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Visualization and Classification of Diseases using Deep Learning Based Convolution Neural Network

Visualization and Classification of Diseases using Deep Learning Based Convolution Neural Network

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Abstract. In the contemporary phase of big data, data visualization is one of the challenging segment of the discovery process. For a classifier, the primary goal is to identify the hidden levels of big data. The performance of classifiers depends on the feature space, number of classes and size of the data. To improve the reliability, efficiency and accuracy of the classifiers, new algorithms are required for analysis. This paper enables classification and visualization of information on diseases using a Deep Learning based Convolution Neural Network classifier. For feature selection and handling massive data in analysis of multivariate data is performed using particle swarm optimization (PSO) and principal component analysis (PCA) techniques. Real-world datasets are utilized for demonstration of the proposed learning algorithm. Deep learning classifiers are scientifically higher and offers better performance when compared to other classifiers according to the comparative study.

1. Introduction

Modern data science uses deep learning and big data most often due to their adaptability towards a wide range of applications. Various sources and sensors produce massive amount of data which is challenging to analyse and handle using the traditional data processing tools. The conventional tools cannot analyse the Exabyte or even larger daily data that is generated by the industries. In order to extract significant information from large quantity of data and learn from it, an advanced technique called machine learning is used [1]. Accurate data representation decides the performance of these techniques. Diminished execution is prompted by machine learning techniques that provides poor representation of data. Distinguishing the data patterns and obtaining a complete perspective of data can be done using visualization. While dealing with massive data, visualization with decent heterogeneity and diversity is a major issue. In applications pertaining to data science, visualization and big data analytics play a major role.

Deep learning is inspired by the human brain functionality and performs data representation and classification by using supervised and unsupervised approaches. In applications pertaining to voice, speech and face recognition, deep learning techniques are exploited by several search engines.

Recognition of significant information from the original data patterns and deficient precision in grouping are caused by the insignificant features. The proposed approach enables classification and visualization of information by means of deep learning based CNN. Deep learning techniques along with the CNN extension provides improved performance benefits in several applications. Fully connected layers, pooling, rectifier logic unit (ReLU), manifold convolution are the key engagements in multi-hidden layer perceptrons (MLPs) based CNN [2]. The classification and visualization results are displayed after examination of the dataset by CNN. This work proposes four major contributions namely – boosting the classifier performance by diminishing the dimensionality, minimization of computational time, improvement in the classifier accuracy and comparison of the proposed model with existing models.

2. Literature Review

A simple sentence classification model using CNN is proposed by Kim et al. using static and task-specific vectors for upgrading the conventional CNN model [3]. For question classification and sentimental analysis, a simple CNN model with single convolution layer works extremely well. In case of large volume of traffic data, prediction and visualization model presented by Ari et al. can be used [4]. Humongous traffic data and pictures are analysed and processed using FIMT-DD in this work. Within a specific sensor point, the traffic stream can be envisioned using the proposed prediction framework.

Together with pooling layers, feature maps and images are generated as a convolution of image filter sets in convolutional layers of CNN. Estimation of a class is performed with an output label on the network through the repetitive processing layers and convolution for extraction of feature maps in image classification [5]. For the purpose of solving the classification problems for any given training datasets, features are generated by the hidden layers where the filter parameters and weights are optimized by CNN rather than using the traditional hand-crafted machine learning features and techniques. The classification error can be minimized using approaches like gradient descent and back propagation for optimizing the network parameters [6].

Multiple learning techniques and PCA is used for dimensionality reduction in huge samples by Farrelly et al. for extraction of global and local features from the datasets [7]. When compared to the complete datasets, high dimensional data involves lower dimensional space and are considered as universal sets in the modern data analytics. In order to guide information towards this lower dimensional space and enable accurate recognition of this space, several dimensionality reduction strategies are established [8]. In problems regarding classification, the effectiveness of dimensionality reduction techniques is demonstrated.

