Detection of Bone Fracture Area Using Convolutional Neural Network

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Abstract

Diagnosis of the fracture site is done using CT-Scan images and based on the doctor's visual diagnosis. This work is very time-consuming and depends on the doctor and his expertise. Systemic methods can help doctors and specialists and can detect the fracture area and the fracture surface. In fractures, only the location of the fracture is determined, but if we want to diagnose the area, high expertise and experience is needed, or in some cases, MRI images are needed. Convolutional neural networks are very powerful in diagnosing diseases and medical complications and can diagnose them correctly. The high accuracy and ability of convolutional neural networks has made this method popular among researchers, and its use is becoming more widespread every day. In this method, fracture location and fracture depth were determined using convolutional neural network. In this work, first the fracture site and then the fracture area are determined. In this study, the location of hip fracture was detected with complete accuracy and the fracture area was obtained with 99.68 accuracy and 99.82% sensitivity. The obtained results indicate that the proposed method is a suitable method for fracture detection.

Keywords: bone fracture, convolutional neural network, aria detection, Pelvis fracture.

1. Introduction

Bone is a living tissue. Bone has blood vessels and living cells. Being alive is what allows it to grow and heal itself. Throughout life, the body's bone tissue is constantly absorbed by the corrosive cells in it (called osteoclasts) and at the same time new bone is replaced by osteoblast cells. In this way, the tissue of all the bones of the body is constantly being renewed [1]. In childhood and youth, bone formation is more than absorption, but in old age, bone is absorbed more than bone is formed, but even in the most severe cases of osteoporosis, the body does not stop building new bone and only its amount decreases. The highest amount of bone density is around the age of twenty [2].

Diagnosis of bone fracture is done by a specialist doctor using MRI and CT_Scan images. In the United States, 2.5 million fractures will occur in 2021. Pelvic fractures are the most serious fractures and the mortality rate is more than 20% per year [3]. More than 50% of patients with hip fracture are not able to return to their previous standing position and approximately 10% of them will need long-term care facilities. Three quarters of hip fractures

occur in women. After the age of 50, the risk of hip fracture during life is 20% higher for women [4]. Therefore, accurate and correct and timely diagnosis using computer methods is very important. The faster, less expensive and more accurate this method is, the more desirable it is. The purpose of this research is to accurately detect the location of the fracture and the fracture area using the convolutional neural network.

2. Related works

Fractures usually occur due to impact, and the more severe the impact, the greater the fracture. Hip fracture is one of the severe and slow healing fractures. Hip fracture occurs in two age groups. In young patients and elderly people, which is 70% more in elderly people than in young people, because the quality of their bones is disturbed [5]. Due to demographic changes, this second group is growing rapidly. While extensive research has been conducted on the nature, epidemiology, and treatment of hip fractures, older people are always at greater risk of hip fracture. CT-scan is a common method in fracture diagnosis. Pickhardt and colleagues have described a CT scan-based method for bone quality analysis. They were able to distinguish fracture and non-fracture with 90% accuracy [6].

Also, Chowdhury and his colleagues introduced a method to diagnose hip fracture based on the cutting diagram theory and morphological examination of the hip bone. They diagnosed the fractures by examining the gap in the hip bone. They reached 98.91% accuracy in diagnosis [7]. Also, in [8], using X-ray images based on deep convolutional neural networks (DCNN), healthy and broken bones have been identified. In this research, fracture was detected with 94.32% accuracy. Also, in another research presented in [9], based on convolutional neural networks, they proposed a method for fracture detection using X-ray images. The detection accuracy in this proposal was not higher than 91.2%. In a research based on convolutional neural network, a method for diagnosing femoral head fracture based on VGG architecture was performed with 95.5% accuracy, which is more than the accuracy of conventional orthopedic surgeons (92.2%).[10] .

Also, Sato and his colleagues in [11] presented a new method for hip fracture detection using CT images based on convolutional neural network. The experimental results of 300 images provided an accuracy of 96.1%, which was a high result at that time. Similar methods for fractures of other bones of the body have also been performed, and in [12], a method for detecting vertebral fractures (VCFs) using deep networks was presented, which reached the highest accuracy of 89.1%. In all common methods, they focus on the fracture and achieved the highest accuracy of 98%, but our goal of this research is to achieve reliable accuracy and also to detect the fracture area, so that doctors can be helped in this matter.

