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Deep Learning Approach to the Normal and Abnormal Blood Cells in Human Blood Smear

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Abstract: This paper provides Deep Neural Network model for analyzing and classifying the blood cells image. Detecting various diseases from the human body is obtained though blood cells and it is one of the better ways to detect the disease accurately. Various diseases like cancer, bone cracks, nerve problems are detected and classified only through certain images such as MRI, CT, X-Ray. Whereas most of the diseases are detected by analyzing the blood cells. This paper does analyze the blood cell images and do detecting and classifying the abnormality using Deep Neural Network method. The DNN is implemented in MATLAB software and the results are compared with the existing Support Vector Machine method and the compared accuracy is given in the paper. From the comparison, it is found that the proposed DNN is better for detecting and classifying the blood cell diseases.

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Keywords: Image Processing, Deep Neural Network, Blood Cell Classification, Support Vector Machine.

Introduction

Deep learning technique is a type of machine learning techniques that are used in for a deep structured learning or any hierarchal learning. Different algorithms are used for maintaining the high-level data abstraction [1, 2]. Algorithms are integrated with artificial intelligence for developing a deep layered network in a hierarchical architecture. Machine learning is used for such deep networks for automation and extraction features [3, 4]. Many applications are developed with the help of Deep learning Techniques such as automatic speech recognition [5], image recognition [6], natural language processing, and bioinformatics [7] etc. deep learning in medical fields is used for saving countless lives and the neural networks are used for auto encoding that results in better performance than any other machine learning techniques. Advanced deep learning isnow used in health industries and even in blood cell departments. Blood molecules are categorized into two types, the red blood cells, white blood cells and the platelets. RBC's are more in number and they are used for carrying oxygen using hemoglobin. Hemoglobin generally comprises of protein that gives the blood red color. White blood cells are otherwise called as leukocytes. White blood cells are responsible for immune system in the human body. White blood cells defend against harmful living things in the blood cells and the blood cells will eventually destroy those foreign particles. Platelets are irregularly shaped particles that are used in forming blood clotting. Platelets are responsible for control bleeding in skin. There are many people affected by blood cell defects. Computer Aided Diagnosis is increasing rapidly in last few years. They are used for detecting different diseases related to blood types. Example, Leukemia is a blood cell related disorder associated with the deficiency of white blood cells. Such types of deficiency are calculated by using automated computer diagnosis.

Related works

Different approaches are carried out in processing blood cells, they are image processing and machine learning methods [8, 9]. Previous researchers say that the blood cell images are

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processed and the processed image could indentify between normal and abnormal images. WBCs are extracted by using K-medoids algorithm and the RBCs are extracted using granulometric analysis. Further counting on RBCs is done by circular Hough Transform with the help of gray scale images [10]. By applying similar transform techniques platelets are counted and the reason for platelets deficiency is identified. By using convolution neural network, the WBC is detected from the microscopic images and the types of WBC's are detected by using this algorithm. ResNet and the Inception Net are also used for counting RBC and WBC in blood cells [11, 12]. The preprocessed images are deployed by using patch normalization method and convolution neural network is deployed for classifying red and white blood cells. Deep learning and Machine learning techniques are induced in Medical IoT. The detection of WBC deficiency using Random Forrest provides 94.3% and with Naïve Bayes, the accuracy rate is about 92.8% [32,33]. KNN also used for classifying the blood cell types.

Proposed system

This paper follows a sequence of image processing methods such as read the input image, and do image acquition. Then preprocess the imageby color conversion, noise removal, and resize the images into a fixed size. It increases the image quality for improving the image processing results. Then apply the DNN for learn and extract the image features. From the feature vector, the class of the blood cells are classified and the shown as the output.

Methodology

The main objective of this system is to detect and classify the blood cells and to detect any abnormalities in the samples using deep learning techniques.

Image Acquisition: The sample images are obtained from online sources and aver 200 images of blood cells are analyzed. The observed blood cells are categorized as five sources such as, normal, achantocyte, sickle cell, and teardrop and elliptocyte cells. In the first step over 21 images are analyzed. Colored images are used for classifying any abnormalities in the blood cell types. It is then classified by using Support Vector Machine and Deep Learning classification. Using image acquisition methods, the images are resized into 256×256 pixels.

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Cropped images: The images are cropped from the downloaded images and the cropped images are arranged into a dataset of the mentioned five categories. The classifier performances are improved by using SVM and deep neural networks. The training of cropped images is done on colored images.

