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A Computerized Meniscus Injury Detection System by Using Convolutional Neural Network

Venesa Olivia Mampa Anak Ngindang[1], Ida Laila Ahmad[1]*, Masnani Mohamed[1]

[1]Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, 86400, MALAYSIA

*Corresponding Author Designation

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Abstract: The meniscus provides a shock absorber between the shinbone and the thighbone. It is a C-shaped piece of tough, rubbery cartilage. One of the most frequent injuries to the knee is a torn meniscus. Meniscal tears can be confirmed clinically by magnetic resonance imaging, which can also review intra- and extra-articular anatomical structures and rule out other diagnoses. Techniques for image processing are now frequently used in many different applications. Meniscus extraction, image segmentation, and image enhancement are used in the image processing technique for meniscus tear detection. Convolution Neural Network (CNN) able to perform canny edge detection is regarded as superior because it can detect all existing edges in an image and is unaffected by noise. It also can identify thin edges in noisy images. Because the CNN method is so proficient at detecting lines in the sample image, it is used in this paper to detect meniscus tears. Based on elements like the quality of training data, model architecture, hyper parameters, and implementation details, a CNN model for meniscus tear detection may differ. To measure the efficacy of such models, evaluation metrics like sensitivity, specificity, precision, and F1 score are frequently employed. The primary goal of this work is to use MRI images to identify meniscus damage. On the provided sample images, the algorithm is tested. The model architecture and the level of expertise of the training data determine how accurate the CNN and the specific accuracy achieved for meniscus tear detection may vary depending on the specific dataset and problem domain, the accuracy of this model is typically 80% above. More accurate predictions imply more trustworthy outcomes.

Keywords: Meniscus Injury, Meniscus Injury Detection System

1. Introduction

In many hospitals, imaging is essential to the diagnosis and management of a wide variety of disorders. The method and process of imaging the body's interior for clinical evaluation and medical intervention, as well as providing a visual representation of the operation of some organs or tissues, is

*Corresponding author: ida@uthm.edu.my

known as medical imaging. MRI is one of many different types of medical imaging. Meniscus injuries in the human body can be found using an MRI. Meniscal tears are frequently brought on by the knee twisting while the body is bearing weight. A torn meniscus results in knee weakness, locking or clicking, and pain. A torn meniscus can be treated with arthroscopy, medication, and exercises.

Sport injuries are common to athletes and normally are inevitable. Prolong exposure to heavy training and aggressive usage causing faster deterioration on various muscles, tissues, tendons, and others. It is damage to the tissues of the body that occurs as a result of sport or exercise [1]. Meniscal tears are most common knee injuries is being categorized as soft tissue injury. The meniscus is a small C- shaped cartilage that acts as a cushion in the knee joint, protecting it from wear and tear and helping to stabilize the joint. There are 2 meniscus that sit between the thigh bone (femur) and the shin bone (tibia), one is on the inside of the knee (medial) and one is on the outside (lateral).

This study's goals are to develop an algorithm for meniscus tear detection, design a graphical user interface (GUI) for the system that has been created, simulate the algorithm using Google Colab and MATLAB, and run accuracy tests to assess the system's performance. The goal is to develop a reliable tool that will enable medical professionals to diagnose and treat patients correctly and as well as an effective and efficient solution for meniscus tear detection.

2. Methodology

In this work, Google Colab and Matlab are used to implement and develop the coding for image classification of meniscus tear detection between normal and abnormal. Google Colab is a robust Python machine learning tool that provides an efficient and collaborative environment based on Jupyter Notebook. It enables remote collaboration by allowing simultaneous editing and seamless collaboration. Matlab software is used for user visualize the detection in meniscus tear based on MRI scan image. This GUI has a lot of benefits, including making it simple to implement and test your algorithms and create computational codes. The model's fully connected layer is made up of two layers. To develop a model to determine the presence of meniscal tears, the MRI data of meniscal tears were classified into the following categories normal, medial meniscus, lateral meniscus, and medial and lateral meniscal tears. Furthermore, a model to distinguish between the different types of meniscal tears such as normal, horizontal, complex, radial, and longitudinal [2]-[4].

