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

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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

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Outline

- Clinical/Research Background
- Features
- Experiments
- Conclusions and Future Work

Clinically: ABCD

- **A**symmetry
  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

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Clinical Decision Support System

Segmentation

Feature Extraction

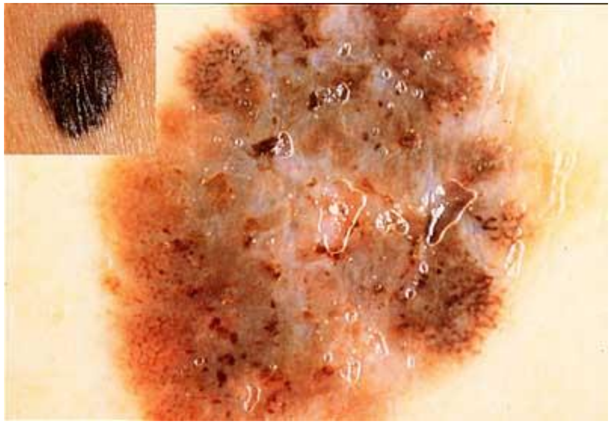
- Asymmetry
- Border Irregularity
- Colour Patterns
- Diameter

Classification

Malignant
Benign

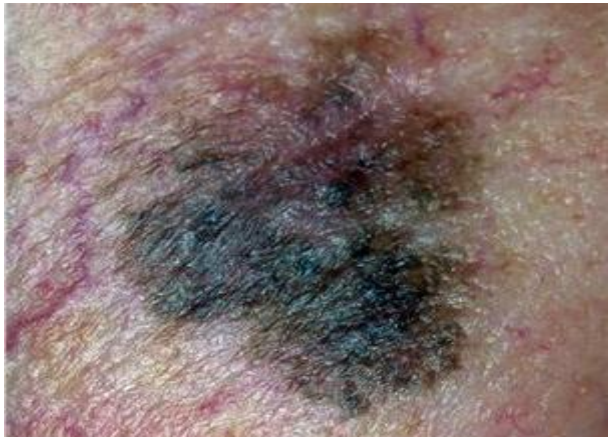
Prior Work

- Dermoscopic images
  - Most prominent in literature
  - Limited clinical use*



Source: www.medilor.be

- Standard images
  - Very new
  - Low barrier to adoption
  - Technical challenges



*Engasser & Warshaw 2010

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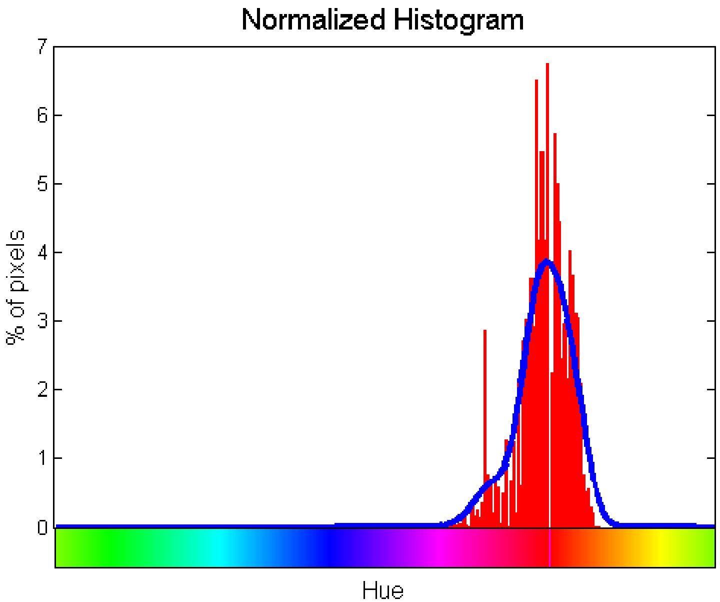
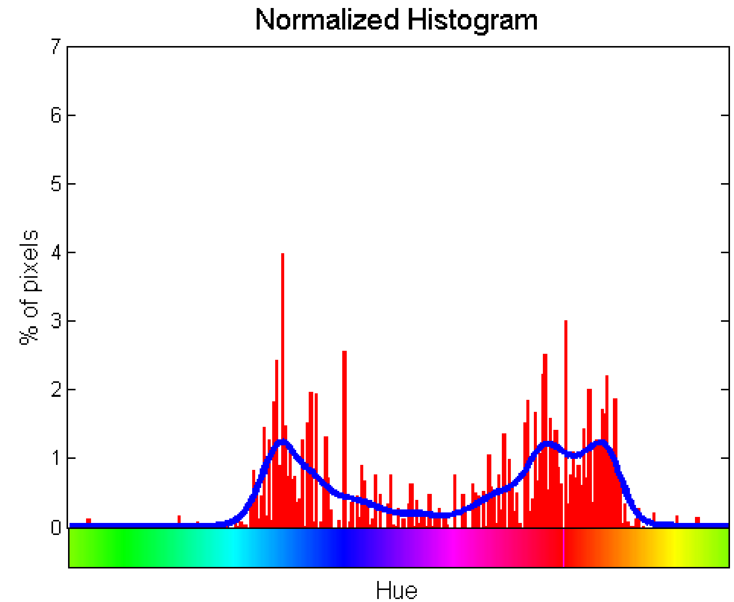
What is State of the Art?

