

A Proposal for Automatic Inference of Pressure Ulcers Grade based on Wound Images and Patient Data

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Abstract. A Pressure ulcer (PU) occurs in a significant amount of patients that must remain in bed without movements for long periods. Data from patient concerning both their individual features and wound origin are collected. PU images and medical diagnosis about PU grade can be stored. Such sets of information can be submitted to data mining procedures in order to be detected some relations between data. It seems to be also possible computationally to generate a PU grade inference that will help medical experts to accomplish therapeutic procedures. Present proposal aims so to support PU diagnosis process and so to accelerate healing process towards important benefits for a better patient life quality with lower medical assistance costs.

1 Introduction¹

Many patients must remain a long time in bed without movement. In such cases pressure ulcers (PU) are very probable to arise. They are tissue necrosis developed when a soft tissue is compressed between an osseous prominence and a hard surface. [1].

Prevalence of PU in USA hospitals vary from 3% to 14%, increasing to 15% to 25% in rest homes. [2] In a study carried out in a Brazilian university hospital, percentages of presented PU cases found were 41.0% in the general intensive care unit, 39.5% in the surgical ward and 42.6% in the general practice ward. [3] The most afflicted areas are the skin regions where there is a smaller quantity of muscular tissue next to osseous prominences, such as sacrum, large trochanter, scapula, lateral

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malleolus, thoracic column, heels, occipital, knees, ischial tuberosities and lateral epicondyles. [1] [4].

Data from patient concerning both their individual features and the wound origin are collected at the beginning of medical assistance. During such assistance it is possible periodically to capture PU images and medical diagnosis about PU grade. Such sets of information can be submitted to data mining procedures in order to be detected some relations between data. It seems to be also possible computationally to generate a PU grade inference that will help medical experts to accomplish therapeutic procedures. Present proposal aims so to support PU diagnosis process and so to accelerate heal towards important benefits for a better life quality for patients with lower medical assistance costs.

2 Basic Ideas

Medical assistance concerning PU patients are quite image dependent. They deliver considerable information for decisions about therapeutic procedures. Besides that information about the patient himself is necessary, because they can explain PU occurrence and evolution, and how the patient will respond to therapy. Such information amount and complexity can be too great to be always considered. This depends strongly on physician experience and available resources to perform new laboratory analysis.

In such context a computational tool that improves considerable data analysis seems to be very suitable. Indeed data mining techniques are widely used to process huge amount of data and to discover new relations between some object attributes. [5][6].

2.1 PU Evaluation

PU evaluation lies on visual information, say color and geometric features, and provide a diagnosis about PU grade and its evolution, and patient data. So PU expert needs periodically to have a PU image and additional data. Based on that he will decide about what kind of therapeutic procedures should be accomplished in order to heal the wound.

2.2 Specific PU Features

Roughly one can distinguish three parts in PU image, say, healthy skin, PU-border and PU-core. Image classification can reduce the image to three classes in correspondence to such parts and the following features can be considered to check its consistence

- a) PU-core is not a lengthy form;
- b) PU-core is usually somewhat red;
- c) PU-core is surrounded by PU-border;

- d) PU-border is usually somewhat light red;
- e) PU-border is surrounded by healthy skin
- f) There is no healthy skin inside PU-core;
- g) Usually PU do not occur one very close to each other

PU can be classified according to depth, in relation to the extension of the layer of tissue involved, in grades from I to IV, been that grade I manifests itself as a defined area of persistent hyperemia, grade II as a partial lesion which comprehends the epidermis, part of the dermis or both, grade III as loss of total cutaneous thickness involving subcutaneous tissue lesion or necrosis and grade IV as the destruction of all the skin's layers, sub-cutaneous and muscular tissue. [7][8][9].

2.3 Features Relations Mining

PU happens in human organisms with different features. So both structural data from patient as periodically captured features are determinant. It seems suitable to look for relations between such data in order to have some explanation about its evolution as well as to preview how PU will modify when some therapy is adopted.