There are six cases involved related to abnormal meniscus tear. These cases are parrot break meniscal tear, radial and horizontal tear, and flap tear. Besides, meniscus bucket handle tear, posterior horn tear, and posterior hor horinzontal tear. The categories of classification have been stated, and also this system involves detecting the normal meniscus also. Python performed for CNN Model Development, export model, and the results. Matlab software was used for visualizing the results more capabilities and easier for users to understand the outcome based on MRI image.

2.1 Data Collection

These include normal and abnormal meniscus datasets that can be found in the Radiopaedia database. There are 118 total datasets used in this work, of which 112 images are related to abnormal meniscus, and 6 images related to normal meniscus. Figure 1 shows the sample dataset used in this work.

2.2 Image Segmentation

Image segmentation is a process that partitions a digital image into distinct segments, making it easier to analyze or process specific regions of interest. In the context of meniscus detection, a Convolutional Neural Network (CNN) classifier can be trained using labeled training and validation sets. CNN learns to recognize patterns and features indicative of meniscus tears. The trained CNN is then applied to new images for meniscus detection in real-world scenarios. This approach allows for automated and accurate identification of meniscus tears, enhancing the efficiency and reliability of diagnosis [5]-[7]. Figure 2 is the process in Matlab software. The CNN architecture for meniscus tear

detection can vary based on factors like dataset size, and computational resources. Architecture used in this work have stated in Figure 3, that can evaluate the CNN model by using VGG Model.

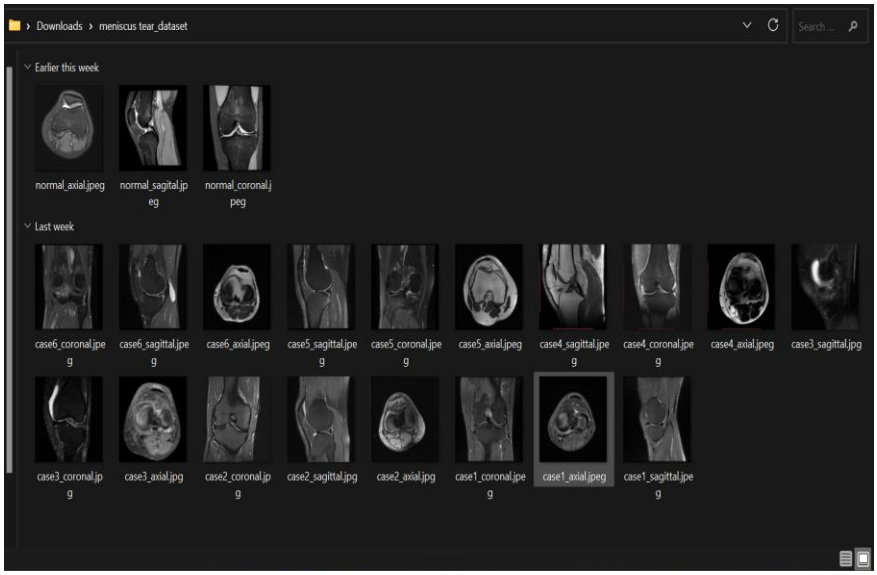

Figure 1: Dataset of Meniscus Tear from Radiopaedia

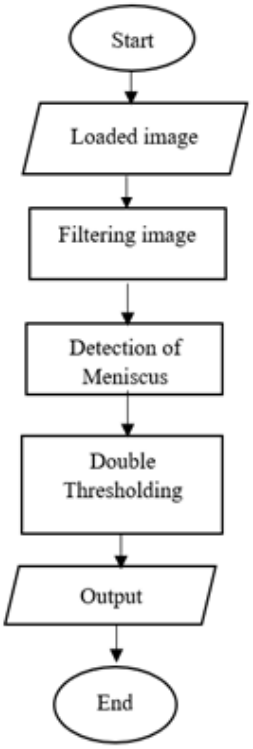

Figure 2: Image segmentation flowchart

3. Results and Discussion

Results analysis will assist in understanding the performance in each area of the curriculum. Furthermore, lead from this able to use the data to identify areas of strength and weakness in order to direct teaching efforts where are most needed. The databases contain MRI images of normal and abnormal meniscus. The analysis result of this system's simulation.

