Medical Image-based Prediction of Brain Tumor by Using Convolutional Neural Network Optimized by Cuckoo Search Algorithm

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I. Introduction

Brain tumors are the most general brain disease. This disease is caused due to uncontrolled growth of unnatural brain cells [1]. Brain tumors are among the deadliest forms of cancer. According to cancer statistics in the United States, about 23,000 were diagnosed with brain tumors in 2015. By the following year, these tumors are considered the leading source of cancer death worldwide in both youngsters and adults [2].

Radiologists utilize medical imaging techniques to detect tumors [3]. Among various techniques available, Magnetic Resonance Imaging (MRI) is commonly preferred for brain tumors due to its non-invasive type [4]. Radiologists identify brain tumors by hand. The process of tumor classification takes a very long time and is based on the expertise and capability of radiologists [5]. As the number of patients increases, the volume of data requiring daily analysis also grows significantly, causing visually interpreted readings expensive and prone to inaccuracies. In addition, the classification of brain tumors into many pathological types is further difficult in contrast to binary classification [6]. This level of difficulty is credited to several reasons such as size, shape, and intensity for the identical tumor type [7] as well as comparable appearance for various pathological types [8]. Misdiagnosis of brain tumors can cause serious problems and reduce the patient's chances of survival. To overcome this downside, it is necessary to put new emphasis on designing automated image processing systems [9].

Computer-aided diagnosis (CAD) techniques [10] are widely suggested by researchers to support radiologists in visualizing [11] and determining tumor types [12]. Conventional machine learning approaches managed in the classification process typically involve various steps for instance preprocessing, dimension reduction, feature extraction, feature selection, and classification [5]. Feature extraction become an important phase in a valuable CAD system [13]. This is a difficult task that involves domain knowledge as the classification accuracy fundamentally relies on the selected extracted features [5]. New CAD methods have achieved improved performance by leveraging deep learning (DL) [14].

Deep learning represents a subset of machine learning that does not necessitate manual feature engineering [15]. This method proved successful in minimizing the distance among human and computer vision in pattern detection surpassing conventional methods in terms of performance [14]. In 2016, around 220 articles were using DL in medical imaging and this number will continue to grow in the coming years, where around 190 of them work using a convolutional neural network (CNN) [16].

Different methods have been advised in recent years for classification and segmentation. In a novel technique for tumor classification proposed by Hemanth et al. [17] in 2014, a modified Neural Network was exploited with 540 brain medical images consisting of four tumor types sized 256x256. This method gives capable results that obtain 95% sensitivity, 98% specificity, and 98% accuracy. Afshar et al. [4] in 2018 proposed a modified CNN architecture known as the capsule network (CapsNet) for classifying brain tumors. The CapsNet study exploits positional connections between the tumor and the nearby tissue. The segmentation of tumors yielded the highest accuracy of 86.56%, while the accuracy for raw brain images reached 72.13%.

In 2019, Sajjad et al. [6] classified multi-grade brain tumors using the CNN model with segmented images from three datasets. The overall results obtained were 90.67% of accuracy, 88.41% of sensitivity, and 96.12% of specificity. In the same year, Abiwinanda et al. [18] examined the implementation of hyper-parameters optimized CNN and proposed seven different neural networks. The best model contains two convolution layers and one fully connected layer. This unsegmented model reached 98.51% of accuracy on the data train and 84.19% on the data test. The process of building CNN architectures can be done through manual tuning or auto-tuning. Most studies still rely on the manual tuning of

CNN. Manual construction of CNN architectures is a challenging task that requires a lot of patience and perseverance. An alternative method for creating CNN architectures through auto-tuning is the use of meta-heuristic methods, such as the cuckoo search algorithm.

The goal of this study is to predict medical image-based brain tumors by using CNN optimized by the cuckoo search algorithm. Cuckoo search is considered more effective compared to other bio-inspired algorithms [19]. The differential evolution (DE), simulated annealing (SA), and particle swarm optimization (PSO) algorithms are particular cases of the CS algorithm, so it is predicted why the CS algorithm surpasses them [19]. The CS algorithm outperforms the DE algorithm regarding convergence speed to achieve the optimal solution [21]. Moreover, the CS algorithm is described to be more computationally efficient than PSO [22].