Automatic sulcal classification using geometric shape descriptors

Christian Laing, Juan B. Gutierrez, Deborah A. Smith, De Witt Sumners, Monica K. Hurdal
Florida State University, Department of Mathematics

1 INTRODUCTION

We propose the use of scaled Gaussian integrals, ropelength and thickness as geometric shape descriptors of curves extracted from MRI scans of human brains. These features provide a way to measure similarity based on morphology [1, 3, 4] while being orientation-independent. Curves representing the fundus of a sulcus were computed for a number of sulci in each cortical surface.

![Brain surface, Sulcus paths, Vector of Geometric Measures](image)

Figure 1. Sulcus paths are space curves. A set of curve shape descriptors are then computed.

High resolution 1.5 Tesla, T1-weighted MRI brain scans (0.86mm x 0.86mm x 1.00mm) from 15 subjects obtained from a static force experiment were used [2]. The five sulci traced on each hemisphere were the central, precentral, calcaine, superior frontal and superior temporal sulci.

2 METHODS: SCALED GAUSS INTEGRALS, CURVATURE, THICKNESS AND ROPELENGTH

Consider a polygonal closed curve $\alpha$. For any regular projection, each crossing can be assigned a value of $Cr(u) = \pm 1$ according to the right hand rule. The writhe of $\alpha$, $Wr(\alpha)$, can be thought as average number of signed crossings of the curve, averaged over all projections $Wr(\alpha) = I_{[1,2]}(\alpha) = \frac{1}{2} \sum_{0<i<j\leq N} W_{ij}$ as seen in figure 2.

![The writhe contribution $W_{ij}$ obtained from a pair of edges $i$ and $j$.](image)

Figure 2. The writhe contribution $W_{ij}$ obtained from a pair of edges $i$ and $j$.

where $W_{ij}$ is the contribution to writhe of the line segments $i$ and $j$ of $\alpha$. $W_{ij}$ can be computed as

$$W_{ij} = \frac{1}{2\pi} \int_{-1}^{1} \int_{-1}^{1} w(t_1, t_2) dt_1 dt_2$$

where

$$w(t_1, t_2) = \frac{[\alpha'(t_1), \alpha(t_1) - \alpha(t_2), \alpha'(t_2)]}{|\alpha(t_1) - \alpha(t_2)|^3}$$

Another measure for curves is the average crossing number which is defined by taking the absolute value of the integrand $I_{[1,2]}(\alpha) = \sum_{0<i<j\leq N} |W_{ij}|$ where $w(t_1, t_2)$ and $W_{ij}$ were defined previously. By constructing various combinations of $W_{ij}$, we can create a whole set of structural measures.

3 RESULTS

![MDA projection shows a clear differentiation between male, female, left and right hemisphere.](image)

Figure 3. MDA projection shows a clear differentiation between male, female, left and right hemisphere.

It was possible to differentiate sulcal paths from the left or right hemispheres, and male vs. female classification were achieved.

4 CONCLUSIONS

We developed a classification protocol for discrimination of sulcal curves extracted from MRI scans of human brains. The associated high dimensional measures were based on a family of geometric measures involving combinations of writhe, average crossing number, ropelengh and thickness. In our preliminary results, an automatic differentiation between sulcal paths from the left or right hemispheres, and male vs. female classification were achieved.

References