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

*Cavalcanti et al. 2011

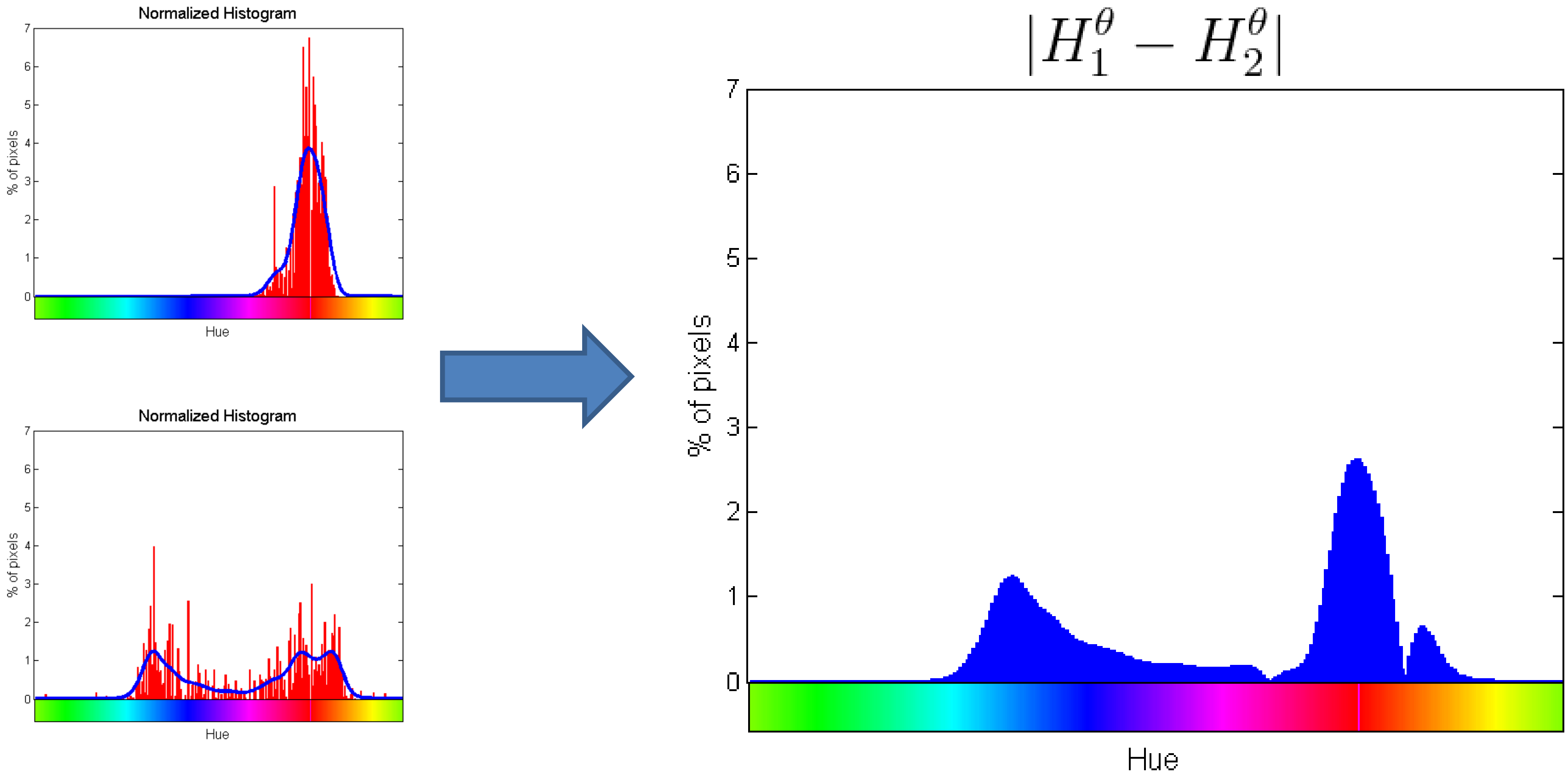
Proposed Features: Asymmetry