3 Methods

The following steps will be performed to achieve the expected results.

3.1 Capture of PU Images and other Data from Patients

Images from PU can be captured with digital camera without any disturbance for patient. This should be done periodically with the more possible similar illumination, distance and resolution conditions, always including wound and area pattern in visual field.

Data from patient are collected at the moment they enter the hospital for medical assistance as well as periodically. The first ones include following subjects.

- Identification
- Neurological evaluation by Frankel scale
- Oxygenizing
- Blood circulation
- Thermal regulation
- Mucosa and cutaneous integrity
- Perception, learning, time and space orientation
- Nutrition and hydrating
- Secretion
- Sleep and rest
- Physical activities, locomotion, personal cares
- Hygiene and body cares

- Physical integrity
- Communication ability
- Leisure and entertainment
- Religiosity and life philosophy

Data that are collected periodically include the following subjects:

- Identification
- Wound classification
- Wound type
- Wound tissue
- Exsudate
- Wound picture
- PU border area
- PU core area
- PU grade

3.2 Preprocessing

Initially data form patients are being written in forms to be later digitized. The system will perform usual consistency procedures before data are charged in PU patient data base. This data base will periodically receive images from PU and will be actualized when any patient data need to be altered, for instance, when patients are allowed to leave the hospital. Images will be periodically captured by digital camera.

Each image will be separated in the images that correspond to blue, green and red bands. Because of texture peculiarities it may happen that isolated points distort parts of the images that belong to healthy skin, PU border or PU core. It was experimentally verified that it is possible to minimize such distortions by convolving each image with a 9x9 mean mask with Idrisi Software. [10] See Figs. 1, 2 and 3.

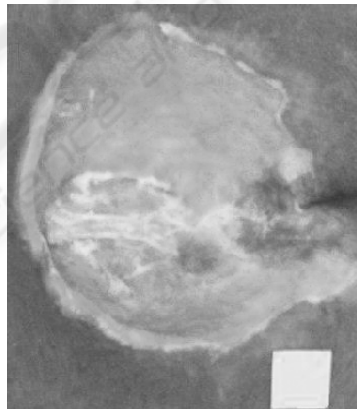


Fig. 1. Original RGB image.



Fig. 2. Isoclust classified image using RGB bands.



Fig. 3. Isoclust classified image after convolution with 9x9 mean mask.

PU area can be adequately estimated in a simple but non pure computational way. Indeed a recent study on Physiotherapy evaluated interobserver agreement and intraobserver reproducibility in PU area evaluation. [11] After PU images were captured they were exposed in a notebook monitor to 25 randomly selected people in university environment. The images had been imported to Motic Images Plus 2.0 ML Software for accomplishment of area evaluation through computational contour marking. The results show that computerized analysis this way presents a high interobserver agreement and intraobserver reproducibility. See an example of this method in Fig. 4.

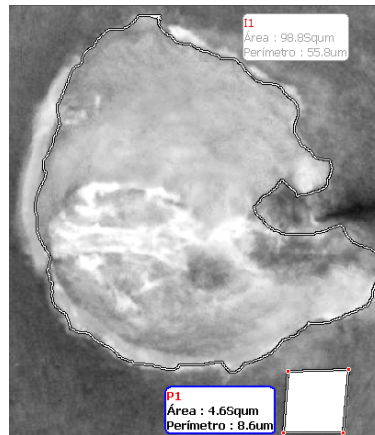


Fig. 4. PU contour marking.

3.3 Intermediate Processing

In order to automate UP area detection, preprocessed images can be classified by means of Isoclust algorithm in software Idrisi. It has already been possible to check its suitability for classification of PU images. [12] This classification procedure is based on Isodata and K-means classification procedures, consisting of an iterative process of class attribution to all the pixels, ending with a predetermined number of iterations or when a pre-determined maximum approximation is reached. [10] [13] This software presents a table with quantity of pixels per class, and each class area can be derived using an area pattern in the image. See Fig.5, 6 and 7.

