Review : Wound Classification using Ensemble Deep CNN

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***Abstract*—Wounds are a challenge to healthcare systems around the world and affect many people's lives annually. Wound classification is a key step in wound diagnosis that would help clinicians to identify an optimal treatment procedure. Hence, having a high-performance classifier assists the specialists in the field to classify the wounds with less financial and time costs. The main difficulties in treating chronic wounds are overcoming the causes of delayed healing, which are essential elements of a thorough approach to wound care. After four weeks of normal care, wounds that don't heal enough should be evaluated for underlying pathology and the need for advanced therapeutic drugs. A Machine Learning based wound classification methods have been proposed in the literature. The proposed system classifies the given image according to the trained data set. We have trained a model for five generalized wound classes namely Burn, Hematoma, Abscessed/infectious, Abrasion and Incision/Cut/ puncture Wound. This model will classify the given input image into its corresponding class in ease. Certain management procedures will also be provided for assisting the wound care. In future where robotic treatment are to come, such models will be of great importance for practical implementations.**

Keywords- Deep Learning; Detection; Segmentation; Wound Management

I. INTRODUCTION

Any kind of scratch or break on the skin's surface is considered a wound. Burns, paper cuts, skin tears, surgical procedures, underlying diseases, or other skin problems that may manifest in the wound, such as eczema or psoriasis, can all result in wounds. Depending on the severity of a particular wound and the amount of time it will take for it to heal, wounds can be categorized in a variety of ways. Throughout their lives, people are likely to sustain several kinds of wounds while going about their regular business.

A wound can range in severity from mild to severe depending on the source, location, and depth. An injury may be open or closed. Open wounds, such as penetrating wounds, are wounds with exposed underlying tissue or organs that are accessible to the outside environment. Conversely, closed wounds are those that don't allow any of the underlying tissue or organs to be exposed. Depending on how long it takes for a wound to heal, it might be classed as acute or chronic. Acute wounds are those that mend smoothly and within the expected time frame. On the other hand, chronic wounds are ones that heal slowly and occasionally with complications. Additionally, the cleanliness or contamination of a wound can be used to classify it. In contrast to contaminated or infected wounds, which may contain dirt, bacteria, or other foreign elements, clean wounds are those that do not contain any foreign material or waste. Both internal and exterior wounds are possible. While external wounds may result from an outside force or trauma brought on by piercing objects or non-penetrating trauma, internal wounds may be the result of impaired circulation, nervous system functions, neuropathy, or other medical conditions, or from a decrease in the supply of blood, oxygen, or other nutrients.

II. DEEP LEARNING AND APPLICATIONS

A. Overview on Deep Learning

A part of machine learning is called deep learning. It is a neural network with numerous parameters and layers. Neural network architectures are used in most deep learning techniques. As a result, it is also known as deep neural networks.

For feature extraction and transformation, deep learning employs a cascade of numerous layers of nonlinear processing units. Higher layers learn more complex features derived from lower layer features, whereas lower layers adjacent to the data input learn simpler features. A hierarchical and potent feature representation is created by the architecture. This indicates that deep learning is well suited for examining and deriving knowledge from both massively enormous amounts of data and data gathered from many sources [01].

B. Deep Learning Applications

The following examples elaborate on a few of the more current and newer deep learning application developments:

i. One example of an application of deep learning in Big Data is Microsoft speech recognition (MAVIS). Using deep learning enables searching of audios and video files through human voices and speeches [02].

ii. Deep learning on Big Data environment is used by Google for image search service. They used deep learning for understanding images so that it can be used for image annotation and tagging that is further useful in image search engines and image retrieval as well as image indexing [02].

iii. The Deep Belief Network and Deep Boltzmann Machine (DBM) approaches can be used to implement medical domain subjects such as translational bioinformatics, medical imaging, pervasive sensing, medical informatics, and public health [03].

C. *Image sensing in Deep Learning*

Numerous automatic segmentation and registration techniques have been researched and put forward for application in clinical settings since medical images provide a wealth of information. Deep learning technology has been applied recently to analyze medical images across a number of sectors, and it excels in tasks like segmentation and registration.

Edge detection filters and a number of mathematical methods are the foundation of the traditional approach to image segmentation. using a variety of strategies, such as dependent thresholding and close-contour methods [04], to enhance the performance of targeted segmentation. As an alternative, segmentation registration was attempted [05]. DNNs, particularly CNNs, have been gradually introduced to enhance segmentation performance connected with medical pictures. The segmentation of tumors and other structures in the brain, lungs, biological cells, and membranes has been attempted [06]. Similar to traditional ML, these methods employed postprocessing and patch-based 2-dimensional CNN techniques. Patch-based methods can be trained, but it can take a while, and depending on how many patches are used, learning might not be achievable.

