SECONDOPONIONNET: A NOVEL NEURAL NETWORK ARCHITECTURE TO DETECT CORONARY ATHEROSCLEROSIS IN CORONARY CT ANGIOGRAPHY.

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Abstract:

Cardiovascular diseases present a group of illnesses that takes millions of lives every year. This has become obvious to researchers and medical practitioners in recent years. As a result, an increased number of awareness campaigns about their prevention has been noticed as well as a dramatic increase in the research funding of their treatment/diagnosis. There has been a recent tendency in literature to utilize advanced machine learning algorithms in the medical field which has been fruitful in terms of demonstrating effective results. Literature in the medical practice has also proved that getting a second opinion reduces medical errors and increases the treatment plans' effectiveness. In this paper, we propose a novel neural network architecture to detect coronary atherosclerosis in coronary CT angiography through mimicking the idea of getting a second opinion from another expert in the medical practice. The proposed model could successfully converge with an accuracy of 90.78, precision of 91.14, recall of 89.98, and F1 measure of 90.55.

Keywords: Neural Networks, Atherosclerosis, CT angiography, Peripheral Artery Disease (PAD).

1. Introduction

According to the World Health Organization, cardiovascular diseases that include atherosclerosis are the leading cause of death worldwide, causing 17.9 million death each year [1]. It is furthermore estimated that more than 200 million lives with Peripheral Artery Disease (PAD) today [2]. These high numbers have serious alerted humanity to take strong actions to reduce them as they highly endanger the survival and the wellbeing of the human race. It is noticed that the amount research funding on PAD has increased dramatically in recent years as well as the awareness campaigns raised about their prevision.

On the other hand, our technological development and maturity allowed us to use advanced algorithms in the medical field which had a significant positive impact on the accuracy of diagnoses and the efficiency of treatments. Medical literature has abundant examples that perfectly demonstrate this. For example, a manually informed neural network was used to enhance the performance of heart failure predictors [3]. The neural networks were also used in the accurate prediction and diagnosis of Parkinson's disease [4][[5]. Some deep learning algorithms such as Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs) have been used to generate biological signals and images [6][7]. In [8], a technique for artifacts rejection of MEG and EEG signals was designed. Even the pain sensation could be measured and quantified through the usage of neural networks [9].

In this paper, we propose a novel neural network architecture that was built to detect coronary atherosclerosis in coronary CT angiography. We believe that this will help in reducing the horrific number of deaths caused by PAD every year. This will be possible as our network will potentially support medical practitioners to have more efficient diagnoses as we shall further demonstrate.

2. Method and Materials

2.1 Dataset

The used dataset has been made publicly available in 2019 [1]. It consists of coronary artery image sets for 500 patients. Each image represents a Mosaic Projection View (MPV) which consists of 18 different views of a straightened coronary artery stacked vertically. The data was divided to ¼ patient ration for testing/training sets, each with 50% normal and 50% diseased cases. Artery images derived from the patient cases in both sets were augmented with the purpose of increasing the number of images in a way that will facilitate the generalization ability of the trained network.

2.2 Methodology

It was found that 15% of diagnosis and 37% treatment plans have changed due to taking a second opinion [2]. The clinical impact of a second opinion is proven to be of a significant impact [2][3][4]. Due to this positive impact, we proposed a neural network that mimics the concept of getting a second opinion in the clinical practice. This is achieved through training two different neural network architectures on the dataset and then taking the features they produce to a diagnosing neural network where the decision or diagnosis will be finalized. Figure 1 shows the overall used methodological neural network architecture.

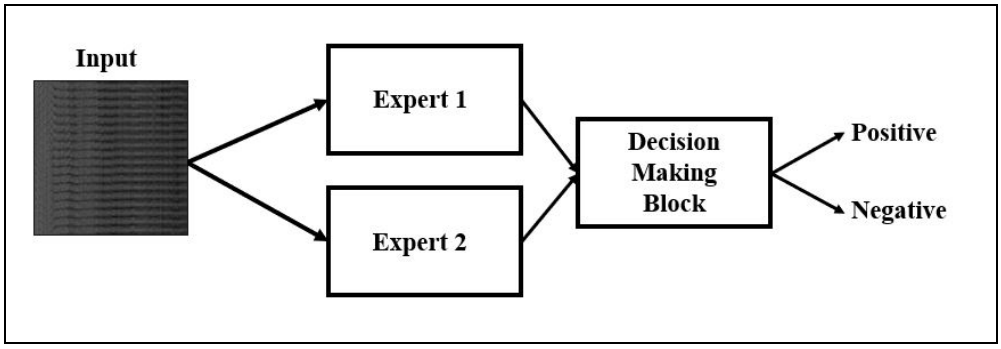

Fig. 1. The General Methodological Architecture of the SecondOponionNet.

Both experts 1 and 2 will investigate the inputted image through different neural networks. The first contains ResNet 18 [5] and the second contains VGG 19 with batch normalization [6]. The decision-making building block contains three fully-connected layers that receive the feature maps from the two experts and output the result of the binary classification (positive or negative) through the SoftMax function [7].

3. Results and Discussion

The developed architecture has been evaluated using the different confusion matrices evaluation factors as shown in Table 1.

Evaluation Factor	Value
$\boldsymbol{accurecy} = \frac{number\ of\ correctly\ pridected\ samples}{total\ number\ of\ samples} x100$	90.78
$\boldsymbol{precision} = \frac{number\ of\ correctly\ pridected\ samples\ in\ i}{total\ number\ of\ predicted\ samples\ in\ i} x100$	91.14
$\boldsymbol{recall} = \frac{number\ of\ correctly\ pridected\ samples\ in\ i}{total\ number\ of\ samples\ in\ i} x100$	89.98
$\boldsymbol{F1\ score} = \frac{2.precision.recall}{precision + recall} x100$	90.55

Table 1: The Evaluation Factors of the Developed Architecture.

When comparing these results with the findings found in similar studies in the literature, an improvement could be noticed [8].

Conclusion

In this study, we proposed a novel neural network architecture to detect coronary atherosclerosis in coronary CT angiography. This was motivated by the increased number of deaths that cardiovascular diseases cause every year. We believe that our proposed solution will somehow help in reducing these numbers as our network will potentially support medical practitioners to have more efficient and earlier diagnoses.

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