3.4 High Level Processing

In Weka software data from a set of patients constitute a file that contains a list of attributes and instantiations of such attributes for every patient. So a decision tree can be build using a chosen machine learning algorithm, where PU grade is leaf attribute. It can happen that some attributes are not included in such decision tree because they are not relevant to determine the leaf attribute. System reports tree performance to find leaf attribute. Afterwards the system can identify clusters concerning PU and patient attributes. If the results are satisfactory the decision tree will be applied to new PU data and so be used to infer PU grade.

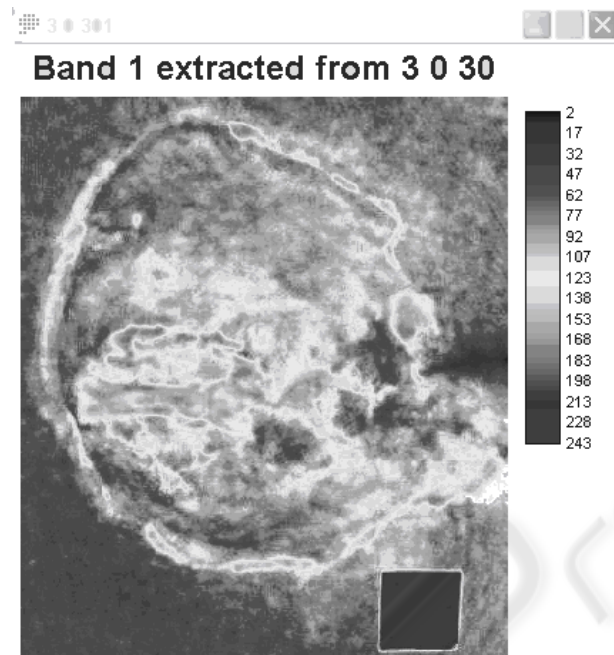
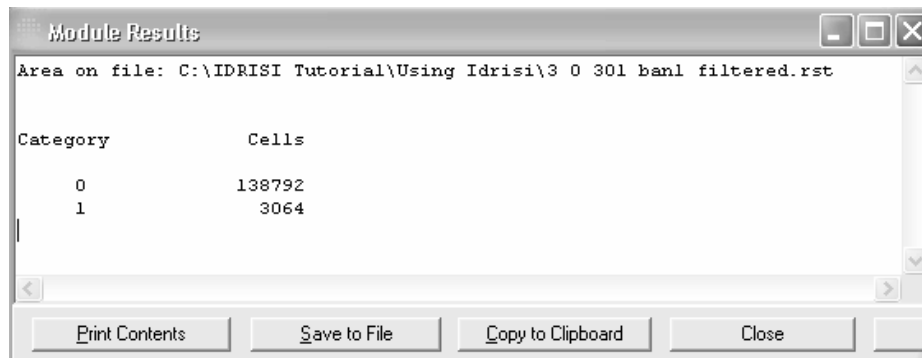


Fig. 5. Band B from original image with intensity scale.



Fig. 6. Enhancement of pixels greater than 198.



Category	Cells
0	138792
1	3064

Fig. 7. Amount of cells per class in last image.

Image and patient data will feed a training set in Weka software that has shown to be adequate after some tests [14].

4 Expected Results

So far a set of patient data is already available and data from other patients are being collected. It is yet necessary to refine the image processing program and to insert data in data mining software. The main results of present system proposal are inferences about PU grade, detection of clusters in U datasets and information providing for system feed-back after evaluation from PU experts.

5 Final Remarks

Present proposal was submitted to National Council for Scientific and Technological Development in Brazil (CNPq), restricted to PU patients in Brasília city. Later research efforts can refer to PU border analysis and encompass more complex PU types and patient population

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