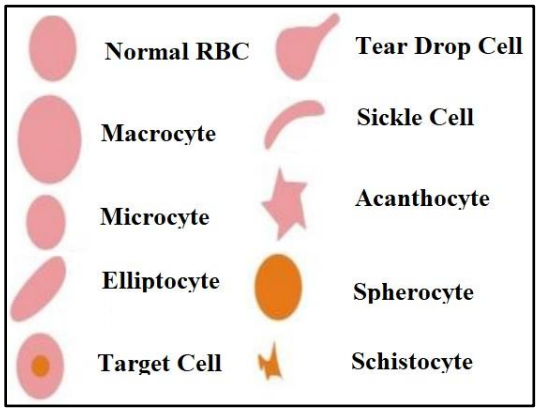

Figure 2 Various Kinds of Blood Cells

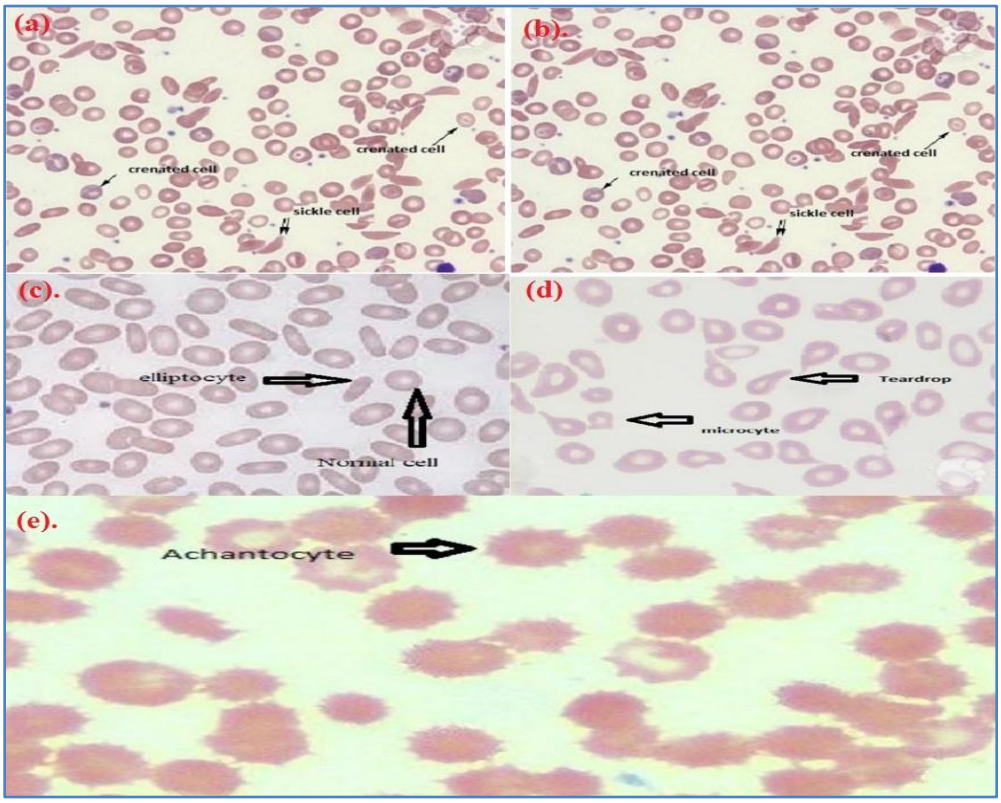

Figure 3 Blood smear image (a) Normal cell; (b) Sickle cell; (c) Elliptocyte cell; (d) Teardrop cell; (e) Achantocyte

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Support Vector Machine

Support vector Machine is an important classifier algorithm and they use feature selection algorithm for classifying blood cell types. In the feature selection, shape feature is used for classification methods. By combining Support Vector Machine and Radial Basis Function, the images are classified in Matlab 2017b software. This feature selection is based on the shape selection and the images are categorized as normal and abnormal based on the size of the blood cells. Linear classification method is used for shape classification and feature classification is also used for almost all types of feature extraction. The absolute value and the linear classification are used for train the whole sets and the sample weight with larger values are more efficient than the sample with smaller weights. Support Vector Machine uses hyper plane with a maximum-margin in higher feature space. Training samples of $\{\boldsymbol{y_i x_i}\}_{\boldsymbol{i=1}}^{\boldsymbol{N}}$ with a label of $\boldsymbol{y_i \varepsilon (-1, +1)}$. This label shows the feature vector with $\boldsymbol{x_i \varepsilon R^d}$. The Support Vector Machine classifier in normal form is shown below:

$$\boldsymbol{F(x) = \sum_{i=1}^{n} \propto_i y_i k(x, v_i) + b} \qquad \textbf{(1)}$$

Feature vectors are defined as x, and this feature vector is normalized into unit length before any classification. The support vectors are defined as $\{\boldsymbol{v_i}\}_{\boldsymbol{i=1}}^{\boldsymbol{n}}$.

Feature Extraction

The healthy blood cells are identified based on the shape of the blood cells. Perfect blood cells are analyzed based on the extracted shapes. They are form factor, Compactness, Eccentricity, minor and major axis.

