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Segmentation of Pressure Ulcer Images for Estimation of Wound Status Using Residual Convolutional Neural Network

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***Abstract*— This study developed a segmentation method for pressure ulcers. To manage the wound in telemedicine approaches, we suggest a segmentation for automated size measurement of different tissues in the wound. We discovered U-Net structures are appropriate for the multi-way classification of pressure ulcers and show high enough accuracy.**

I. Introduction

A pressure ulcer is an injury with open skin usually caused by long-term pressure to the skin and underlying tissue [1]. Patients with mobility problem are at the high risk from the injuries and it makes difficult to come to the hospital frequently, which indicates the importance of telemedicine in wound care especially in the recent pandemic. To provide periodical assessment and prevent deterioration of wounds, current telemedicine requires patients to send their response to the questionnaire form to their telemedicine nurses. Measuring the wound size and assessing the wound status by patient or family will not be easy and accurate. Thus, we suggest a system that analyzes the wound image and provides wound size measurement and tissue size measurement automatically. In addition, the system would allow efficient data entry into the electronic medical record for better wound management.

II. Methods

In previous studies, the segmentation of wound area was done to mask only the wound area. And U-Net had been shown great performance for medical image segmentation. However, information of the existence of necrotic tissue, exposure of dermis, size of the wound, and depth of the pressure ulcers are necessary for the diagnosis. We examined U-Net and U-Net with residual connectivity [2]. Also, by repeating the convolutional layers in the process of encoding, the structure was expected to show better localization of segmentation using context of image [3].

Using 125 images of pressure ulcers, we replicated them in 40 different ways such as rotations, flips, Gaussian blur, changing gamma contrast, controlling hue, and saturation. With the small number of images, we tried to vary the color of the images as the photo of the wound can differ by various issues caused by the environment and skill of the user. For the training, 100 images were randomly chosen, and 25 images were used for testing.

In each image, pixels were labeled in non-skin, normal skin, erythema, dermis, mild necrotic tissue, severe necrotic tissue, and unknown depth.

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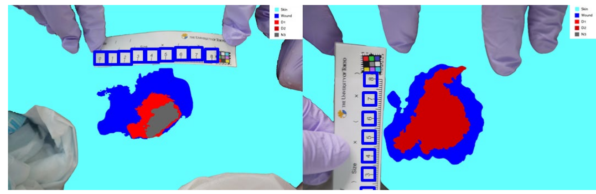

Figure 1. Example of output of the system

III. Results

The system could provide each size of the wound, and each tissue in the wound area (Fig. 1). Classification for Pressure ulcer area showed 92.1% using R2U-Net with recurrent convolutional units that following three sub-sequential recurrent convolutional layers (Table 1). Also, high accuracy showed in the classification of wound area of dermal exposure (91.0%) and necrotic tissue (94.5%). Based on this segmentation, the size of the wound area was calculated and recorded in each image by recognizing the distance of numbers in the ruler in the photos.

Table 1. U-Net structures tested for multi-way classification

Methods	F1-score	Accuracy	AUC
U-Net	0.913	0.912	0.907
RU-Net	0.919	0.919	0.909
R2U-Net_t2	0.918	0.919	0.908
R2U-Net_t3	0.921	0.921	0.909

IV. Discussion & Conclusion

In this study, wound tissue segmentation is developed with high accuracy. With this application, the user would need only a camera and a ruler to record the wound size without measuring or calculating the size. Further study is needed for more specific wound segmentation such as classifying the granulation tissues for accurate diagnosis.

References

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