3.1 Result

Figure 3 shows the most critical part in this work which is the development of the CNN model. The results obtained from python were accurate for the meniscus detection involves the region of interest (ROI). To recognize various objects or tissue types in images, clustering is a technique used in a variety application especially in medical imaging. The outcomes from Figure 2 process are able to increase image segmentation's effectiveness and accuracy. Then the user is able to see the outcome clearly and easier to understand the results from the observation.

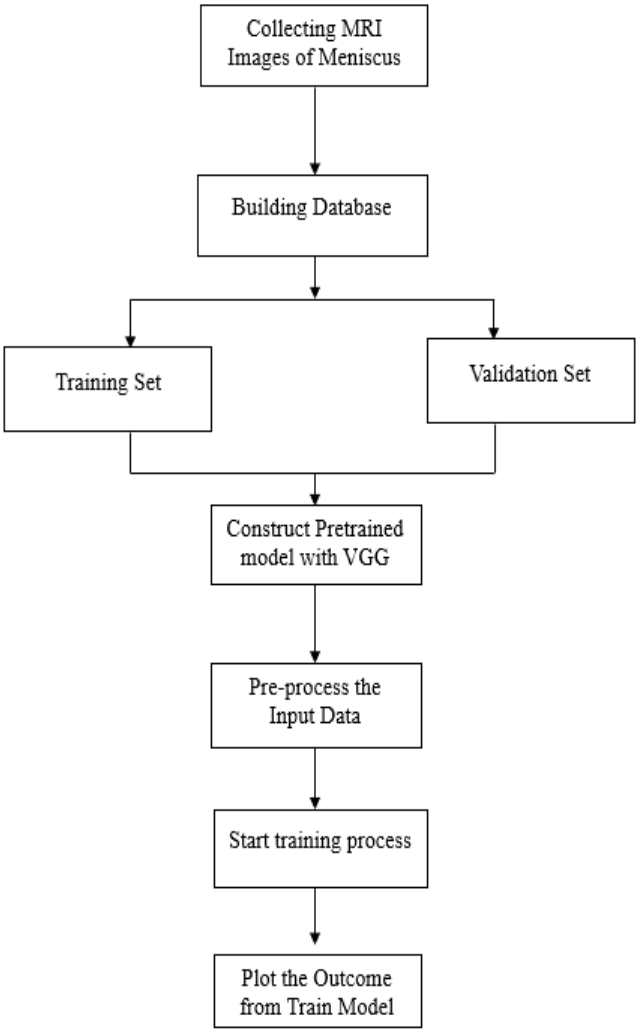

Figure 3: Train Dataset by using CNN Model

Pre-processing plays a crucial role in image processing as it enhances image quality, reduces noise, and extracts relevant features. Equalization is a crucial step that widens the intensity range by adjusting the pixel intensity levels to enhance image contrast. Another essential process that eliminates low-intensity variations and contributes in noise reduction is thresholding. To focus on the meniscus tear area, a region of interest (ROI) is defined using a mask, which improves accuracy and reduces computational load. Finally, the Canny edge detection technique is applied to identify and extract the boundaries of the meniscus tear region. Overall, pre-processing techniques like equalization, thresholding, ROI selection, and edge detection contribute to accurate segmentation and analysis of meniscus tear regions in MRI images. Figure 4 shows the result of meniscus tear detection while Figure 5 shows the percentage of accuracy.

