Enhanced classification of malignant melanoma lesions via the integration of physiological features from dermatological photographs

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Outline

Background

Contributions to State of Art

Results

Conclusion and Future Work
Dermatological Images
ABCD(E) Visual assessment by dermatologist looking at the topologically visible features of the lesion before proceeding with biopsy.

- Asymmetry
- Border irregularity
- Colour variegation
- Diameter
- Evolution
Skin Cancer Diagnosis using Dermatological images

ABCD(E) The visual method suffers from:\n
▶ Clinician subjectivity
▶ Low sensitivity

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Skin Cancer Diagnosis using Dermatological images

Automated diagnostic methods utilize extractable features from dermatological images

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LLF  Low level image features ($S_L$)$^2$
  ▶ Numerous features extracted using existing image processing techniques

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**LLF** Low level image features ($S_L^2$)
- Numerous features extracted using existing image processing techniques

**HLIF** High level intuitive features ($S_H^3$)
- Features extracted for the specific application of being compared against ABCD(E) criteria

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Skin Cancer Diagnosis using Dermatological images

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- Numerous features extracted using existing image processing techniques

**HLIF** High level intuitive features ($S_H$)$^3$
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**PF** Physiological features ($S_P$)$^4$
- Extracting physiological features from lesion colour in dermatological photographs

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Skin Cancer Diagnosis using Dermatological images

Hybrid Models of feature sets have been proposed to improve classification accuracy

$S_C$ Combining the LLF and PFs proposed by Cavalcanti et al.

$S_{LH}$ Combining LLFs and HLIFs
Contributions to State of Art

1. Propose a novel physiological feature set for skin cancer classification in addition to PFs proposed by Cavalcanti et al.
2. Present a hybrid feature set that combines LLFs, HLIFs and PFs for improved skin cancer detection performance
Physiological Features

Anatomical knowledge of cutaneous skin cancer

- Overgrowth of melanocytes
- Non-uniform distribution of eumelanin and pheomelanin
- Angiogenesis leading to increased uptake of oxygenated blood
Physiological Features

Anatomical knowledge of cancer motivates the extraction of five features:

- $f_1$ mean eumelanin concentration inside the lesion
- $f_2$ mean pheomelanin concentration inside the lesion
- $f_3$ variance of eumelanin concentration inside the lesion
- $f_4$ variance of pheomelanin concentration inside the lesion
- $f_5$ mean blood oxygen saturation inside the lesion
Physiological Feature Extraction

Generate an inverse nearest neighbour model; extension of Cavalcanti et al.

**Step 1** Using a biophysically-based spectral model for simulating light-human skin interaction proposed by Krishnaswamy and Baranoski\(^5\), varying eumelanin, pheomelanin and blood oxygen saturation levels to produced forward model

**Step 2** Use a nearest neighbour approach for the inverse model to estimate eumelanin, pheomelanin and blood oxygen levels on a pixel-by-pixel basis

Concentration Maps

(a) Dermatological photograph

(b) Eumelanin map

(c) Pheomelanin map

(d) Blood oxygen sat. map
Experimental Setup

To determine the performance of the hybrid feature set with the novel physiological features:

- DermIS\textsuperscript{6} and DermQuest\textsuperscript{7} databases
  - 206 confirmed cases
  - 87 negative cases
- Illumination correction for skin cancer images applied \textsuperscript{8}
- Randomly sampled: 90\% for training and 10\% for testing
- Bayesian classification scheme to assess separability of the classes
- Classes are modelled as conditional multivariate normal distributions
- Testing repeated 50 times

**Classification Results**

Table: Summary of classification results between Cavalcanti *et al.* ($S_C$) and $S_{LP}$.

<table>
<thead>
<tr>
<th>Feature set</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Precision</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_C$</td>
<td>81.60</td>
<td>71.23</td>
<td>81.06</td>
<td>77.71</td>
</tr>
<tr>
<td>$S_{LP}$</td>
<td><strong>84.02</strong></td>
<td><strong>72.40</strong></td>
<td><strong>81.97</strong></td>
<td><strong>79.62</strong></td>
</tr>
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</table>
Table: Summary of classification results from the different feature models.

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<thead>
<tr>
<th>Feature set</th>
<th>Sensitivity</th>
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<th>Precision</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_L$</td>
<td>84.95</td>
<td>70.69</td>
<td>80.93</td>
<td>79.00</td>
</tr>
<tr>
<td>$S_{LP}$</td>
<td>85.96</td>
<td>75.47</td>
<td>83.62</td>
<td>81.76</td>
</tr>
<tr>
<td>$S_{LH}$</td>
<td>85.94</td>
<td>72.07</td>
<td>81.45</td>
<td>80.10</td>
</tr>
<tr>
<td>$S_{LHP}$</td>
<td><strong>87.73</strong></td>
<td><strong>76.34</strong></td>
<td><strong>84.38</strong></td>
<td><strong>83.05</strong></td>
</tr>
</tbody>
</table>
Conclusion and Future Work

We have demonstrated improved skin cancer classification performance with the inclusion of additional physiological features and combining LLFs, HLIFs and PFs into a hybrid feature set.

Future work:

- Identifying feature contributions and either removing and/or adding additional features for improving classification performance.
- Testing rigorously with more advanced classifiers to assess classification performance and prove significance.
Funding and Questions

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References


