

An Image-Based Wounds Assessment Model for Pressure Injuries with Artificial Intelligence in Hospital Practice

Chun Chia, Chen^{1, 2} Tsung-Yu, Tseng³

Department of Plastic Surgery, Chi Mei Medical Center, Tainan, Taiwan¹

Wound Center, Chung Shan Medical University Hospital, Taichung, Taiwan²

Department of Industrial Engineering and Engineering Management, National Tsing Hua University, Hsinchu, Taiwan³

Abstract

In a modern healthcare system, the pressure injuries are still a serious challenging in in-hospital patients. In hospitals, nurses are responsible for pressure injuries assessment. However, a comprehensive wound assessment is time-consumption and depends on nurses’ experience. However, their assessment validity is insufficient to initiate targeted therapeutic strategy for each patient. The use of image-based artificial intelligence in wound assessment with machine learning techniques can be a promising strategy to provide automated clinical information and decision-making assists. Future research will provide more accurate definitions of the ambiguity of wound characteristics and the relevant information on the proportion of different tissues in the wound, in order to improve the accuracy of the identification; it can also enable the treatment assistance system using this classification model to immediately remind the medical staff when the symptoms of the pressure injuries are improved or worsened, and make corresponding adjustments in the treatment methods and medication, so as to make further contributions to clinical treatment and to reduce nursing’s burdens.

Background:

In a modern healthcare system, the pressure injuries are still a serious challenging in in-hospital patients, especially in the elderly. Although the occurrence of pressure injuries is not a direct reason of mortality, it increases duration of hospital stay, morbidity, nursing burden and healthcare costs significantly. In hospitals, nurses are usually responsible for pressure injuries assessment using several kinds of assessment tools. However, a comprehensive wound assessment is time-consumption and depends on nurses’ experience. However, their assessment validity is insufficient to initiate targeted therapeutic strategy for each patient and resulted in wound progressing. The use of image-based artificial intelligence in wound assessment with machine learning techniques is an ideal strategy to provide automated clinical information to make a therapeutic decision, instead of a specialist’s consultation [1, 2, 3]. The purpose of this study was to demonstrate a machine learning model for pressure injuries wound assessment which included feature variables that can assist clinicians to make a therapeutic decision for in-hospital patients by nurses who routinely input the image data to electronic health records. We also compared different machine learning models to create an efficacious model.

Materials and Methods:

Image data were collected from electronic health records in a single hospital. The assessment for each image of pressure injury wound was evaluated by two experts. Initially, the dataset has a total of 561 images of pressure injury wounds, which the images are grouped into six categories as stage I, II, III, IV, deep tissue injury (DTI) and Unstageable. The methodology of this study can be divided into three stages: data pre-processing, image recognition and evaluation methods. The scheme was shown in Figure 1 and algorithm in Figure 2.

