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Hybrid Techniques for MRI Spine Images Classification

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The number of persons suffering from spinal tumor has increased significantly from 2010 to 2016. Tumor is one of the major diseases of spinal cord. Thousands of researchers have concentrated on this disease to provide more efficient diagnosis with better understanding of the classification of spinal cord tumor. The proposed convolutional neural network (CNN) is tested with two hybrid recognized techniques of image detection which are K–nearest neighbor (KNN) with principal component analysis (PCA), local binary patterns (LBP) with support vector machine (SVM). Above three techniques overall accuracy is demonstrated, which show that LBP with SVM gives better result compared to KNN with PCA. The proposed CNN provides high accuracy classification and detection of spine diseases compared to other three techniques, which have obtained a best detection accuracy of 99.41 %. This process is fully implemented in MATLAB tool.

Keywords: CNN, KNN, LBP, PCA, SVM

Introduction

Spine tumor is located within the tissue surrounded by the bony spinal column.[1] Tumor cells growth when out of control affects also the normal cells and can spread to any part of the body[2] to disrupt body functions. Tumor can be present inside (or) on spinal cord as spine tumor.[3] Here we utilized proton density weighted with sagittal MRI image.[4] In this paper, we used two hybrid techniques, and one neural network technique for spine tumor detection which are K-nearest neighbor (K-NN) with principal component analysis (PCA), local binary patterns (LBP) with support vector machine (SVM) and convolutional neural network (CNN). LBP with SVM provides high accuracy compared KNN with PCA. Convolutional neural network also classify and provide high accuracy result.[5]

Materials and Methods

The proposed method is employed in the following techniques: PCA, K-NN, LBP, SVM and CNN. It has three stages: (1) feature extraction, (2) feature reduction, and (3) classification. Original image diagram is shown in Fig 1. Proposed block diagram of the proposed method of spine tumor detection is illustrated in Fig 2. Basics of K-NN, PCA, LBP, SVM and CNN are explained ahead.

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Feature Reduction by PCA

Principal component analysis (PCA) is a statistical procedure, that works with the orthogonal transformation, it's convertsa set of correlated feature variables into a set of uncorrelated feature variables. PCA is used to analyse the data for identifying pattern. It helps reducing the dataset dimensions without more loss of information. Thus, PCA begins with the covariance matrix calculation and then solves the characteristic Eq. (1)

$$CG_i = \lambda_i G_i,$$

Where, $i = 1, ...$ … (1)

The First principal component represents original data to achieve the goal of reducing data size without much loss of information.

Feature Extraction based LBP

Local Binary Pattern (LBP) is a texture-based feature extraction technique also very useful for spine tumor classification in MRI. The LBP operator works by thresholding the neighbourhood of each central pixel with clockwise or counterclockwise direction and produces a binary value histogram. Those binary values are evaluated. If the neighbor value is greater than central value 1 is set to position, otherwise 0 is set. Then 8 points of 3 × 3 block will generate an 8 bit binary number. LBP rate will be acquired. The LBP operator is defined as Eq. (2)

