A Convolutional Neural Network-Based Framework for Medical Images Analyzing in Enhancing Medical Diagnosis

Ayad Hameed Mousa¹, Zahraa Noor Aldeen², Ali Hussein Mohammed³, Mohammed G. K. Abboosh⁴,
¹College of Science, University of Kerbala, Karbala, 65001, Iraq
²Faculty of Tourism science, Department of Hotels Management, University of Kerbala, Kerbala, 65001, Iraq
³Directorate General of Education, Kerbala, 65001, Iraq
⁴Department: Electrical Engineering, University of Kirkuk, Kirkuk Province, 36001, Iraq

Abstract: Medical image processing plays a significant role in the healthcare industry. Consequently, speed up the process of analyzing medical images, lead to more reliable the results will be in terms of rapid medical diagnosis. Besides, in medical image processing, there is an urgent need for special applications utilized for medical image processing, interpretation, and analysis of medical images and to extract important information for use in medical diagnosis. The adoption of machine learning techniques and deep learning can support the acceleration of medical image processing as well as obtaining accurate information. A framework using deep learning techniques for use in shortening and analyzing medical images for use in medical diagnosis is proposed in this paper. The proposed framework will utilize as a guideline to implement an expert system that serves the medical diagnosis by presents several operations of medical image processing routines and provides facilities and supports radiologists for making an accurate and speed up diagnosis. The expected result by applying the proposed framework, an expert system will be evaluated using several images dataset from medical and biological experiments in comparison with the existing system. Ultimately, the anticipated experimental findings hopefully, confirm that the efficiency of the proposed framework and its expert system in learning from brain imaging data and speed up the brain's clinical data analysis.

Keywords: Deep Learning Algorithm, Convolutional Neural Network, Medical Image Processing, Medical Image Analyzing


1. Introduction and Motivation

The critical point of the human acquisition and interpretation system for images is poor to remember the details of the image, which usually contain a huge amount of meaningful information [1]. The advanced and continued improvement in medical image processing provides the possibility of analyzing and interpret images commonly used in different sectors such as medical image processing applications [2]. Recently, image processing becomes contributed to almost all modern science branches. These include fields such as spatial imaging, embedded systems, industrial, virtual reality systems, as well as medical imaging. Generally, medical imaging is given to the set of techniques and processes which produce images of the human organs, sometimes the whole body, to use them in medical and scientific usage [3]. Therefore, increasing attention has paid to the discovery of ways to enhance the extraction of valuable information from medical images.

In the same aspect, the analysis of medical images is considering one of the significant studies in healthcare which leads to a positive impact on diagnosis, treatment planning. Besides, the advent of developments in medical imaging and medical image processing led to speed up for intervention in the treatment of various diseases. Medical images require the sequential application of several image-processing technologies such as image zooming, image restoration, image regularization, image segmentation, and image registration; to be used for extract, interpretive, and analysis of intended features. These features might be specific parts of the image as well as they might be statistical features spread over the entire image.

In all branches of modern science, the analysis and interpretation of the digital images have obtained through variant technologies has become a subject of major significance. The major purpose of choosing this research area is named the possibility of applying computer science algorithms in the healthcare sector. Undoubtedly, the importance of machine learning is due to the same factors that have made other techniques such as data mining and Bayesian analysis commonly used than ever. All of these mean it's possible to quickly and automatically produce models that can be analyzed a huge amount of data, more complex data, and deliver faster, interpret more accurate results even on a very large scale.

2. Problem Statement
The medical image analysis is one of the significant research fields that gradually receives growing extraordinary attention from both the academic research community and the healthcare industry. In the medical image processing field, even though several frameworks have developed, to enable the managing of medical imaging data "manually manner, semi-automated manner, or fully-automated manner" [4]. However, effective use of many of such application domains requires a remarkable amount of manual interaction. This situation creates several limitations such as difficulty in analyzing, use, and diversity, which leads to inaccurate on acquired, results. The information and data they obtained from such frameworks and their applications might not be perfectly fitting for some applications, particularly for clinical research.

3. Research Questions
The major research question of this research is how to design, develop, and build up an application framework and use it as a basis to develop a prototype application, which enables the analysis, interpretation, and quantification of intended features in medical images for the diagnosis improvement? From the given main research question, a sub-question of this proposal be outlined as follows:

a. What the main components of the proposed framework?
b. How to design and develop the proposed framework application basis on machine learning algorithms?
c. How to develop a prototype application based on the proposed model?
d. Are the proposed framework and its prototype have an influence of the framework and its prototype in the diagnosis improvement in terms of accuracy and speed up?