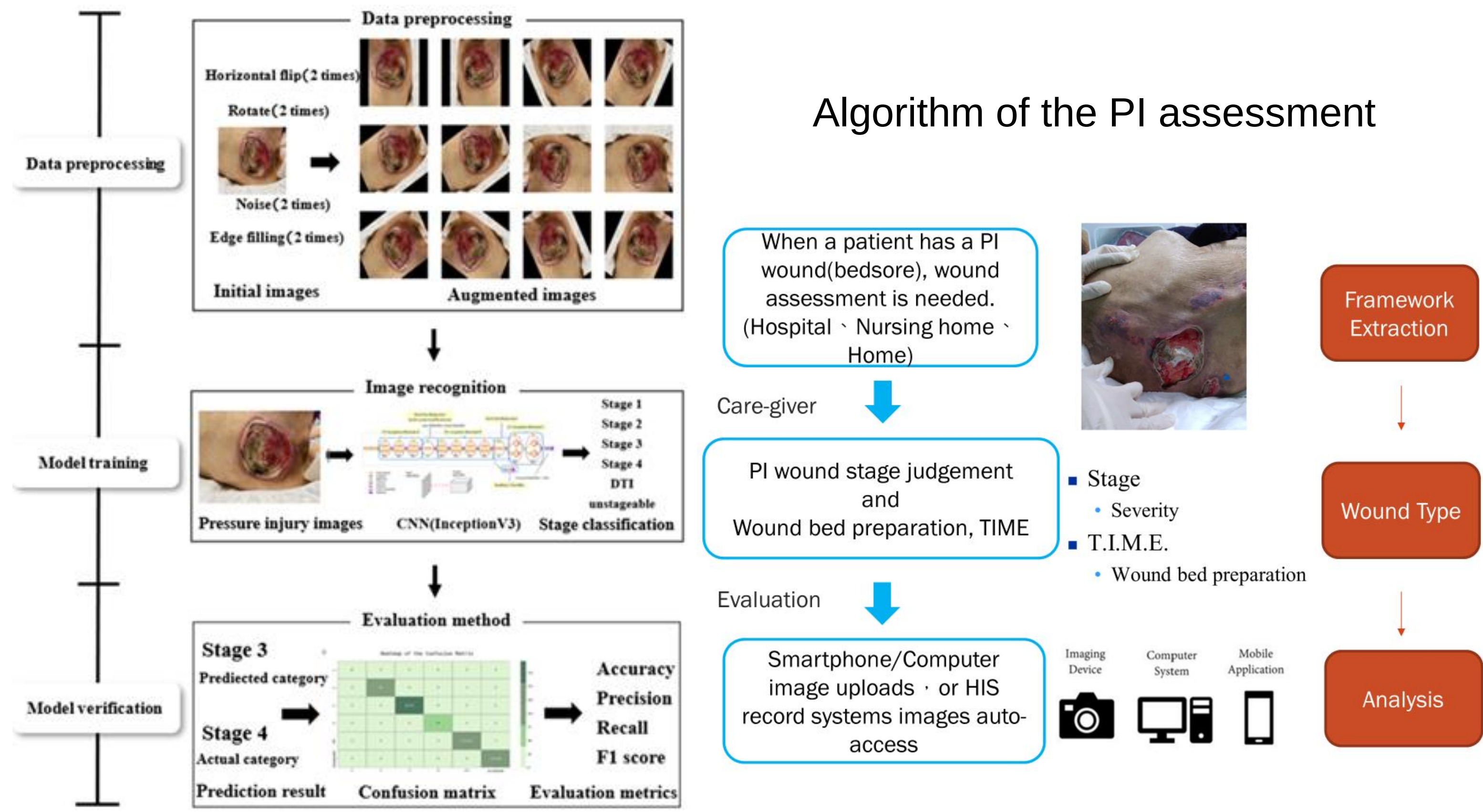


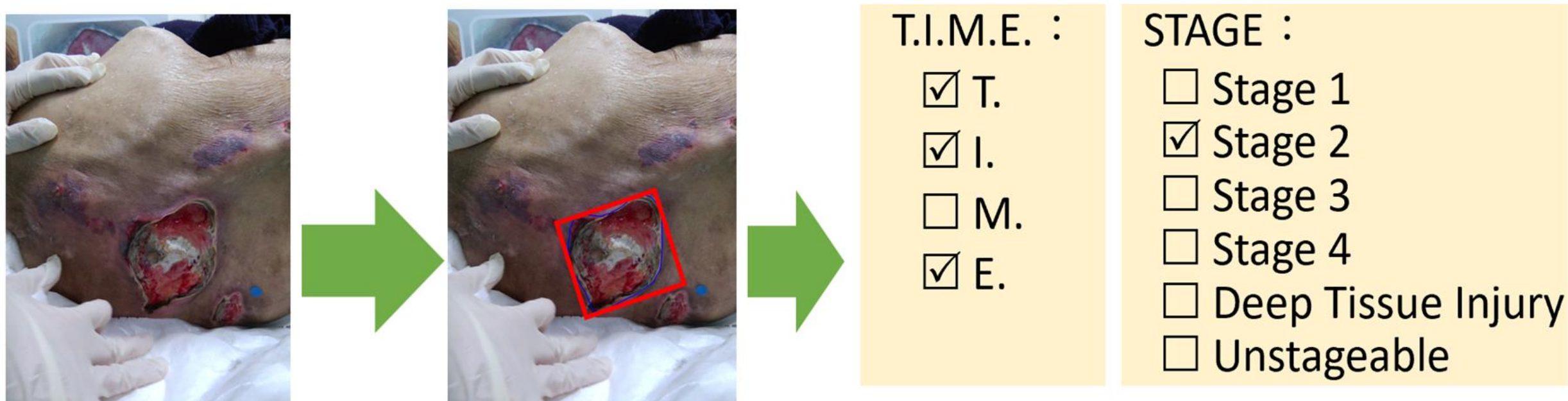
Figure1 & 2: Section 2.1 is the procedure of data preprocessing. Section 2.2 is the training of the image recognition model, which we introduce the image recognition model used in the method and its principle. Section 2.3 is the evaluation of model performance using some common metrics.