3. Materials and Methods

3-1 Database

The dataset was used from the Kaggle database site. which is available on the site under the name "ChestPelvisCSpineScans". This database contains 876 images in two groups consisting of 404 normal images and 472 hip fracture images. Figure 1 shows two sample images.

Fig.1. Images of a healthy pelvis and a fractured pelvis

3.2 Preprocessing

At this stage, the images are first converted to the standard size to enter the convolutional neural network so that they can enter the next stage. In the first part of the processing, two groups were separated. For this stage, two groups of broken bones and healthy bones were separated.

In this part, the two-dimensional convolutional neural network with the common and widely used AlexNet architecture was used, which has been used in many studies and has had favorable results. Figure 2 shows the 2D convolutional neural network classifier.

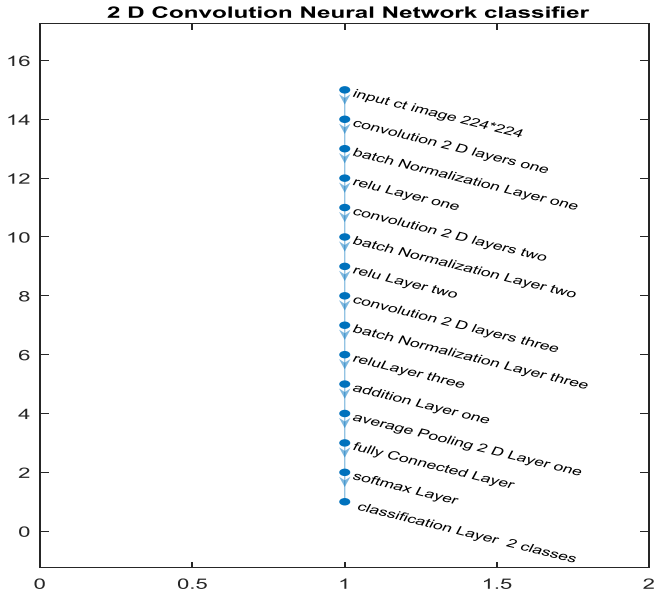

Fig.2. Two-dimensional convolutional neural network classifier

In the next step, the fracture site is diagnosed in the unhealthy group. In this part, the fracture location is detected using the RCNN method. Figure 3 shows the structure of Region convolutional neural network.

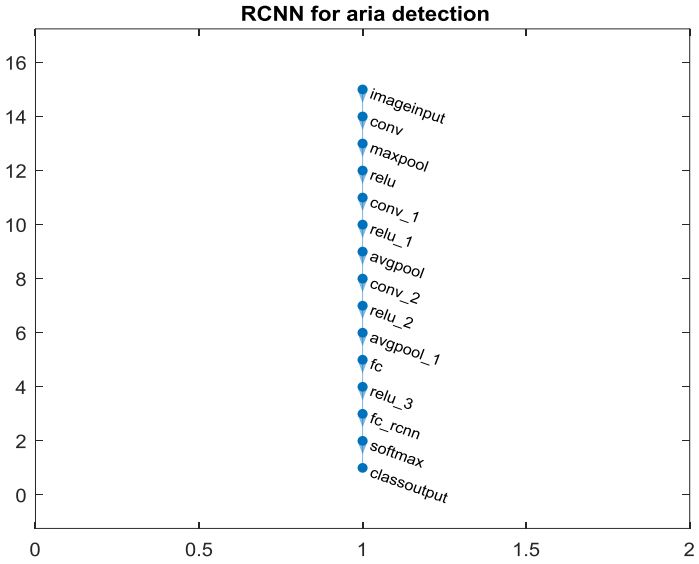

Fig. 3. Region convolutional neural network structure

4. Results

All steps have been done using Asus Cori7-8700 laptop with 16GB RAM by MATLAB 2017b software. The results are calculated based on the confusion matrix. Figure 4 shows the confusion matrix of one of the situations for distinguishing healthy and broken bones.