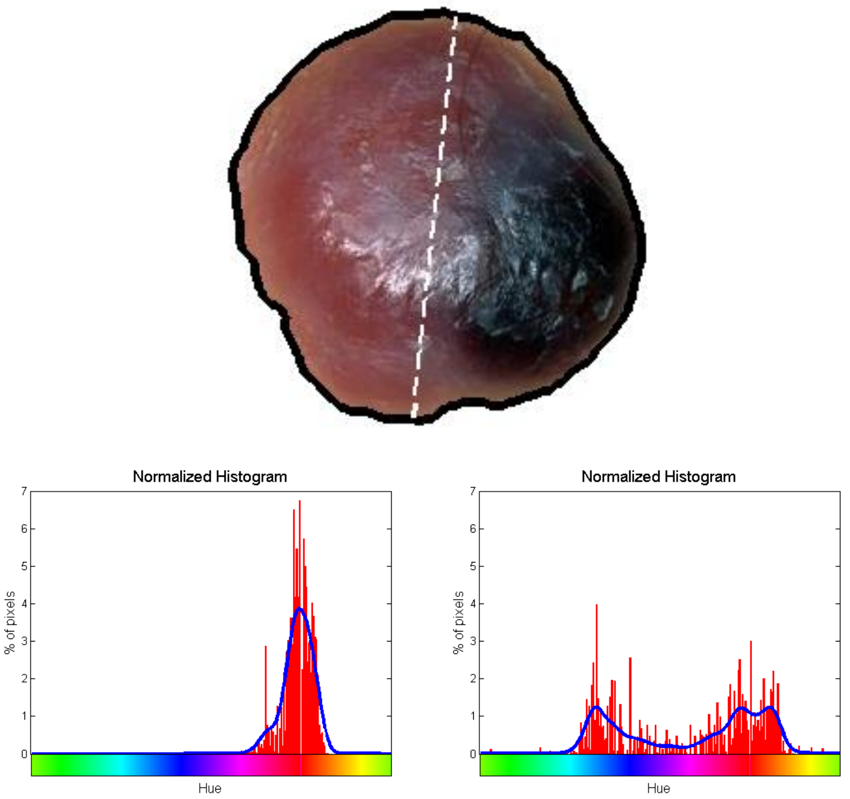
$$f_1^A = \max_{\theta} \left\{ \frac{1}{2} \sum_{i=1}^{nbins} \left| H_1^{\theta}(i) - H_2^{\theta}(i) \right| \right\}$$