Deep learning networks have recently been repeatedly suggested for enhancing segmentation performance in medical imaging. Regression, registration, or multitasking with segmentation and classification all work together to improve segmentation performance [08]. Studies have been done to take label ambiguity into account when segmentation performance improves [07]. Additionally, semi supervised/unsupervised learning algorithms using unlabeled data have been suggested [09] due to the expensive expense of medical labelling. These studies are seen as having future relevance as a technique that can address the significant imbalances in medical imaging because they have not yet outperformed the segmentation performance of supervised learning.

III. CLASSIFICATION OF WOUNDS

A. *Burn*

The skin's direct contact with an open flame or a hot surface is what typically results in burn injuries. Contact with a heated liquid might result in scaling. Other types of burns include chemical burns brought on by potent acids or bases and radiation burns, the most well-known of which is a sunburn brought on by UV light. urns are classified by degree, where severity increases with a higher degree. Burns are divided into three groups under a more recent classification scheme: superficial, partial thickness, and full thickness burns. The third-degree burn is full thickness on the patient in the scenario. This typically causes the patient's skin to lose its outermost layer, or epidermis, leaving it feeling numb, hard, and leathery to the touch. Since burns of this severity do not heal on their own, quick medical intervention is necessary. The appearance of a black eschar at the location of the wound indicates that proteins at the injured spot denature and that cells eventually perish. The skin's homeostatic mechanisms are lost if the skin barrier is breached. Rapid loss of blood plasma and bodily fluids can occasionally result in swelling that is visible to the naked eye.

B. *Hematoma*

A blood collection outside of blood arteries is known as a hematoma. Hematomas are most frequently brought on by damage to a blood vessel's wall, which allows blood to leak into the nearby tissues. Any sort of blood vessel injury might lead to a hematoma (artery, vein, or small capillary). While a hemorrhage denotes active, ongoing bleeding, a hematoma typically indicates bleeding that has more or less clotted. Hematoma is a relatively frequent issue that many people deal with at some point in their lives. Hematomas can appear as various-sized reddish bruises under the skin or nails. Contusions are another name for skin bruises. Deep inside the body, where they might not be apparent, hematomas can also form. Hematomas can occasionally take the shape of a lump or mass that can be felt.

C. *Abscess*

A skin abscess is a sensitive lump that is typically bordered by a pinkish to deep red colored region. Abscesses are frequently detectable by touch. Infections are the primary cause of the great majority of them. They are filled with pus, germs, and debris inside. Painful and warm to touch, abscesses can show up any place on your body. Antibiotics seldom can't treat an abscess on their own, unlike other infections. In order to become better, an abscess typically needs to open up and drain. Sometimes draining happens on its own, but most of the time it needs to be opened by a doctor performing an incision and drainage surgery, or by a heated compress. Bacteria can penetrate the skin when the usual skin barrier is compromised, even by tiny injuries, small tears, or inflammation. As your body's defenses try to eradicate these pathogens through an inflammatory response (white blood cells = pus), an abscess may develop. An abscess can also be brought on by obstruction in a sweat or oil (sebaceous) gland, a hair follicle, or a cyst that already exists.

D. *Abrasion*

The skin rubbing against a rough surface can result in an abrasion, a specific kind of open wound. It could be described as a graze or a scrape. Abrasions are a relatively prevalent type of injury. From moderate to severe, they can exist. Since many of the skin's nerve endings might occasionally be exposed, abrasions can be painful. They rarely result in significant bleeding, though. Almost all abrasions are treatable at home. Most of the time, abrasion wounds are not as serious as laceration or incision wounds. These wounds often damage the deeper layers of the skin. They could result in significant bleeding and demand medical attention.

E. Cut or Incision

A cut made through the skin during surgery is known as an incision. A surgical wound is another name for it. There are both little and long incisions. The type of surgery you underwent will determine the size of the incision. A surgical wound is a cut or incision in the skin that occurs during surgery and is often created with a scalpel. A drain inserted during surgery may also result in a surgical wound. The size of surgical wounds varies widely. Sutures are typically used to close them, but they are occasionally left open during healing.

IV. RELATED WORKS

In this part, we examine earlier studies that classified wound images. An end-to-end DCNN-based categorization strategy has been used to structure the paper.

In [13], a two-tier transfer learning strategy was used to train the deep architectures MobileNet, InceptionV2, ResNet101, and InceptionResNetV2 for the deep learning-based classification methods. By transferring only the lower level features or all of the characteristics from a previously trained model to the new model, this method uses both partial and full transfer learning. The framework used was TensorFlow. For applications like classification, trained deep architectures were used after object localization algorithms like R-FCN and Faster R-CNN. The best model was said to be a combination of Faster R-CNN and InceptionV2.