References:

- Sofia Zahia, Begonya Garcia-Zapirain, and Adel Elmaghraby. 2020. Integrating 3D model representation for an accurate non-invasive assessment of pressure injuries with Deep Learning. Sensors 20, 10 (2020), 2933.
- Che Wei Chang et al. 2022. Deep Learning Approach based on superpixel segmentation assisted labeling for automatic pressure ulcer diagnosis. PLOS ONE 17, 2 (2022).
- Mengyao Jiang et al. 2021. Using machine learning technologies in pressure injury management: Systematic review. JMIR Medical Informatics 9, 3 (2021).
- Gerald S. Lazarus et al. 1994. Definitions and guidelines for assessment of wounds and evaluation of healing. Wound Repair and Regeneration 2, 3 (1994), 165–170.
- Shuxin Li, Ali H. Mohamedi, Jon Senkowsky, Ashwin Nair, and Liping Tang. 2020. Imaging in chronic wound diagnostics. Advances in Wound Care 9, 5 (2020), 245–263.
- Raelina S. Howell et al. 2021. Development of a method for clinical evaluation of Artificial Intelligence–Based Digital Wound Assessment Tools. JAMA Network Open 4, 5 (2021).
- Gojiro Nakagami et al. 2021. Supervised machine learning-based prediction for in-hospital pressure injury development using electronic health records: A retrospective observational cohort study in a University Hospital in Japan. International Journal of Nursing Studies 119 (2021), 103932.

Table1. Evaluation indicators for each category of the best classification results of pressure injuries

	Precision	Recall	F1 score
Stage 1	1.0000	0.8000	0.8889
Stage 2	0.8750	0.8750	0.8750
Stage 3	0.8421	0.9412	0.8889
Stage 4	0.8571	1.0000	0.9231
DTI	1.0000	0.8333	0.9091
Unstageable	1.0000	0.8571	0.9231
Total Accuracy		0.8947	
Average F1 score		0.8949	



Figures 3: PI was evaluated automatically staging and classification.



Figures 4: Clinician interface phone and portal showed the final AI-assisted images, staging and classification.

Discussion

Chronic wounds represent a worldwide problem and an impacted Medicare beneficiary for laboratory and clinical research to adequately address this problem. Therefore, the assessment of a wound in the environment in which it occurs is essential for diagnosis, treatment, management, and study [11]. Although significant progress has been made in the development of wound treatments recently, very few advances have been made in wound diagnosis [12]. With the development of artificial intelligence, image–based wound assessment and pressure injuries prediction tools emerged rapidly in recent years [3]. However, the insufficient validity is still concerned about their performance in helping clinicians obtain accurate wound assessments to guide clinical care [13]. Using machine learning models on routinely collected electronic health records data, successful prediction in pressure injuries development during hospitalization was described [14].

In this study, we sued to optimize out machine learning models. In the past literatures, it has rarely been mentioned to be used in assessing pressure injury wounds. In this study, it’s successfully to develop an ideal machine learning model for the assessment of pressure injury wounds.

Summary:

Pressure injuries remain a serious challenge for hospitalized patients in a modern healthcare system. This study aimed to develop a visual artificial intelligence approach for assessing pressure injuries in inpatients using images from electronic health records. By the methods we adopted, pressure injury staging classification is successfully integrated with our artificial intelligence wound assessment model. With this proposed model, physicians and wound care providers could reduce nursing burdens and increase wound assessment accuracy.