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Comparative Study for Classification of WBC Segmented images using Bag of Words and WEKA

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***Abstract*— The representation of the image in a meaningful and easy-to-analyze way can be done with the help of image segmentation. Diagnosis, treatment planning, tumour localization, WBC count, Leukocytes classification etc. can only be performed after image segmentation. For accurate diagnosing of disease, correctly classified leukocytes, and its subclass are required. Whether the segmented image cells are belongs to benign or malignant are carried out by best classification method. In this paper comparative study of two types of classification techniques like WEKA and Bag of Words have evaluated. Geometrical, textural, and statistical features of different images are extracted and applied in classification algorithms. WEKA is made up of machine learning (ML) techniques hence multi level based classification developed using the different classifiers like Lib SVM, Naïve Bayes, J48, Zero R, PART and Random Forest classifiers are considered. The Bag-of-Words (BoW) model is used to construct the feature vectors from densely extracted local features, such as dense scale-invariant feature transform (SIFT) and Speeded Up Robust Features (SURF). The two types of algorithm are tested using 120 test images and 311 training image sets with many image using MATLAB code. Performance indices and classification accuracy of the two classifiers are compared and check the comparative results of the BoW model and WEKA classifiers.**

***Index Terms*— Leukocytes, Lib SVM, WEKA, SIFT, BoW model, SURF, Geometric Features, Statistical Features, Textural Features.**

I. INTRODUCTION

Segmentation is basic need for computer vision for the division of areas that have similar properties. The processing of microscopic blood smear images also helps us to detect WBCs/RBCs/platelets, count the number of cells, calculate their sizes, and normal percentages in human blood. Leukocytes consist of five sub-categories known as monocyte, lymphocytes, basophil, eosinophil, and neutrophils [1][2]. In order to diagnose and correctly detect leukocyte and its underlying sub-class, a multi-class classification is considered as the best option, which can be used to efficiently classify each category. To accomplish this task, firstly need to detect WBCs in microscopic blood smear images. There are two possible methods to detect WBCs in blood smear images: manual segmentation and automatic segmentation [3]. Manual segmentation of nucleus from WBCs and their classification is based on a pre-defined procedure, which is inherently difficult, prone to errors, and time consuming due to the involvement of human labour.
Furthermore, the instruments used by experts for manual segmentation and classification of WBCs are not affordable by all hospitals and clinics, especially in remote areas [4].

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Image classification is based on different image features like histogram of gradients (HOG), edges, geometric, texture, and statistical features [5]. First step in image classification is pre-processing, which includes image sharpening, contrast adjustment, and noise removal. Different techniques are used for the enhancement of microscopic images. The enhanced image is further processed for segmentation of WBCs using different segmentation techniques such as manual thresholding[6], OTSU binarization, fuzzy c-means (FCM)[7], and active contours [8]. Active contours are well-known segmentation algorithms and are widely used in various applications such as medical image analysis and computer vision. Active contour models segment the objects from an image using curves, which start around the object and move toward its inner normal. When it reaches the boundary of the segmented object, it stops moving. From the stopping point, shape of the object is detected [9]. The work in [21] employed contour signature to identify the irregularities in the nucleus boundary. The work in [20] employed selective filtering to segment leukocytes from the other blood components. FCM is unsupervised clustering technique which is frequently used in image segmentation, allowing a chunk of data belong to two or more clusters [10].

Most of the proposed approaches for classifying WBCs use features from nucleus, cytoplasm and cell. Sabino et al. [12] computed shape, size, color and texture features of nucleus and cytoplasm to classify 5 types of WBCs. They are used a Naive Bayesian classifier, achieving errors as 10.93%. Data mining is going out from the raw data to information, which can be used to make that are useful in real world. It contains large number of algorithms for classification. WEKA is collection of machine learning algorithms for data mining tasks. This tool is free, open source software. Different classification techniques are compared using the Waikato Environment for Knowledge Analysis in short WEKA. The University of Waikato, New Zealand developed WEKA that can done with real-world data mining algorithms using the JAVA language and It can be run in Linux, mac and windows. The algorithm applied directly to a dataset or called from our own java code. The steps of the method include learning from samples, image segmentation, and object (segment) classification. By learning from samples, the method avoids developing complex statistical models or decision rules of classification for the images of a wide range of sensors. The classification model is constructed by learning (training), the consequent extraction can be automatically performed. For the learning and classification steps, the key concept is to construct the proper features of clouds, and to use an adequate sample to build an effective classification model [12].