4. Research Aim and Objectives
The major aim of this research is to design, develop, and build up an application framework and use it as a basis to develop a prototype application, which enables the analysis, interpretation, and quantification of intended features in medical images for diagnosis improvement. From the given main aim, a sub-objective of this proposal can be summarized as follows:

a. To identify the main components of the proposed framework.
b. To design and develop the proposed framework application basis on machine learning algorithms.
c. To develop a prototype application based on the proposed model.
d. To test the influence of the framework and its prototype in the diagnosis improvement in terms of accuracy and speed up.

5. Research Gap
Based on the research problems as discussed in the previous section, then, the following research gaps have extracted:

a. Some restrictions and aspects that have considered when developing the existing medical image analyzing models and frameworks do not specified in the current models and approaches in terms of date data accuracy and speed up data interpretation.
b. Due to the dynamic change of the healthcare sector's needs, the traditional medical image processing approaches do not fully support the emerging healthcare needs of diagnosis improvement support.

Therefore, there is a need for a comprehensive framework for medical image analyzing that not only serves the specialists in diagnosis, but this framework will be a guide for developers in this area for developing any application of medical image analyzing.

6. **The Proposed Solution**

In filling the mentioned research gaps, the study-in-progress proposes an analysis based on a machine-learning framework for medical images to diagnose improvement, which is defined as the application of a systematic approach that includes processes and methods for the development of medical image analyzing applications. The proposed framework illustrated in figure 1.

![Fig 1: A Convolutional Neural Network-Based Framework](http://doi.org/10.36295/ASRO.2020.231340)
7. Expected Contributions
The study-in-progress will contribute generally to the body of knowledge and healthcare industry within the specific area of medical image processing. Generally, this study focuses on designing and developing an analysis based on a machine-learning framework for medical images for diagnosis improvement.

7.1. A universal review of medical image processing literature will made, and medical image processing routines and mathematical relations among them will investigated in a deep manner as well as machine learning algorithms. Therefore, this review can be a guide for other researchers in this area.
7.2. Design and develop the proposed framework.
7.3. Develop a prototype based on the proposed model using machine-learning algorithms.

8. State of Art
The state of art divided into several sections; the first section a brief description of the medical image processing and the relevant techniques, which connected with medical imaging challenges. Followed by in the second section a brief description of machine learning (ML) as well as the techniques, which connected with various machine-learning stages as well as the corresponding challenges.

8.1. Medical Imaging:
It is a common technique which widely used for medical purposes by providing images of human-body. These intended images can be for all human-body or can be a part of the human body. The extracted data from the medical imaging usually used to present whether anatomical structures for human-body are normal or abnormal physiologically. Besides, specialists can use medical imaging data and techniques for treatment planning as well as diagnosis [5]. In the same aspects, specialists use these data as a guideline for medical intervention or sometimes to avoid it.

8.2. Medical Image Processing:
Medical image processing is a subfield of Image processing, where the input is an image, while the output either processing is image or retriever the meaningful information from the input image. Medical Image processing involves several techniques such as MRI, NMR spectroscopy, PET, SPECT, CT, and Ultrasonography. Noteworthy, there are several purposes for medical image processing like 2D/3D visualization, diagnosing, registration, segmentation, and restoration [4, 6].

On the same aspect, one of the significant parts of the medical image processing is a quantitative analysis which uses to diagnosis and prognosis phase of several diseases. Moreover, Quantification of radiographic information involves various properties like linear measurements, estimation of cross-section and surface areas, volume quantization, estimation tissue density, monitoring tumor growth, verification of treatment, and comparison of patient’s information with anatomical atlases [7, 8].

According to [9], the extracted information from medical data may suffer degradations and/or deformations. For example, MRI intensity heterogeneous may occur due to RF file imperfections. There are several operations of medical image processing that should be considering and adopted sequentially to obtain quantification analysis of medical image data. These medical image operations were classified into three major sets as a basis of their work: (1) registration of medical images; (2) segmentation of medical images; and (3) smoothing and restoration of medical images. In the following sub-paragraphs, brief descriptions for each of them are outlined.

8.2.1 Image Registration
Image registration is an iterative process of searching for the best mathematical transformation model, which aligns a 2-dimensional (2-D) or 3-D image data to another 2-D or 3-D image data. Data may be multiple photographs, data from different sensors, times, depths, or viewpoints. It is used in computer vision, medical imaging military automatic target recognition, and compiling and analyzing images and

data from satellites. Registration is necessary in order to be able to compare or integrate the data obtained from these different measurements.

8.2.2 Image Segmentation
The main aim of image segmentation is to cluster pixels into salient image regions, for example, regions corresponding to individual surfaces, objects, or natural parts of objects. The result of image segmentation is a set of segments that collectively cover the entire image or a set of contours extracted from the image (see edge detection). Each of the pixels in a region is similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s). When applied to a stack of images, typical in medical imaging, the resulting contours after image segmentation can be used to create 3D reconstructions with the help of interpolation algorithms like marching cubes.

