Project Title

Development of an Explainable Artificial Intelligence Model for Asian Vascular Wound Images

Project Lead and Members

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Organisation(s) Involved

Woodlands Health, Tan Tock Seng Hospital, AITI Solutions and Nanyang Technological University (Lee Kong Chian School of Medicine)

Healthcare Family Group(s) Involved in this Project

Medical, Nursing, Administration

Applicable Specialty or Discipline

General Surgery, Nursing

Project Period

Start date: Not Applicable

Completed date: Not Applicable

Aims

To develop an explainable AI model for analysing Asian Vascular wound images

Project Attachment

See poster attached/below

Background

See poster attached/below

Methods

See poster attached/below

Results

See poster attached/below

Lessons Learnt

See poster attached/below

Conclusion

See poster attached/below

Additional Information

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Project Category

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Development of an Explainable Artificial Intelligence Model for Asian Vascular Wound Images

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INTRODUCTION

- Chronic wounds contribute to significant healthcare and economic burden worldwide.[1,2]
- The course of wound healing can have varying trajectories given the complex and dynamic nature of wound care, and there can be significant variability in the assessment and management across different healthcare professionals.
- Commercial wound imaging systems are available[3] and can be used as adjuncts in the assessment and monitoring of chronic wounds.
- However, they can be costly to implement and difficult to tailor to specific patient populations.
- The use of artificial intelligence (AI) and machine learning is a promising tool to provide individualized and data-driven outcomes in wound care. [4,5]
- The use of explainable AI (XAI) modelling can help with its integration and acceptance in healthcare systems. [6]

AIM

- To develop an explainable AI model for analysing Asian Vascular wound images

METHODOLOGY

- We utilized 2957 wound images from a vascular wound image registry from a tertiary institution in Singapore to train, validate, and test our AI model
- A total of 2539 images were used for wound classification, comprising 1212 (47.7%) VLU, 1002 39.5%) NIU, 203 (8.0%) SSI, and 122 (4.8%) PU
- Of 2957 images, 2367 (80.0%) were utilized as training images, while 295 (10%) used for validation and 295 (10%) used for testing
- Annotation of the images were performed on an in-house program (AITIS Image Annotator Version 1.1.1.0, 2021)
- Image annotation included the following:
    1. **Wound type**
    2. **Anatomical location of wound**
    3. **Wound segmentation** (total of 18 pixel classes)
- A web browser application was developed to demonstrate results of the wound AI model with explainability
- After development, the model was tested on additional 15476 unlabeled images to evaluate effectiveness.

RESULTS

		Accuracy (%)	F1 Score	AUROC
Validation Statistics	Classification	96.3	0.96	
	Measurement (depth)	92.6	0.93	
	Measurement (width and length)	87.8		
	Wound Segmentation	88.7		
Test (Final Model) Statistics	Classification	95.9		0.99
	Measurement (depth)	85.0		0.97
	Measurement (width and length)	87.1		0.92
	Wound Segmentation	87.8		0.95

Table 1. *Summary of model results*

		Confidence Score (%)	Explainability Score (%)
Wound Classification	Overall, Mean	82.8	
	NIU	86.8	54.7
	SSI	94.9	76.6
	VLU	75.2	39.0
	PU	66.6	73.0
Measurement (Depth)	Deep	75.9	90.3
	Dermal	93.3	67.8
	Epidermal	61.4	23.7
Measurement (Width and length)		93.0	76.6
Wound segmentation		82.9	72.1