In a different study, Goyal et al. classified diabetic foot ulcers using convolutional neural networks [14]. 397 photos from a DFU image dataset were displayed. To enhance the quantity of samples, data augmentation techniques were used. For patch-wise classification of the foot ulcers into normal or abnormal classes, they presented DFUNet, a deep neural network. The concept of joining the outputs of three parallel convolutional layers with various filter sizes was employed by DFUNet. According to the authors, by employing this concept, multiple-level characteristics were recovered from the input, leading to a network with increased discriminative strength. The proposed method's accuracy was reported to be 92.5 percent. The main problem with this research is that the patch classifier the authors suggested is not very useful for tasks involving the classification of medical images. Working with a whole-image classifier rather than a patch classification model is, in fact, more useful and makes more sense to physicians.

For the classification of venous ulcer images, Nilsson et al. suggested a CNN-based technique [15]. A VGG-19 network was used to categories the images into venous or non-venous categories. The used dataset had 300 samples. The pre-training of the VGG-19 network was done using a different dataset of dermoscopic images, and the network was subsequently fine-tuned using the related dataset. 85 percent, 82 percent, and 75 percent, respectively, were the results for accuracy, precision, and recall. The frameworks used were Caffe, TensorFlow, and Keras.

Deep convolutional neural networks were used by Alaskar et al. for wireless capsule endoscopy imaging to detect intestinal ulcers [10]. The input photos were divided into ulcer (abnormal) and non-ulcer (normal) categories using the AlexNet and GoogleNet architectures. The studies were carried out in a MATLAB environment, and the dataset included 1875 images taken from wireless capsule endoscopy video frames. For both networks, the authors reported perfect classification accuracy.

In a different study, Shenoy et al. suggested utilizing deep CNNs to classify wound images into several categories [12]. This study made use of a dataset that included 1335 wound photos that were gathered online and via smartphones. Nine separate labels were developed after pre-processing and augmentation, and for each label, two positive and negative subcategories were taken into account. Three distinct variations of the WoundNet network, which the authors modified from the VGG16 network, were pre-trained on the ImageNet dataset. Additionally, a different network called Deepwound, an ensemble model, was created to average the results from the three distinct WoundNet topologies. In Keras, the algorithms were put into practice. Additionally, a mobile phone application was developed to improve patient-physician dialogue and wound healing assessment.

A DCNN for binary categorization of diabetic foot ulcers was presented by Alzubaidi et al. [11]. This study offered a brand-new dataset made up of 754-foot photos taken with smartphones. The samples were to be divided into categories of normal or abnormal (DFU) skin. Using data augmentation techniques, normal and abnormal patches were isolated from the photos, and the number of samples was raised. The suggested network, DFU QUTNet, has 58 layers total, including 17 convolutional layers. The proposed model's width has grown in contrast to standard DCNNs while being computationally simple. The network would therefore be able to glean additional data from the input, increasing classification accuracy. DFU QUTNet was used as a feature extractor with SVM and KNN classifiers in one experiment and as an end-to-end classification task in another. The greatest reported F1-Score, which was derived from fusing DFU QUTNet and SVM, was 94.5 percent. Although creating a high-performance patch classifier can be a commendable feat, this research's drawback is that a complete picture classification system would be more helpful in clinical settings.

V. CONCLUSION

The importance of studying deep learning and machine learning is discussed in this paper. It has shown the progress of machine learning and deep learning as well as the applications that have been studied by researchers over the past few decades. A variety of frameworks are available and are explored for constructing any machine learning or deep learning application. Deep learning has numerous new areas of application. There is still a lot of room for research into potential applications for deep learning.

In recognition and computer vision tasks, deep learning has already demonstrated performance that is on par with that of humans. It is realistic to assume that healthcare practices may undergo some significant modifications as a result of these technological advancements. Instead than replacing doctors, when it comes to the application of AI in medical imaging, we believe that this technological advancement will operate as a collaborative tool in reducing the load and distraction from many mundane and repetitive duties. A good shared knowledge of AI technology and the best suitable clinical practice and workflow by doctors and computer scientists/engineers would be one of the important aspects for its development and proper clinical use in medicine. For the development of AI in the use of clinical picture data, there are a number of additional challenges, such as ethical, regulatory, and legal issues to resolve and overcome.

Now that we've reviewed the applications, we can study any of the more recent uses for deep learning, which will produce better outcomes and further the field's ongoing research. Given that research is still in its early stages, there is still room for developing new deep learning architectures. In addition, the sub-domain of analysis and prediction can be improved.

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