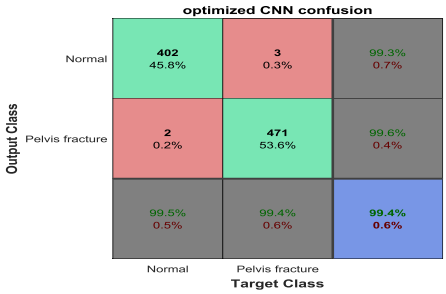

Fig. 4. Confusion matrix of one of the states to distinguish healthy and broken bone.

The accuracy and sensitivity results for the detection of healthy and broken bones have been calculated using 10-fold cross-validation. Figure 5 shows the accuracy results for fracture detection with 10-fold validation.

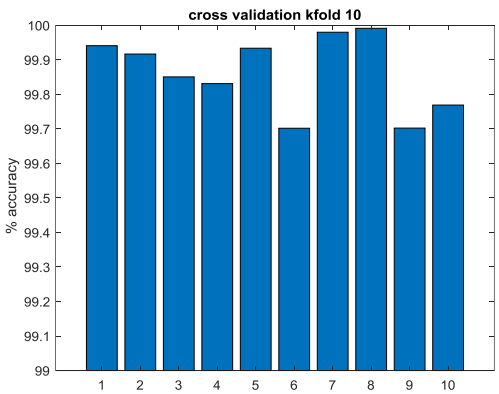

Fig.5. Accuracy results for fracture detection with 10 validations.

Figure 6 shows the sensitivity results for fracture detection with 10-fold validation.

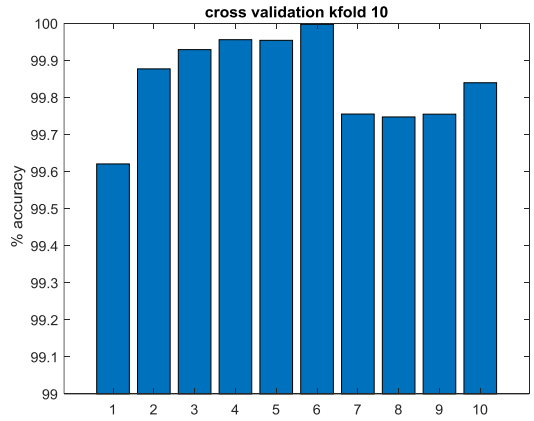

Fig.6. Sensitivity results for fracture detection with 10-fold validation

Finally, the location of the fracture was obtained using RCNN .Figure 7 shows the results of calculating the broken area using RCNN.

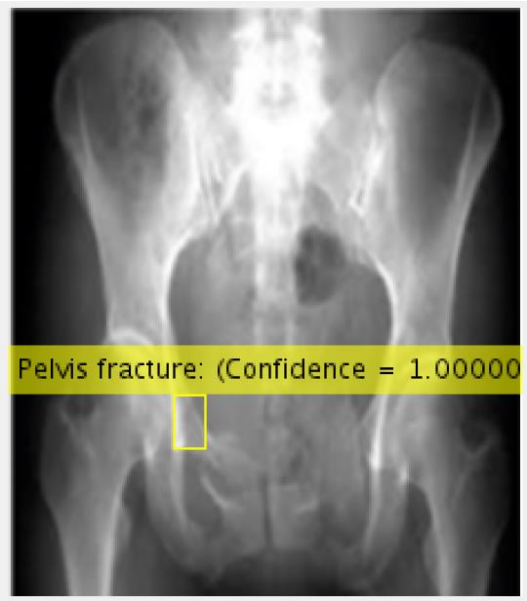

Fig.7. Results of calculating the broken area using RCNN

5. Discussion

Fracture of the femur has many complications due to its location, and if the fracture is not diagnosed, it will cause many problems. In all the common methods examined, healthy and broken bones are detected, but in the conducted research, fractures are detected and then the fracture area is obtained using the RCNN method. In this article, the location of hip fracture was detected with complete accuracy and the fracture area was obtained with 99.68 accuracy and 99.82% sensitivity with 10-fold validation.

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