The large amount of features in datasets were identified and examined by [9-19]. For efficient classification, it was identified hat not all the features were valuable. The performance of the classifier is reduced by the repetitive and unwanted features. Hence the performance improvement is done by implementing feature selection for choosing the features that contain significant attributes rather than using all the available features [11-18]. Particle Swarm Optimization is used for feature selection and to improve the classifier performance.

3. Proposed Methodology

Prediction and visualization of disease data using three different techniques namely pre-processing of information, selection of prominent features and classification is analyzed in this section. Figure 1 represents the architectural model of the proposed deep learning based CNN.

3.1. Data Preprocessing

While handling big data, it is essential to represent the data with lowest possible proportions without misplacement or losing the originality of the information. For this purpose, dimensionality reduction technique is used. Principal component analysis technique is used for reducing the big data dimensionality. The underlying features are combined to producing new features using principal component analysis [19-26]. Mapping of the given dataset and its occurrences from one dimensional space to another such that the second dimension is larger than the first is performed by PCA. Considering the first dimension as g and second as p, g enables the generation of a new set of principal components p. These principle component PCk can be represented using the following expression.

$$PC_k = x_1Y_1 + x_2Y_2 + \cdot \cdot \cdot + x_gY_g$$

Where x_i is the numerical coefficient of the original feature Y_i.

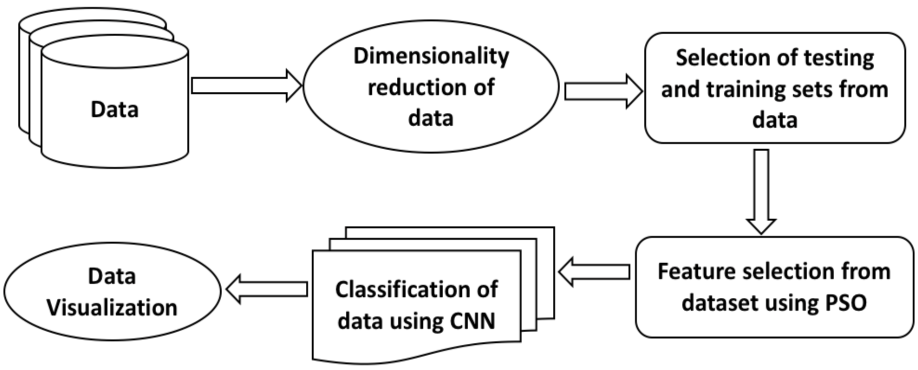

Figure 1: Architecture of the proposed model

3.2. Feature Selection

Feature selection assists in selection of a subset of unique features for improving the performance of the classifier. In text visualization and classification, feature selection is a substantially challenging task. [12] Multiple features are available in such data with high dimensionality which makes visualization and classification of the content more complex. Particle Swarm Optimization with swarm intelligence is used in this paper for extracting unique and suitable features from the feature subset [27-35]. Algorithms relating to fish schooling or bird flocking can also be used for stimulating the features. The steps involved in PSO algorithm is as represented below. The steps form a loop and iterates unless the completion state is met.

Input: Dataset
Output: Optimized subset of features

Step 1: Speed, position and population factors are initiated by the user
Step 2: The individual particle fitness is surveyed (Pbest)
Step 3: The most raised individual fitness is screened (Gbest)
Step 4: The speed of location of Pbest and Gbest is changed
Step 5: Particle position is refreshed
Step 6: If the condition is met, end, else go to Step 3

Step 1 and 2 are not very significant. The objective task receives positive responses for the fitness assessment. Position, universal ideal fitness and entity are updated in contrast with the fitness values assessed recently with respect to the individual and past global best fitness values. It is critical to replace positions and the best fitness values. The PSO technique is streamlined by refreshing the position and speed of the operational data volume. The performance of the classifier is improved by the algorithm by decreasing the classifier complexity through selection of optimal feature subset.