Fig 1 — Original Spine Image

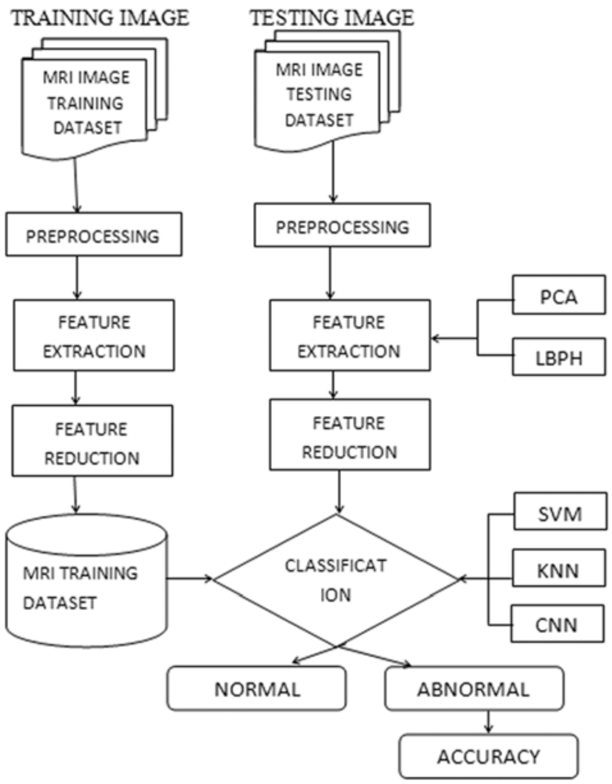

Fig 2 — Proposed blockdiagramof the proposed technique for Spine Tumor Detection

$$LBP_{P,R}(x_{c,}\, y_c) = \sum_{p=0}^{p-1} s(g_p - g_c)2^p \qquad \dots (2)$$

Where there are P neighbours, with radius of neighbourhood R, $(x_{c,}\ y_c)$ are co-ordinates of pixel at the centre of the local region, and $g_p, g_c$are gray intensity values of neighbouring pixel and sampling centre pixel. This technique of description enables researchers to acquire image information, since LBP characteristics are capable of depicting local image texture features.

KNN based Classifier

The k-nearest neighbour technique was used for Classification. It is non-parametric method and can handle multi-class problems. Whole spine data is classified into training and test sample data. It's not required to retrain for attaching new training pattern. From training item to new item, distance is evaluated using Euclidean distance. Euclidean distance between training data and testing data is set as final classification output. In KNN, setting a new data items depends on K value. K shows as Count of neighboring training items. Different k value gives different classification results. If k value is low, curve can overfit, if k value is too high, curve can be underfit the. If neighboring k sample is chosen from training items, more votes of class may take place. K have only odd number to neglect confusion. They have two classes which are class 1 and class 2. The class 1 represented as red asterisks, class 2 represents blue circle.

SVM based Classifier

SVM can be employed in both types of classification and regression problems. SVM generates hyperplane to separate a training sample by decision function. SVM is a binary classifier that classifies two different classes of data. When the classification problem involves more than two classes, as is the case in our study of tumor classification, multiclass SVM is used. There are several techniques to address the classification of multiple classes. We used the one-vs-one technique in our method. This technique is constructed k (k-1)/s classifier where each classifier is trained in two classes of data.

Classification by CNN

Spinal cord image is set as the input for extracting the features in spinal cord image using CNN. Once image was ready, they were fed to the CNN and trained and tested. *Convolutional neural network* have convolutional layer, max-pooling layer, followed by fully connected layer. First convolutional layer performs the initial segmentation of the image, interconnection with nodes. Then we need to decrease the data size using pooling layer (without over fitting), the 2ndand 3rdconvolutional layer identified the spine problem (tumor) and got more information about spinal cord tumor. The convolutional layer represented by Eq (3) calculated the state of one isolated neuron using convolution, there set q input connections.

$$F^H = \sum_{i=1}^{q} W_i * x^i + b \qquad \dots (3)$$

Here, F^Hdenotes neuron state with one convolutional layer. H Denotes kernel filtered image, b denotes bias factor, bias factor value has 0 or 1. x^i represented the value of input nodes in past layer into current layer i-th node. When CNN was trained, the bias factor is calculated extract and adjusted the correlations between the nodes. The image is divided into smaller parts in which overlapping was created in certain part of the image being used for search. If overlapping was increased, it prepares more window images so procedure of classification gets slow.

Our Convolutional layer gets input of 128 × 128 × 3 (weight × height × color). Here grayscale image is utilized. Rectified linear unit function replaced all negative value to zero. The convolutional results image is smaller image compared to original image using max-pooling layer, which decreases the size of these images into data chunks. Then we obtained maximum value of all image. The convolutional filter is very simple matrix. It convolutes the image matrix and this filter utilizes edge detection sharpening images.

In the case of fully connected layers, each neuron are fully connected in the previous layer, as in ordinary feed forward neural networks which is used to classify the spine image either normal or abnormal image.