Proposed Features: Asymmetry

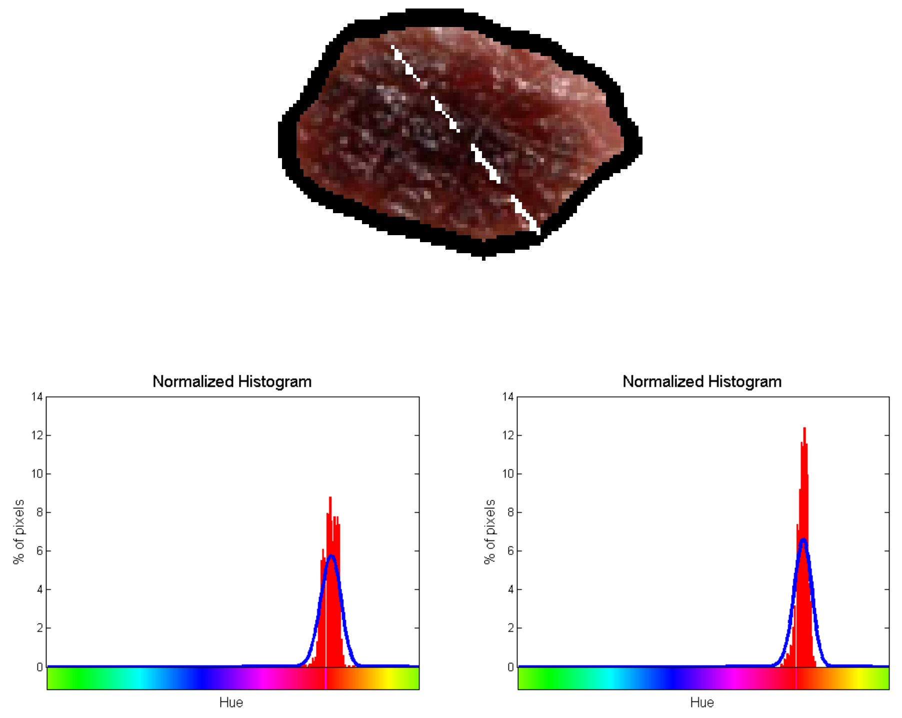


$$f_1^A = \max_\theta \left\{ \frac{1}{2} \sum_{i=1}^{nbins} |H_1^\theta(i) - H_2^\theta(i)| \right\}$$

Example

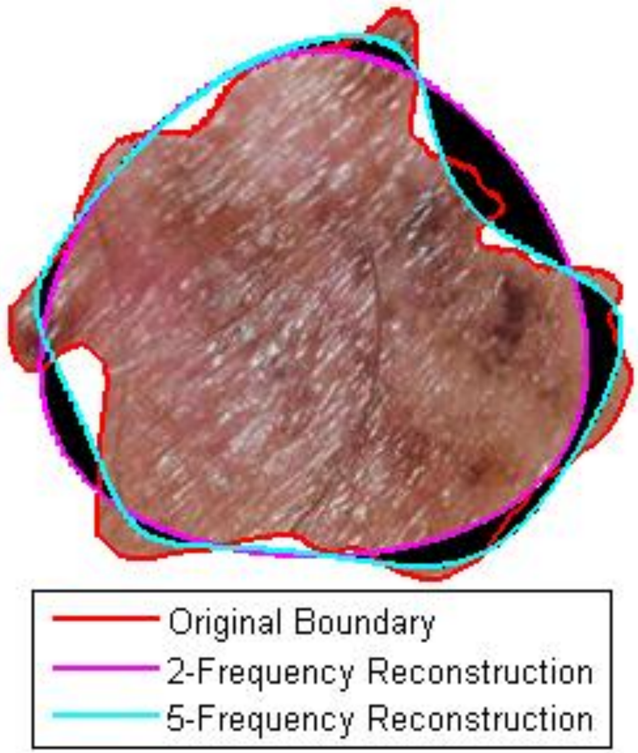


$$f_1^A = 0.5300$$



$$f_1^A = 0.0960$$

Proposed Features: Asymmetry



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

(Updated)