Gradient ascent technique called activation maximization is used by the CNN for visualization of features learnt on observation of respective neuron activation [14]. This technique is also called as feature visualization. The input image gradient is calculated in alignment to the specific neuron's mean

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output value by feeding the neural network with a random noise image as input [15]. Gradients can be added repetitively to the input image and the image can be optimized based on the high activation neuron direction for feature visualization of the captured neuron.

3.3. Classification
The performance of the classifier is improved by the decent portrayal of information. In this paper, we use CNN for visualization and classification of information. Feature map layer, classification layer and several other layers are available in the Convolutional Neural Network [16]. Fully connected layers, pooling and specific convolutional layers are the major categories of layers in CNN. The future portrayal of input is accomplished and learnt using the convolutional layer. This layer receives and acknowledges the data from the input layer during the operation of CNN. The convolutional layer is accountable for the channel maps of the convolution tasks to be of smaller number and of similar sizes [17]. The future layer sizes are deteriorated when the yield from convolution layer is directed to the sampling layer. The number of connections between the layers of convolution are reduced by the pooling layer thereby reducing the computational load. The CNN performance is improved by using a suitable activation function for a specific task. Figure 2 represents the various components and layers of CNN.

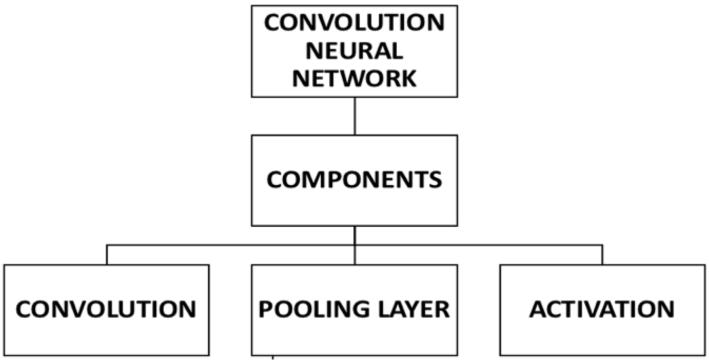

Figure 2: CNN and its components

4. Proposed Methodology

Classification and visualization of the disease data is the foremost aim of the proposed technique. Random weights are used for initialization of the network. Segmentation of the images are performed based on the pixel values. Based on the experimentation condition and type of images, the time taken per epoch is calculated and optimized. Traditionally the learned features are visualized with naïve ways for extraction of the output of hidden or intermediate layers. The calculation is halted at the layer of interest on passing the image to CNN. The assessment of the proposed classifier through various experimental analysis is discussed in this section.

4.1. Experimental Setup
The datasets of three diseases namely liver, migraine and mifem (myocardial infarction) are used in this approach for performance analysis of the proposed methodology. Along with CNN, PSO and PCA techniques have also been used in this paper for visualization and classification purposes. ANN and KNN models are compared with the proposed CNN model. Statistical measurements such as precision, G-mean, accuracy and specificity are analysed and compared for evaluation.

4.2. Performance Metrics
The efficiency of machine learning models are determined by true and false positive and negative rates. Specificity and accuracy evaluation using these parameters are calculated by the following formulae.

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Specificity = TN/ (TN+FP)
Accuracy = (TP+TN)/ (TP+FP+TN+FN)

4.3. Experimental Results

For the given datasets, various strategies are implemented and the classification accuracy is analysed. K nearest neighbour (KNN), Artificial Neural Network (ANN) and proposed deep learning enabled Convolution Neural Network (CNN) classifiers are compared for samples datasets of liver, migraine and mifem as represented in figure 3.