Results and Discussion

We used ROC (receiver operating characteristic) graph to select the proposed performance based system. The ROC area under the curve (ROC AUC) characterizes performance of classification model. The classification result depicts that KNN technique with PCA technique (one of the most popularly used dimensionality reduction technique) results 93.38% accuracy. Spine image extracted features by applying LBP operator, to classify image either normal or abnormal using SVM algorithms. The SVM learning curve using LBP features extraction in spinal cord image is shown in Fig 3. Training score was usually high by iterations as demonstrated in Fig 3. But, the testing values were increasing while training iterations increased and obtained high classification accuracy results of 95.71% through SVM classification in Spine image. Finally, CNN classification accuracy and loss scores between training and validation set of training process were considered. The training process taken 80% of the dataset while testing took the remaining 20%. All epoch (train cycle), passed all images once by training process. Training process reached 43 epochs for training set classification accuracy. In the process, the network computed topology fit value by calculating classification images without error. The system evaluates accuracy and features extraction, also shown very good classification in spine images

We explained the techniques utilized to calculate the approaches proposed. The results obtained overall accuracy of MRI spine tumor detection value for various count of training image, will be examined and calculated for accuracy of image.

The experimental training image and testing image are separated into four parts:

- 1 – 80: 400 (20% of data in training image).
- 2 – 160: 400 (40% of data in training image)
- 3 – 240: 400 (60% of data in training image)
- 4 – 320: 400 (80% of data in training image)

Overall accuracy of Spine image is shown in Table 1. The best result was achieved as 99.41% accuracy using CNN for 320 training images. The worst result was obtained as 85.42% accuracy using hybrid KNN with PCA algorithms for 40 training images. Thus, CNN gave high accuracy classification results, achieved best results of 99.41% accuracy.

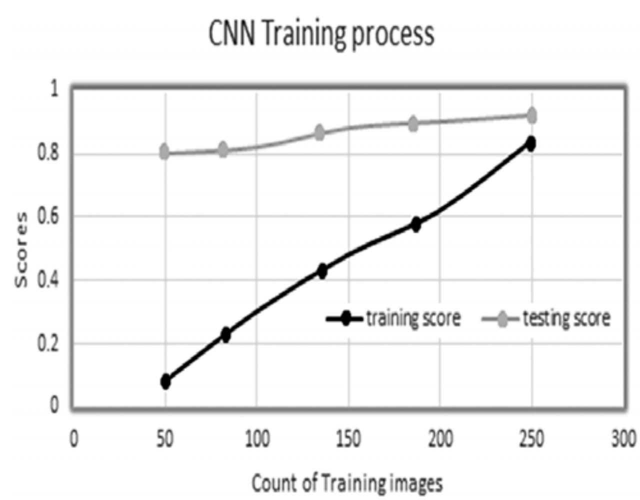

Fig 3 — SVM learning Curve using LBP Features

Table 1 — Overall Accuracy of Spine image Detection

Methods	Count of Training and Testing image			
	1	2	3	4
KNN+PCA %	85.42	87.86	92.17	93.88
LBP+SVM %	88.75	91.25	93.56	95.78
Proposed CNN %	94.95	96.72	98.37	99.41

Conclusions

In this work, the overall performance was achieved using the various count of training image and testing image. The KNN with PCA reduced the data dimensionality also speed up the calculation of KNN and effectively improves performance of KNN result. Local binary model and Support Vector Machine algorithm are utilized to feature extraction of Spinal Cord tumor MRI images. The local binary pattern algorithm can used to image detection based on translational rotation invariance. SVM is used in classification of Normal or Abnormal spinal cord image.

CNN is utilized to feature extract of trained image and test image and classify the output as normal or abnormal spinal cord image. Our proposed CNN result achieved the highest accuracy for 320 training images. The lowest accuracy result of 85.42% was obtaining by KNN+PCA methods for 40 training images. The proposed CNN provides high accuracy classification and detection of spine tumor, achieved best results of 99.41% accuracy. It's very helpful for detection of spine tumor cell accurately without missing tumor cell.

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