Table 2. *Summary of model results on unlabeled images*

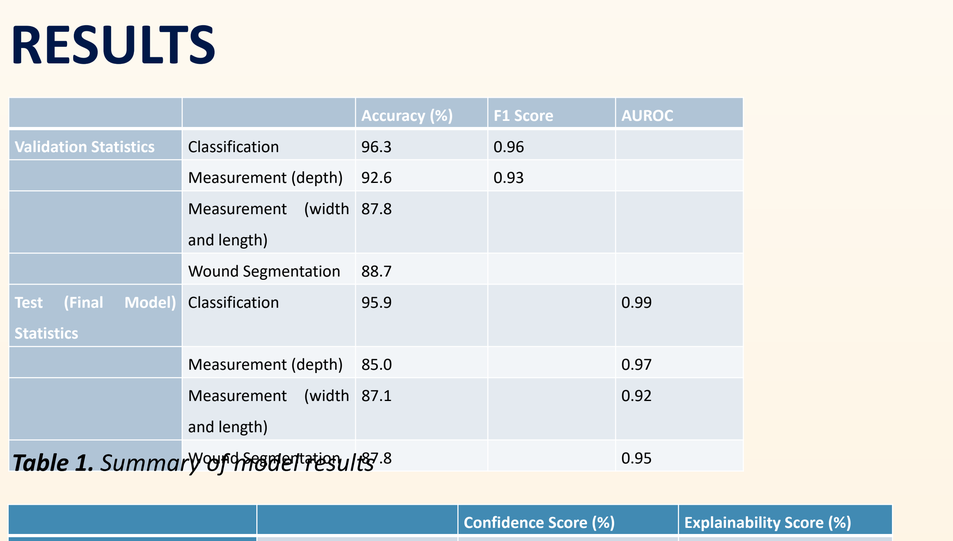

Figure 1. *Demonstration of AITIS Wound App showing model results, accuracy and explainability*

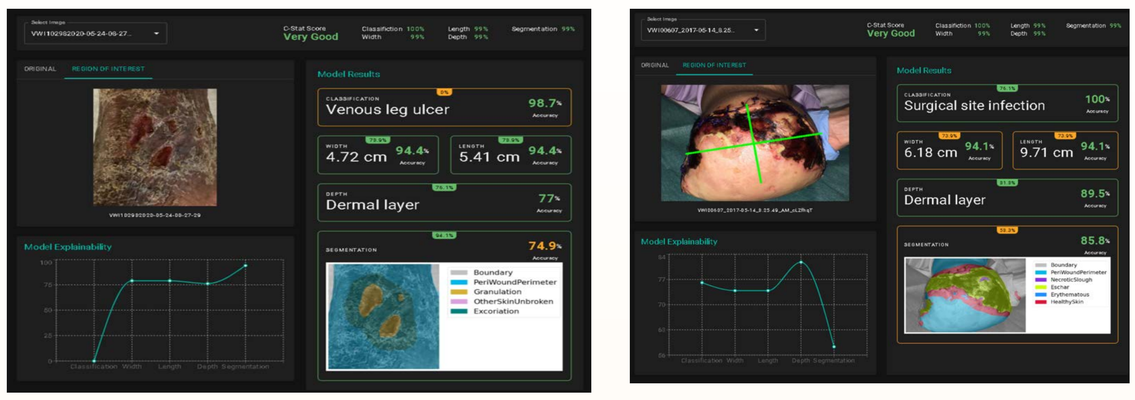

Figure 2. *Further Demonstration of AITIS Wound App showing model explainability in domains of classification, wound measurement, and segmentation.*

- The web application allows the end-user to upload images locally and presents to the user results of wound classification, wound measurements, and wound segmentation with accuracy of the model results and confidence of explainability
- The model achieved average area under Receiver Operating Characteristic (AUROC) of 0.99 for wound classifications with a mean accuracy of 82.65% and explainability of 60.32%.

DISCUSSION

- Wound care starts with accurate wound assessment and documentation, and wound characteristics have been shown to predict eventual wound outcomes.
- Imaging technologies can help to provide measurements of the optical properties of wound components, which can be analyzed and interpreted to assess wound severity, healing potential and progress in a rapid, objective, and non-invasive manner
- Previous studies have reported the use of AI in wound assessment[7] but are limited by data size and applicability outside their population set.
- The commercial systems currently available with good inter-rated reliability often require the use of proprietary equipment or software.
- The training of our model with a large number of wound images from a multi-ethnic population enhances its applicability in wound care in the tropics.

CONCLUSION

- Using explainable AI models, we have developed an application for analysis of wound images from an Asian cohort with accuracy and explainability.
- It can be applied for wound classification, automatic estimation of width, length, and depth, as well as wound segmentation.
- With further data and development, it can be utilized as a clinical decision support system and integrated into existing healthcare electronic systems.
- Other applications include use for wound care education and as a patient empowerment tool to improve confidence in wound assessment.

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