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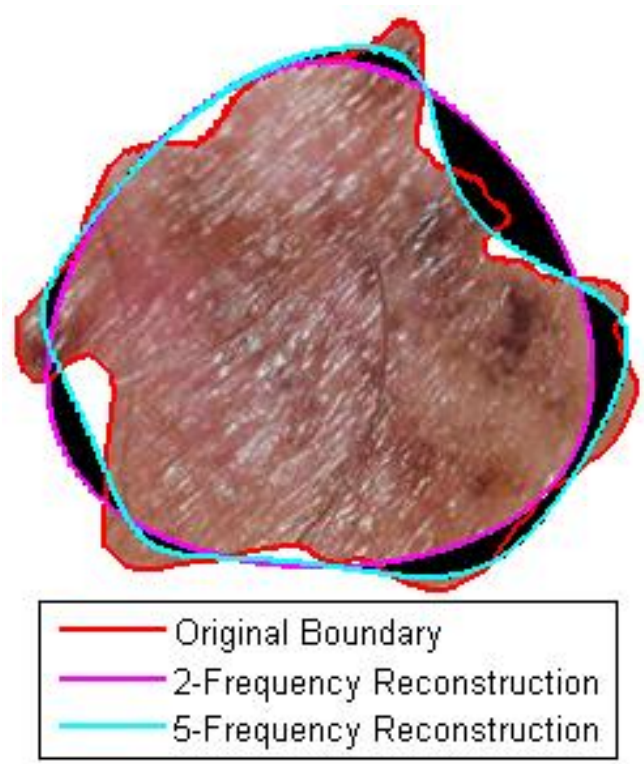
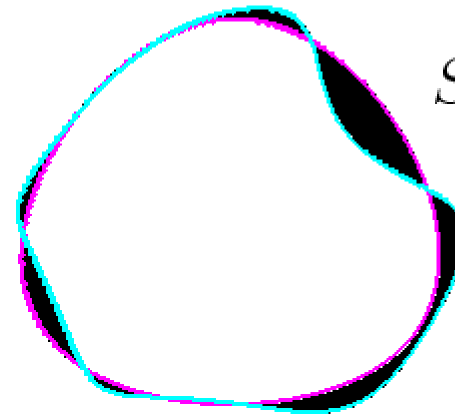
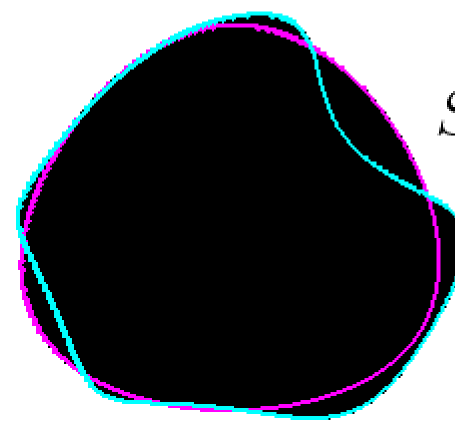
Proposed Features: Asymmetry