8.2.3 Image Smoothing
The simplest approach is neighborhood averaging, where each pixel has replaced by the average value of the pixels contained in some neighborhood about it. Smoothing is often used to reduce noise within an image or to produce a less pixelated image. Most smoothing methods are based on low pass filters. See Low Pass Filtering for more information. Smoothing is also usually based on a single value representing the image, such as the average value of the image or the middle (median) value. The following examples show how to smooth using average and middle values.

8.2.4 Image Restoration
Image restoration is the operation of taking a corrupt/noisy image and estimating the clean, original image. Corruption may come in many forms such as motion blur, noise and camera mis-focus [1]. Image restoration is performed by reversing the process that blurred the image and such is performed by imaging a point source and use the point source image, which is called the Point Spread Function (PSF) to restore the image information lost to the blurring process.

8.3. Machine learning
According to [10], machine learning can be defined as “The discipline focused on two interrelated questions: How can one construct computer systems that automatically improve through experience?, and What are the fundamental statistical computational-information-theoretic laws that govern all learning systems, including computers, humans, and organizations?”.

Moreover, ML methods using neural networks was used in the extraction of meaningful information or training methods involved in the analysis and dealing with medical images.

The traditional training of machine learning algorithms such as uses traditional neural network-based and Support Vector Machine (SVM), approaches which don't work in properly obtaining the intended features and thus, an advent method of learning “deep learning” can help in solving the challenges of medical image processing [11]. In the same aspects, Non-convention

8.4. Convolutional Neural Network
A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning algorithm that can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image, and be able to differentiate one from the other. The pre-processing required in a ConvNet is much lower as compared to other classification algorithms. While in primitive methods filters are hand-engineered, with enough training, ConvNets can learn these filters/characteristics. on the other hand, A ConvNet can successfully capture the Spatial and Temporal dependencies in an image through the application of relevant filters. The architecture performs a better fitting to the image dataset due to the reduction in the number of parameters involved and the reusability of weights. In other words, the network can be trained to understand the sophistication of the image better.

9. Research Methodology

In this proposal, Design Research Methodology (DRM) which introduced by [15] is adapted. There are two main reasons for using DRM; the first reason is to aids to identify the criteria of successful research; while the second reason is to help the researchers to design rigorous and efficient research. Besides, DRM has four main stages: Research Clarification (RC), Descriptive Study I (DS-I), Prescriptive Study (PS), and Descriptive Study II (DS-II) as depicted in Figure 2 and outline brief description each in the following sub-paragraphs.

**Figure 2: Research Approach**

As clearly indicated in Figure 1, each component of such methodology has three sub-phases, the first one is to presents the flow of phases, the second one is present the methods that are used in each phase and finally, the third one is present their outcomes, figure details are as follows:

**9.1. Research clarification (RC):**
This phase specifies the research problem by identifying the criteria for success. The success criterion of this research is identifying the factors that influence the performance of using deep learning in medical image processing. This is achieved by the realization and reviewing of the existing deep learning method and algorithms. Additionally, problems of deep learning-based methods are also addressed.

**9.2. Descriptive Study I (DS-I):**
This phase is dedicated to study and investigate the related work of the specific problems of deep learning for medical image processing. The outcome of this phase represents the gaps and drawbacks of the current deep learning algorithms in medical image processing. The methods that are used to find these gaps will be studied the related work of deep learning in medical image processing, investigate the current solutions of segmentation, analysis, of the existing medical image processing methods and algorithms to address the gaps and drawbacks of these methods.

**9.3. Prescriptive Study (PS):**
This phase represents will be care about designing and implementation of the framework and its prototype that solve the gaps and drawbacks in supporting analyzing the medical image processing based on deep learning

**9.4. Descriptive Study II (DS-II):**
This phase includes an analysis of the results that are produced from the previous phase. This phase concerns with validation and evaluation of the proposed method through some evaluation metrics (effectiveness and efficiency metrics) and comparison with recent works.

**10. Conclusion**
Using machine-learning algorithms in analyzing medical images is beneficial in terms of efficiency and effectiveness; this will give a high positive influence on the diagnosis of the diseases. The authors believe
that the proposed framework based Convolutional Neural Network algorithm will give an enhancing of the diagnosis process efficiently and effectively.

11. Acknowledgment
This research are totally supporting by the University of Kerbala. We thank our colleagues from the University of Kerbala who provided insight and expertise that greatly assisted the research. We thank the ministry of health in Iraq for assistance with providing and supporting us with all relevant information.

References