Prenatal Computer-Aided Diagnosis of Craniosynostosis Using Shape Analysis

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Purpose
To quantitatively evaluate prenatal ultrasounds to diagnose craniosynostosis.

Background

Craniosynostosis
• Premature closing of sutures¹
• Affects 1/2500¹
• Surgical correction within first year generally leads to good prognosis²

Diagnosis
• Currently diagnose post-natal examination from dysmorphic shape of infant’s skull³
• Some false-negatives, delays intervention⁴
• Some studies suggest prenatal diagnosis possible from ultrasound, but no proposed methodology³

Method
Manually identify the skull boundary
Measure the skull radii at every 10° on ImageJ
Parameterize the skull by its lengths and normalize
Find the principal directions and train classifier

Results

Example skull shapes

Table 1: SVM results using leave-one-out cross validation
Accuracy: = 89%, Sensitivity = 82%, Specificity = 95%

<table>
<thead>
<tr>
<th>Confusion Matrix</th>
<th>Predicted True</th>
<th>Predicted False</th>
</tr>
</thead>
<tbody>
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<td>4</td>
</tr>
<tr>
<td>Actual False</td>
<td>1</td>
<td>21</td>
</tr>
</tbody>
</table>

Table 2: Random forest results using leave-one-out cross validation
Accuracy: = 84%, Sensitivity = 82%, Specificity = 86%

<table>
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<tr>
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<td>4</td>
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<tr>
<td>Actual False</td>
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<td>19</td>
</tr>
</tbody>
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Discussion
We present a reliable tool for quantitatively assessing prenatal ultrasound images for craniosynostosis. Two experienced doctors visually inspected the images. Their accuracies were 40-50%, compared to the program’s 89%. Our program can flag cases that are at risk earlier for better treatment planning.

Conclusion
Our results show that a formal shape analysis of prenatal ultrasounds identifies craniosynostosis with high accuracy. With more training cases and further refinement of the procedure, we hope to include this as a standard routine in the clinic.

References