$S_{low} \oplus S_2$



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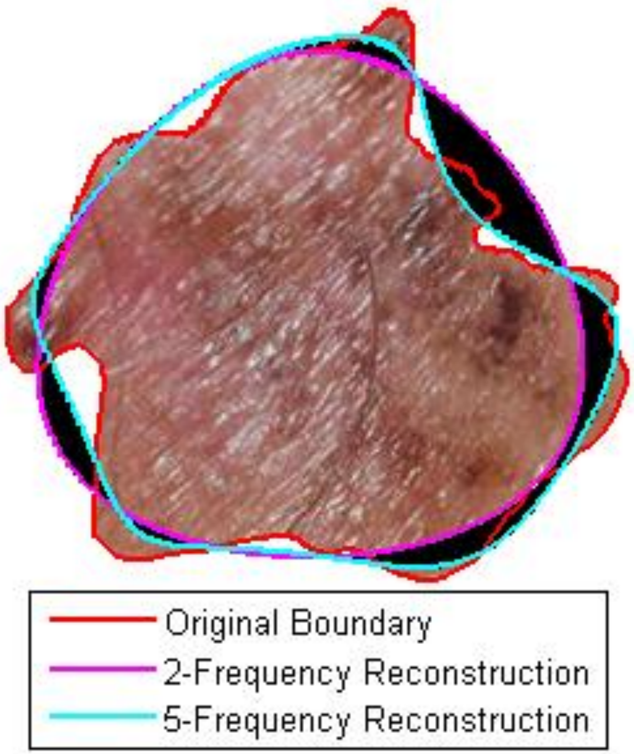
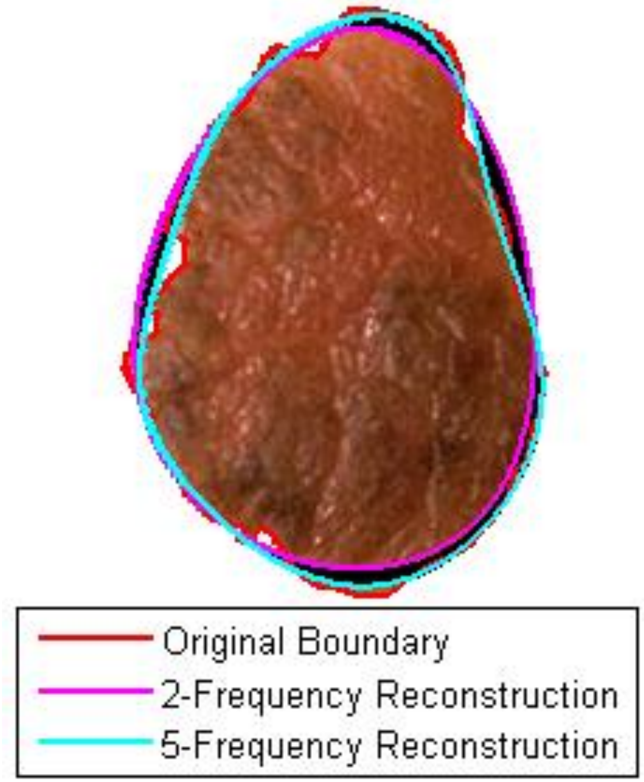


$$f_2^A = 0.1199$$



$$f_2^A = 0.0801$$

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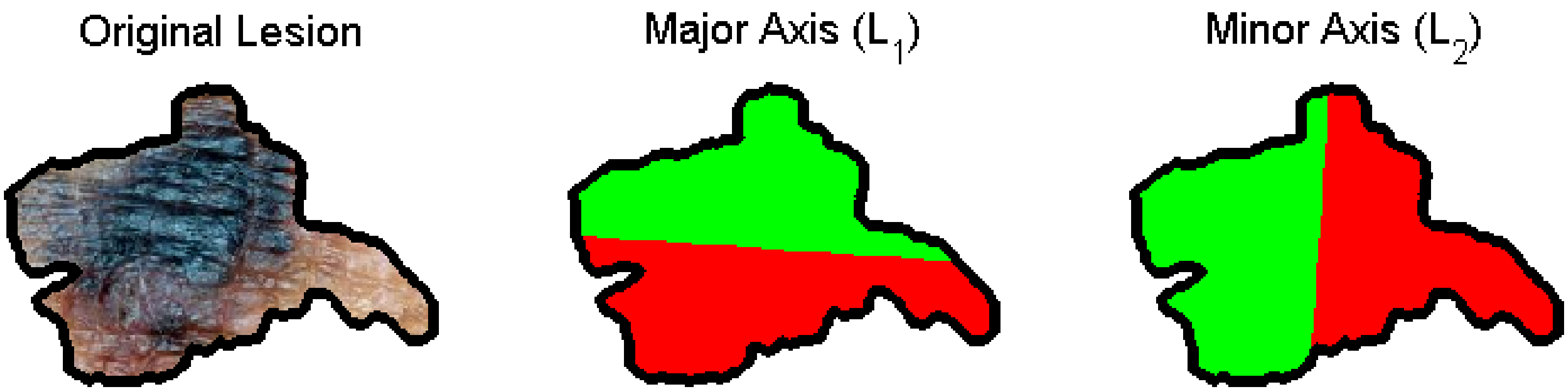
Proposed Features: Asymmetry



