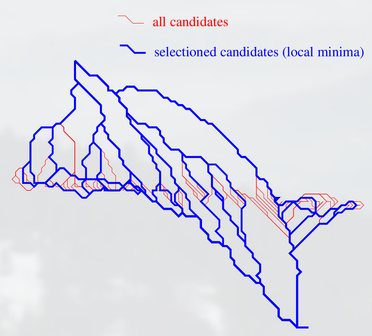
- **Step 1: selection based on local minima values of the coast (A_1)**

For each contour associated to point p_k the cost value G_k is defined as:

$$G_k = G(S(P_b, p_k)) + G(S(p_k, P_e))$$

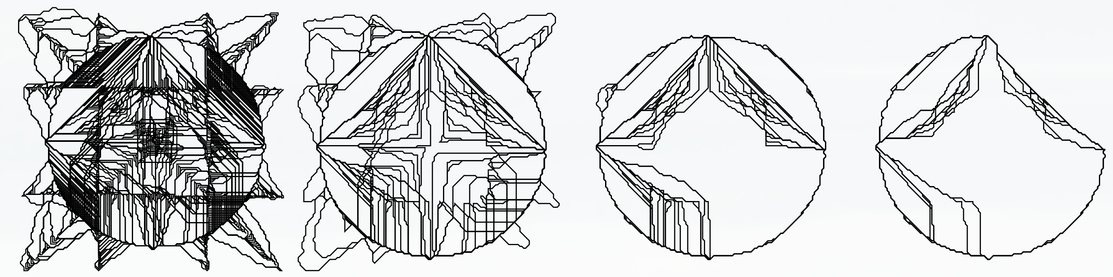
with $G(S_k)$ representing the mean coast extracted from the shortest path algorithm.





- **Step 2: selection according length constraint**

$$A_2 = \{p_k \in A_1 | \frac{|L_k - L_{ref}|}{L_{ref}} < Err_{peri}\};$$

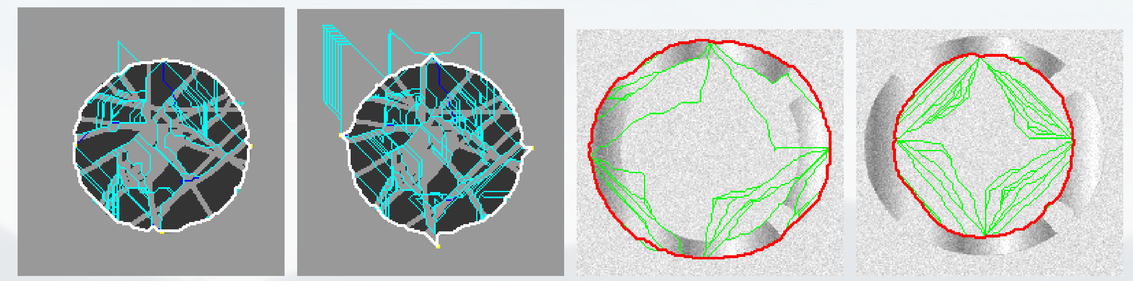


(a) (b) (c) $Err_{peri} < 10\%$ (d) $Err_{peri} < 5\%$

- **Step 3: selection from curvature constraint**
- Select contours from bounds on mean curvature C_k^*: $A_2 = \{p_k \in A_2 | C_{Min} \leq C_k^* \leq C_{Max}\}$
- The final contour with the minimal error to the reference curvature ($(C_k - C_{ref})^2$) is selected.

4 Experiments and Applications

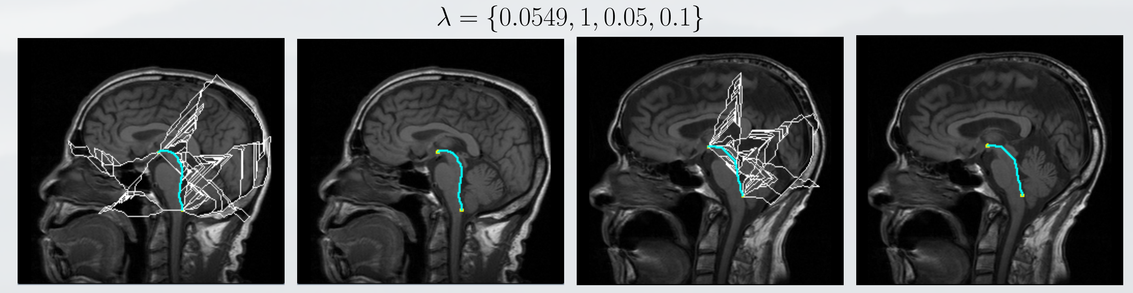
- **Contour selection on synthetic images:** $\lambda = (C_{ref}, Err_{peri}, C_{min}, C_{max})$



$\lambda = 0.0164, 0.2, 0, 0.3$ $\lambda = 0.0164, 0.2, 0, 0.3$ $\lambda = (0.0114, 0.2, 0.005, 0.2)$ $\lambda = (0.0153, 0.2, 0.005, 0.2)$

- **Results on brain images**

$\lambda = \{0.0549, 1, 0.05, 0.1\}$



5 Conclusion

We have proposed new simple method to extract image contours by using predefined curvature informations. The extraction was based on a robust curvature estimator and on the construction of shortest paths from image gradient informations. The application to medical application appears promising and future work will deal with the medical validation in the context of the Parkinson's atypical disease.

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