High-dimensional vectors of such patterns usually lead to high- computational complexity. To solve this problem, the bag-of-words (BOW) model [14] is employed in constructing compact feature vectors of clouds from densely extracted local features. This algorithm is different from the classification-based algorithms, such as in [6]. To build the BOW model, dense SIFT features [15] are extracted from each object obtained by segmentation. K-means clustering is then used for the generation of the code book of the features. A training sample of cloud and non cloud objects is then selected. After learning from the samples by support vector machines (SVMs) [16]. The paper is organized as follows. Section 2 explains the WEKA classifier and Bag of Words using various techniques and states their limitations. The details of comparison of the algorithm including the constraints handled, the creation of the dataset and the architecture of the system. Section 3 presents the details of the results of experiments performed using the dataset and the classifier are presented and in Section 4 explains the conclusion of the experiments and acknowledgment in Section 5.

II. PROPOSED METHOD

Figure 1. GUI of proposed method

The important section in early detection of WBC related diseases are the segmentation. In this paper segmentation using Gradient vector force (GVF) is compared with Kmeans clustering and thresholding segmentation. Feature selection and feature extraction has carried out as shown in Fig.1. Statistical features, geometrical features and textural features etc. are extracted. All the extracted features are saved as datasets. These dataset is used for classification for identifying benign cells or malignant cells. In this paper comparison of the classification using different WEKA classifiers and Bagging of Visual words has carried out.

A. WEKA GUI Classifier

WEKA contains preprocessing, classification, regression, clustering, association rules and visualization developing new machine learning schemes as shown in Fig 2. The WEKA software uses the data set in the ARFF or CSV extension, in this document it uses the Leukemia. arff data set. WEKA has an explorer in which data can be processed with or without filters and then classification, regression etc can carried out. It also includes visualization tools. WEKA is open source software released under the Public General license [17]. The objective of this review is to analyze the efficiency of various classification or grouping methods for a large dataset. The different classifiers are the J48 decision tree classifier, the Nave Bayes classifier, the SVM classifier (LibSVM). Segmented leukemia data with 72 instances invoked to test and compare the performance between the different classifiers. WEKA data is in ARFF format, includes attribute: names, types, values and data as shown in Fig 4. After the dataset uploaded, select the explorer to perform further analysis. The different steps in WEKA

- Install WEKA
- Explore the Explorer interface
- Load the dataset into WEKA
- Use filters for preprocessing
- Explore it using interactive visualization
- Apply classification algorithms
- Interpret the output
- Understand evaluation methods

Figure 2. WEKA GUI Panel.

There are four interfaces in WEKA

Explorer: It will be commonly using for small scale Experimenter: For large scale perfomance comparisons for different machine learning methods on different datasets Knowledge flow: It is a graphical user interface to WEKA tools

Simple CLI: It is command line interface

- Exploring the explorer: By clicking Explorer there are five panels: the preprocessing panel, the classify panel, here build the classifiers for datasets, clustering the dataset, association rules and attribute selection and visualization which are shown in Figure 4.
- Exploring the datasets: But mainly preprocessing panel, explores the datasets, it's have attributes, instances and classification problems predicts the class value.

The histogram of the attribute values is obtained as different colors as the class value here blue color for YES and red color for NO. The attributes or features can be continuous or discrete are shown in Figure 4.

Figure 3. Different Panels in Explorer

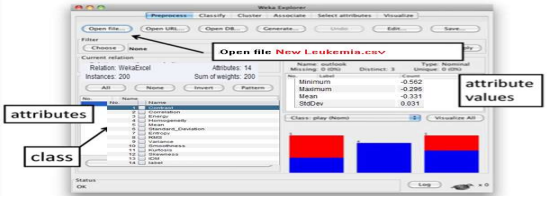

Figure 4. Histogram and datasets uploaded in WEKA Classifier

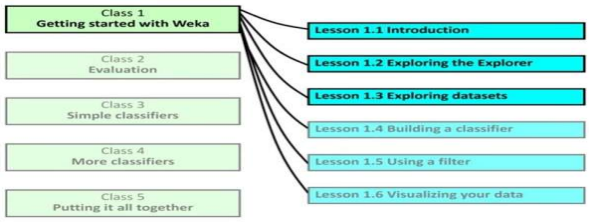

Figure 5. Different steps in Exploring Datasets

Building a classifier: There are different kinds of classifiers in WEKA, which has Bayes classifier, function classifiers, lazy classifiers, meta classifiers, decision rules, decision treesandsoonasshowninFigure6