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

Results

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

Description	# features	Sensitivity	Specificity
Cavalcanti (Asym)	11	71.43%	58.62%
Proposed (Asym)	6	**79.83%**	**68.97%**

(Updated)

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(Updated)

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New Feature Set	54	**91.60%**	**80.46%**

(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!

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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!

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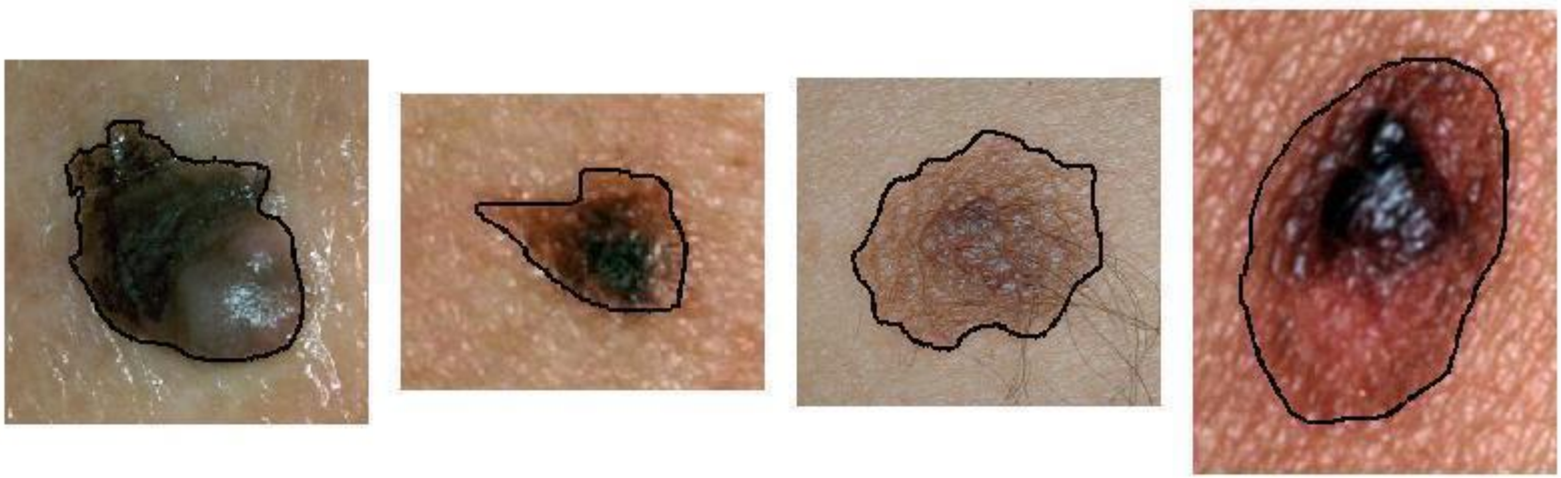
Sources of Error

Missed malignant cases



Missed benign cases