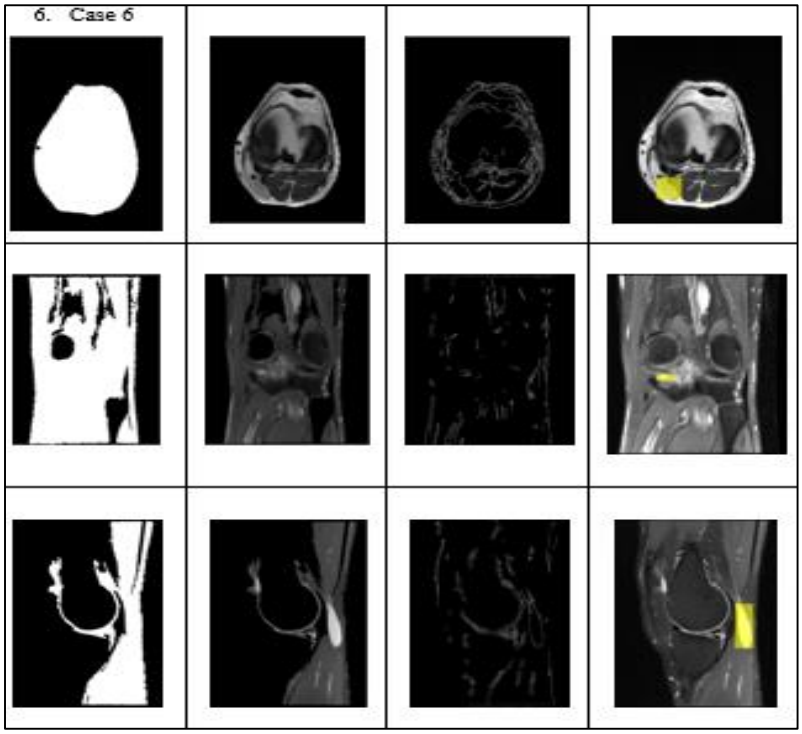

Figure 4: Result of Meniscus tear detection

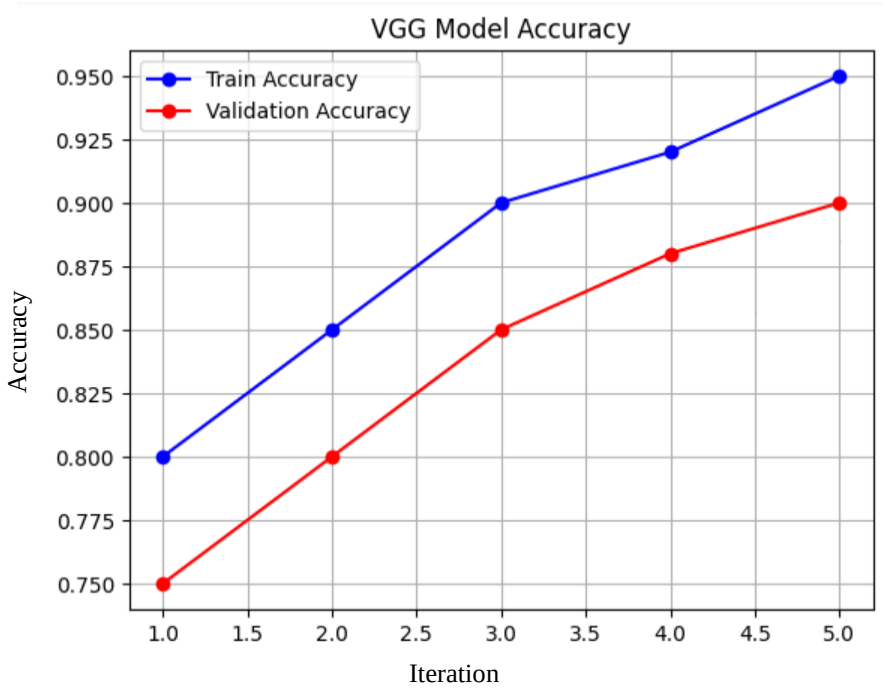

Figure 5: Percentage of accuracy of the train model

3.2 Discussions

The University of Oxford's VGG (Visual Geometry Group) CNN architecture is renowned for its outstanding performance in image classification tasks. Convolutional, pooling, and fully connected layers are all included in the VGG number, which represents the total number of layers. VGG exhibits robust generalization abilities, which means it can correctly categorize untrained images into the same classes as the training set. This is especially helpful in the detection of meniscus tears because it can accurately classify newly acquired MRI images of knees with tears, even if they were not part of the

training dataset. When training a dataset for meniscus tear detection, VGG is a potent CNN architecture that offers trustworthy evaluation and performance. Based on Figure 5, the x-axis and y-axis refer to iteration and accuracy of the dataset, respectively. VGG Model suitable for my system after various trial by using others model. This model only shows that values of accuracy that almost near to the targeted value.

4. Conclusion

The purpose of this research was to propose a suitable algorithm for meniscus tear detection, and to design a graphical user interface (GUI) of the developed system. Several key findings and contributions have been made throughout the study. Finding an appropriate MRI dataset from any sources is necessary for this work to get started. Most datasets are incompatible with the system. The development of an accurate system that performs disease detection using GUI is also slightly challenging. The platforms used in this system can carry out the detection of meniscsus tears between normal and abnormal meniscus.

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