Bayes classifier: Bayesian network: The probabilistic method which adopts graphical model which represents knowledge concerning a set of random variables[16]. It is otherwise known as belief network in this model, each node in the graph represents a random variable, and the edges between the variables represent the conditional dependencies[17]. The Naive Bayes algorithm is based on the Bayesian theorem and operates on conditional probability. Despite its simplicity, it is a powerful algorithm for predictive modeling.

Function classifier: Logistic regression: logistic regression measures the relationship between a response variable and independent variables, like linear regression, and belongs to the family of exponential classifiers [18]. Logistic regression classifies an observation into one of two classes[19], and this algorithm analysis can be used when the variables are nominal or binary. i.e. data are analyzed after the discretization process for the continuous variables, similar to the Bayesian group.

Decision Tree classifier: J48 algorithm: this algorithms name is derived from its tree-like structure and is based on supervised learning techniques. It is a frequently used algorithm due to its ease of implementation, low cost, and reliability. Decision trees roots consist of decision nodes, branches, and leaves[20]. In the WEKA software, the J48 algorithm uses the rules of the C4.5 algorithms. Random Forest is also the decision tree classifier which produces more than one tree [21]. Each tree produces a classifier, and these classifiers vote to determine the algorithm that gets the most votes [22]. 1is classification algorithm is then used to classify the dataset.

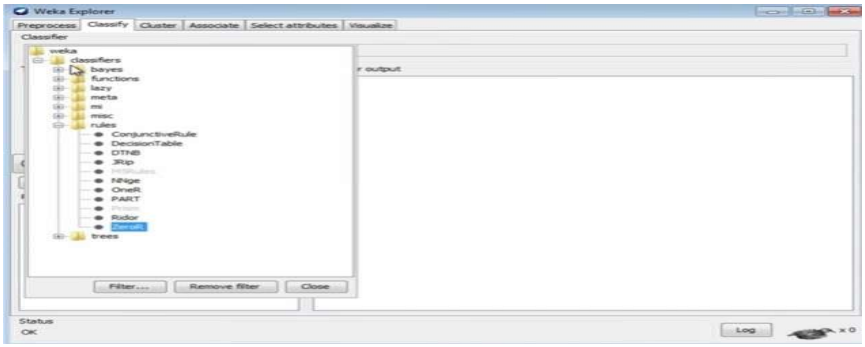

Figure 6. Different Classifier rules in WEKA

Decision Rule classifier: Learn a decision rule(classifier) assigning in WEKA representations of images to different classes. libSVM is the main decision rule in WEKA. Here in order to draw the decision boundary, training dataare required. Here SVM is used to create decision boundary. This classifier learns the regularities in the data. Different kernels in SVM classifiers are linear classifier, polynomial classifier and Radial basis function (RBF).

B. Bagging of Words (BoW classifier)

Image classification having positive training images containing on object class and the main objective of these is to classify test image into appropriate class. Bagging of features approach is the process of identifying a specific object or class of objects in an image and it involves a class label to the image. Hence bagging of features characterized as an order less collection of image features. It originates from the Bag of Words (BoW) model representation.

Here coding and pooling are used for these approach i.e. coding means hard assigning of each local descriptor to the closet visual word and pooling averages the local descriptor projections. The final BoW vector is a histogram counting the occurrences of each visual word in the image. The dataset used is Leukemia dataset which contains around 431 images features and each image have size 300x200 pixels. Here in this paper 20 percent images are used for training per class and remaining for testing.

