Use of Computer Vision Technology to Interpret Clinical Pain in Children

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BACKGROUND
• Pain assessment in children is difficult owing to developmental and cognitive barriers and reliance on proxy measures (parent report).
• Information exists in the face for assessing pain. However, person-observers inadequately evaluate pain in facial expressions.
• This project employs computer vision and machine learning techniques to estimate pain from facial movement.

METHODS
• Six children (10-14 years) hospitalized for acute pancreatitis underwent multiple pain assessments with video recordings.
• At each session, subjects were video recorded during a rest period (no stimulus) and a pain stimulus (abdominal exam). Subjects reported pain level on a scale of 0-10.
• Representative video segments were passed through the Computer Expression Recognition Toolbox, a computer vision system for measuring facial expressions in real time. Median facial action intensity over each video segment was computed.
• Nine facial actions associated with pain were analyzed in comparison to self-reports of pain.
• Facial action measures were combined in a multiple regression model to jointly predict self-reports of pain. Subjects re: which facial action units correlated with pain.

FACIAL ACTIONS
• The Facial Action Coding System is a method for describing facial expressions in terms of 46 component movements, which correspond roughly to individual facial muscles. Sample facial action units are shown below.

CORRELATIONS BETWEEN FACIAL ACTION UNITS AND PAIN

<table>
<thead>
<tr>
<th>Facial Action Unit</th>
<th>Correlation @ Rest (N=16)</th>
<th>Correlation @ Pain Stimulus (N=16)</th>
<th>Overall Correlation (N=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.31</td>
<td>-0.24</td>
<td>0.09</td>
</tr>
<tr>
<td>6</td>
<td>0.09</td>
<td>-0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>7</td>
<td>0.08</td>
<td>-0.11</td>
<td>0.03</td>
</tr>
<tr>
<td>9</td>
<td>0.56*</td>
<td>0.40</td>
<td>0.52***</td>
</tr>
<tr>
<td>10</td>
<td>0.59*</td>
<td>0.12</td>
<td>0.43*</td>
</tr>
<tr>
<td>12</td>
<td>0.38</td>
<td>0.09</td>
<td>0.32</td>
</tr>
<tr>
<td>20</td>
<td>0.47</td>
<td>-0.32</td>
<td>0.36*</td>
</tr>
<tr>
<td>25</td>
<td>0.13</td>
<td>0.12</td>
<td>0.24</td>
</tr>
<tr>
<td>43</td>
<td>0.72**</td>
<td>0.49</td>
<td>0.65***</td>
</tr>
</tbody>
</table>

CLINICAL PAIN MEASUREMENTS
Sample data from one subject is shown below: Two facial measures are plotted against self-report of pain on the left, and elapsed time (duration of hospital stay) on the right.

RESULTS
• Looking at individual facial actions across subjects, four of the nine pain-associated facial action units had significant correlations with self-report of pain: AUs 9, 10 (levator action), 20 (risorius – lip stretching), 43 (eye closure).
• Within-subject analysis demonstrated that variations exist between subjects re: which facial action units correlated with pain.
• The pain estimation model was a multiple regression on the nine facial actions previously associated with pain using data from the six subjects. Pain estimates from the model correlated with self-report of pain at r=0.58, p<0.002.

PRELIMINARY PAIN PREDICTION MODEL

CONCLUSIONS
• These results provide support for automatic estimation of pain from computer vision and machine learning.
• Self-report of pain intensity was reliably estimated from automatic facial expression analysis.
• The pain prediction method is a statistical model built from observed data. With six subjects we show proof of principle. More data is being collected to improve the statistical model. Additional research is also underway to explore machine learning techniques to improve pain estimation.
• Further evaluation and study is required to determine whether this technology may be effectively used in the clinical setting for real time assessment of pain.

REFERENCES
• Lucey et al, 2011