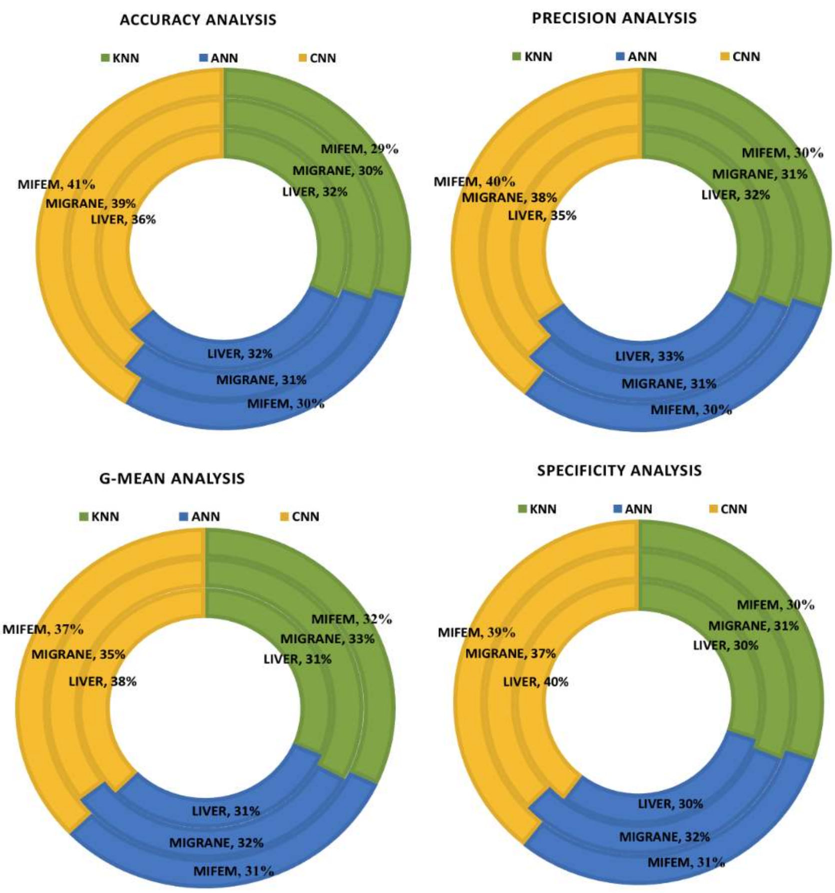

Figure 3: Performance Analysis of proposed approach

The accuracy of classification, precision, G-Mean and specificity analysis shows improved performance of the proposed deep learning based CNN classifier when compared to other classifiers. The proposed methodology is analysed statistically for classification of diseases as shown in table 1.

Table 1: Analysis of operational indicators of the proposed classifier

Sl. No.	Operational Indicators	Dataset	Obtained Value
1	Accuracy	Liver	0.8
		Migraine	0.85
		Mifem	0.9
2	Precision	Liver	0.78
		Migraine	0.87
		Mifem	0.95

3	G-mean	Liver	0.87
		Migraine	0.84
		Mifem	0.91
4	Specificity	Liver	0.76
		Migraine	0.87
		Mifem	0.94

The images of the diseased region can be understood in a much clearer manner using feature visualization techniques in the deep learning architectures and models. Reference based visualization, Grad-CAM visualization, Gradient-based visualization and Perturbation-based visualization techniques are used for this purpose. Saliency map and heat maps are some of the commonly used visualization maps. Heat maps often fail to detect some of the diseased regions from the input images. In order to overcome this issue, guided back propagation technique is used in saliency maps such that all diseased regions are identified accurately. Hence saliency maps provide better results when compared to the heat maps. Classification of specific diseases are done using semantic dictionary and feature visualization on a wide range of applications. The attention maps can be interpreted for accurate understanding of the diseased region in the images.

5. Conclusion and Future Scope

In recent days, text, speech, image and voice processing is performed using CNNs (Convolutional Neural Networks). Despite the extraordinary progress made my CNNs in the experimental assessments, various issues that requires examination still exist. In order to train the information, CNN requires huge computing power as well as large datasets. This paper offers an efficient solution for classification and visualization of disease datasets using CNN classifier. Liver, migraine and mifem (myocardial infarction) datasets can be analysed and evaluated using the proposed technique. The experimental results demonstrate that the proposed classifier offers improved efficiency in comparison with the other existing classifiers.

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