- Form Factor: the ratio between the cell area and the square of its perimeter shows the cell measurement. A and P are area and the perimeter of the cell.

  $$\boldsymbol{form\ factor = \frac{4\pi A}{P^2}} \qquad \textbf{(2)}$$

- **Compactness =** $\boldsymbol{\frac{\sqrt{\frac{4A}{\pi}}}{maximum\ diameter}}$ **(3)**

- **Eccentricty=** $\boldsymbol{\sqrt{1 - \frac{L_{minor}^2}{L_{major}^2}}}$ **(4)**

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$\mathbf{L_{minor}}$and $\mathbf{L_{major}}$ is the length of minor and major principal axis.

Major axis refers to the total number of pixels of the longest diameter in which the blood cells are passing through the centre. Minor axis refers to the small diameter passes through the diameter and the minor axis is perpendicular to the major axis.

Deep Neural Network Architecture

Deep learning network is a machine learning used for training datasets from the images, sounds, or even from texts. Neural network is used for deep leaning techniques and deep learning refers to the network with deeper layers. Deep learning is categorized as supervised learning and unsupervised learning. Matlab 2017b is used for training the datasets and this training uses AlexNet architecture. AlexNet is different from LeNet-5 architecture. Each architecture uses convolution layers and they also have pooling layers. Rectifying linear unit or ReLU function applies a transformation to the output of every layer and maps the corresponding to either positive or negative value. ReLU function is given as

$$\boldsymbol{f(z_i) = \max(0, z_i)} \quad \textbf{(5)}$$

The input of nonlinear activation function $\boldsymbol{f}$ of the $\boldsymbol{i^{th}}$channel is represented as $\boldsymbol{z_i}$. The pooling layer transforms the activation step by reducing the dimensionality of the features map by considering the output of the neuron. Every layer is mapped with their previous layer and AlexNet architecture will test the blood cell images and the tested images are used in the SVM classifier. The below image shows the workflow diagram of deep neural network. This proposed system uses more than two hundred colored images and the performance of SVM is drastically improved with the integration of deep neural networks.

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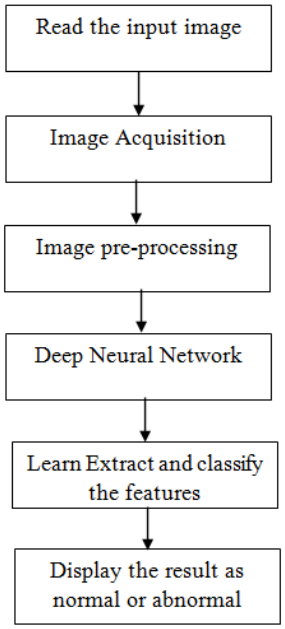

Figure 3 Proposed Work Flow

Accuracy Calculation

The accuracy of this proposed model is based on the benchmark values such as false positive (FP), false negative (FN), true positive (TP) and true negative (YN). The false positive and negative condition occurs when the result image is found to be normal and abnormal images. The true positive condition indicates the cell with positive forecast and the true negative condition indicates both classifier values. The accuracy value has been determined as the proportion of effective cells and it is equivalent to all the values of true positive and true negative. These values are separated by aggregate number of blood cells.

$$\boldsymbol{Accuracy = \frac{TP+TN}{N}} \qquad \textbf{(6)}$$

Table-1. Accuracy Comparison

Classes	**Existing SVM Model (%)**	**Proposed DNN Model (%)**
Achantocyte	98	99
Elliptocyte	76	78
Sickle cell	89	89

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Teardrop	99	99
Normal	100	100

From the experiment the obtained results are compared with the existing results and given in Table-1. From the comparison it is clear that the proposed method provides the highest accuracy in terms of classification than the existing SVM method.

Limitation of Deep Networks in Classifying Blood Cells

SVM model is used for training the sample images with the help of feature selection by selecting the feature such as shape and size of the blood cells. The performance of the model is high while using deep neural networks. This proposed model is based on the AlexNet architecture incorporated in the deep networks and the colored images are used for training the blood cells and this model will identify between the normal and abnormal cells. The sample images should be clearer for greater accuracy while using deep networks. The main disadvantage of this proposed model is that the blood cells are abundance in nature and the clearer microscopic image is difficult. This reduces the accuracy in finding the blood cell types and their condition. This abundance nature makes deep learning networks more prone to mistakes. Medical blood cell images must be certified by medical experts, so the data available for testing and classifying the blood samples are more difficult because a very little number of clearer samples are available. Deep networks need more classified datasets with clear blood sample images.

Conclusion

The main objective of this paper is to detect and classify the blood cell diseases using image processing methods. It uses deep neural network model, learn, extract and classify the features of the blood cell images for classifying the diseases. The proposed DNN and the existing SVM models are implemented in MATLAB software and the results are compared in terms of classification accuracy. From the comparison it is proved that DNN preforms better than the SVM since SVM can not have more classes like DNN.

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