Extracting High-Level Intuitive Features (HLIF) For Classifying Skin Lesions Using Standard Camera Images

Robert Amelard,
Alexander Wong, David A. Clausi
Vision and Image Processing Group
University of Waterloo
Motivation

• Melanoma: deadliest skin disease
• Early detection
  – 5-year survival rate
• Dermatologists
  – Time-constrained
  – 82.6% correct malignant*
  – 70.0% correct benign*

*Morton & Mackie 1998
Outline

• Clinical/Research Background
• Features
• Experiments
• Conclusions and Future Work
Clinically: ABCD

- Asymmetry
- Border Irregularity
- Colour Patterns
- Diameter

- High-Level Intuitive Features (HLIFs)
  - Modeled from human-observable phenomena
  - Quantitatively describe ABCD

*All images courtesy of www.dermis.net unless noted*
Clinical Decision Support System

Segmentation

Malignant
Benign

Classification

Feature Extraction

Asymmetry
Border Irregularity
Colour Patterns
Diameter
Prior Work

• Dermoscopic images
  – Most prominent in literature
  – Limited clinical use*

• Standard images
  – Very new
  – Low barrier to adoption
  – Technical challenges

*Engasser & Warshaw 2010
What is State of the Art?

• 52 low-level features*
  – Abstract mathematical/statistical descriptions
• Computationally complex
• Sub-optimal results

*Cavalcanti et al. 2011
Proposed Features: Asymmetry

\[ f_1^A = \max_\theta \left\{ \frac{1}{2} \sum_{i=1}^{nbins} |H_1^\theta(i) - H_2^\theta(i)| \right\} \]
Proposed Features: Asymmetry

\[ |H_1^\theta - H_2^\theta| \]

\[ f_1^A = \max_\theta \left\{ \frac{1}{2} \sum_{i=1}^{nbins} |H_1^\theta(i) - H_2^\theta(i)| \right\} \]
Example

\[ f_1^A = 0.5300 \]

\[ f_1^A = 0.0960 \]
Proposed Features: Asymmetry

\[ f_2^A = \frac{\text{area}(S_{\text{low}} \oplus S_2)}{\text{area}(S_{\text{low}} \cup S_2)} \]  

(Updated)
Proposed Features: Asymmetry

\[ f_2^A = \frac{\text{area}(S_{low} \oplus S_2)}{\text{area}(S_{low} \cup S_2)} \]

(Updated)
Example

\[ f_2^A = 0.1199 \]

\[ f_2^A = 0.0801 \]
Proposed Features: Asymmetry

Original Lesion

Major Axis ($L_1$)

Minor Axis ($L_2$)

\[ f_3^A = (A_1 - A_2)/A \text{ with respect to } L_1, \]
\[ f_4^A = (A_1 - A_2)/A \text{ with respect to } L_2, \]
\[ f_5^A = (A_1 - A_2)/A_2 \text{ with respect to } L_1, \]
\[ f_6^A = (A_1 - A_2)/A_2 \text{ with respect to } L_2. \]
Results

- 206 images from Dermatology Information System & DermQuest
- Linear Support Vector Machine
  - **Sensitivity**: % malignant cases identified
  - **Specificity**: % benign cases identified

<table>
<thead>
<tr>
<th>Description</th>
<th># features</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavalcanti (Asym)</td>
<td>11</td>
<td>71.43%</td>
<td>58.62%</td>
</tr>
<tr>
<td>Proposed (Asym)</td>
<td>6</td>
<td>79.83%</td>
<td>68.97%</td>
</tr>
</tbody>
</table>
Results

• 206 images from Dermatology Information System & DermQuest

• Linear Support Vector Machine
  
  – **Sensitivity**: % malignant cases identified
  
  – **Specificity**: % benign cases identified

<table>
<thead>
<tr>
<th>Description</th>
<th># features</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavalcanti (Asym)</td>
<td>11</td>
<td>71.43%</td>
<td>58.62%</td>
</tr>
<tr>
<td>Proposed (Asym)</td>
<td>6</td>
<td>79.83%</td>
<td>68.97%</td>
</tr>
<tr>
<td>Cavalcanti</td>
<td>52</td>
<td><strong>84.87%</strong></td>
<td><strong>78.16%</strong></td>
</tr>
</tbody>
</table>
Results

• 206 images from Dermatology Information System & DermQuest

• Linear Support Vector Machine
  – **Sensitivity**: % malignant cases identified
  – **Specificity**: % benign cases identified

<table>
<thead>
<tr>
<th>Description</th>
<th># features</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavalcanti (Asym)</td>
<td>11</td>
<td>71.43%</td>
<td>58.62%</td>
</tr>
<tr>
<td>Proposed (Asym)</td>
<td>6</td>
<td>79.83%</td>
<td>68.97%</td>
</tr>
<tr>
<td>Cavalcanti</td>
<td>52</td>
<td>84.87%</td>
<td><strong>78.16%</strong></td>
</tr>
<tr>
<td>Cavalcanti Modified</td>
<td>48</td>
<td><strong>86.55%</strong></td>
<td>75.86%</td>
</tr>
</tbody>
</table>
Results

• 206 images from Dermatology Information System & DermQuest

• Linear Support Vector Machine
  – **Sensitivity**: % malignant cases identified
  – **Specificity**: % benign cases identified

<table>
<thead>
<tr>
<th>Description</th>
<th># features</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavalcanti (Asym)</td>
<td>11</td>
<td>71.43%</td>
<td>58.62%</td>
</tr>
<tr>
<td>Proposed (Asym)</td>
<td>6</td>
<td>79.83%</td>
<td>68.97%</td>
</tr>
<tr>
<td>Cavalcanti</td>
<td>52</td>
<td>84.87%</td>
<td>78.16%</td>
</tr>
<tr>
<td>Cavalcanti Modified</td>
<td>48</td>
<td>86.55%</td>
<td>75.86%</td>
</tr>
<tr>
<td>New Feature Set</td>
<td>54</td>
<td>91.60%</td>
<td>80.46%</td>
</tr>
</tbody>
</table>

(Updated)
Conclusions

• High-level intuitive features (HLIFs) result in understandable, low-dimensional feature spaces
• Adding HLIFs to low-level features generates very high success metrics
• HLIFs are generalisable!
Future Work

• Design HLIFs to describe Border Irregularity, Colour Patterns
• Test on larger data set, more statistical meaning
• Diagnosis can be “queried” by doctor for rationale
• Saving more lives through early detection
Thank You!

ramelard@uwaterloo.ca
http://vip.uwaterloo.ca
Sources of Error

Missed malignant cases

Missed benign cases