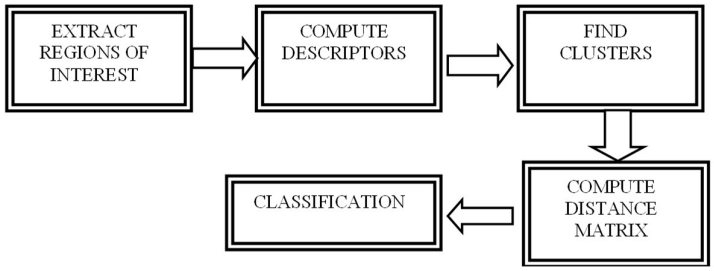

Figure 7. Different steps in BoW model

These approach adopts following steps The detailed explanation of the BOW model is shown

- First extract the features or interest regions by using SIFT (Scale-Invariant Feature Transform), Harris and Dense (take every nth pixel as interest point). Here in this paper SIFT is applying. SIFT is the best feature detection algorithm in computer vision to detect and describe local features in images. SIFT key points of objects are first extracted from a set of reference images [1] and stored in a database. Load the image collection using the MATLAB code function image Data store which help the managing of data. This function operates on image file locations and therefore does not load all images in memory. By using count Each Label number of images per category can easily inspect it and count it.
- Prepare training and validation image sets by using MATLAB code split Each Label. Create visual vocabulary and train an image classifier since the images do not actually contain discrete words first construct the vocabulary extract features representing each image category. This can be done by the descriptor. Hence compute Descriptor around each interest point by using SURF (Speeded Up Robust Features), which is a patented local feature detector and descriptor. By using these different tasks such as object recognition, image registration, classification can be done. SURF is several times faster than SIFT and claimed by its authors to be more robust against different image transformations than SIFT. The visual vocabulary as in clusters shown in Figure 8.
- Construct visual vocabulary by reducing the number of features through quantization of feature space or find clusters by using k means clustering. Assign each visual image word to a cluster to build Vocabulary and then build frequency histogram. Then the recomputed the mean for each clusters for each iteration. Bag of features uses the MATLAB code function encode method for counting the visual word occurrences in an image. Hence it reproduced the histogram that becomes a new and reduced representation of an image.

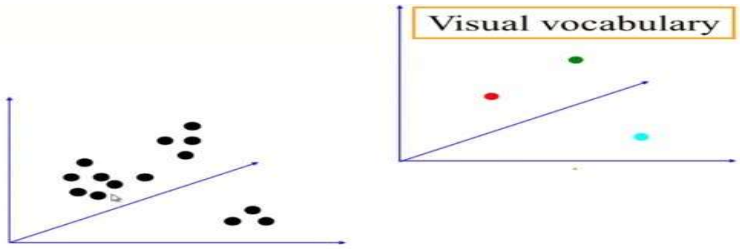

Figure 8. Visual vocabulary as in clusters in BoW model

The histogram counting the occurrences in BoW model shown in Figure 9.

Figure 9. Histogram counting the occurrences in BoW model

- Replace the cluster centers with the mean of the clusters by distance matrix. Finally, division of cluster points carried out by calculating mean and represented by vector data.
- Classification: Encoded pictures from each division are entered into a classification technique that relies on SVM classifier by the MATLAB code train Image Category Classifier function. Learn a decision rule(classifier) assigning bag of features representations of images to different classes. In order to draw the decision boundary training data are required. Here SVM is used to create decision boundary. This classifier learns the regularities in the data. Different SVM classifiers are linear classifier, polynomial classifier and Radial bias function (RBF). Maximizing the margin and minimizing the classification error between each classy i,{-1,1} from x-dimensional input data. In this case, xi represents the features extracted, i.e.,energy and entropy, while, yi labels the benign class (+1, red color) and malignant class (-1, blue color) Equation(1) below explains the mathematical representation of [3] hyperplane.

$$w.xi+b=0 \qquad (1)$$

Kernel Function: The distribution of data diversely is the main hurdle in the classification [3] [10]. Hence it will not be easy for linear separation [18,19]. In this case, SVM has the kernel function K(xn, xi), which transforms [7] the original data space into any other space with a higher dimension.

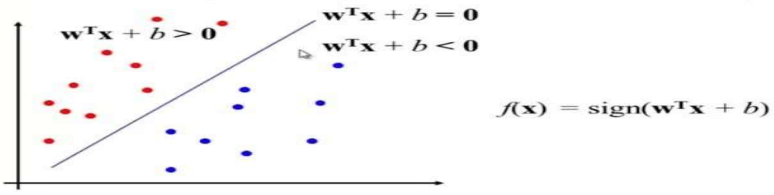

Figure 10. Hyper plane in SVM classifier

This process includes the transformation function with dot product φ(x). By using the kernel function, the data can have upgraded into a high dimension and separated easily.

$$K(x_n, x_i) = \varphi(x_n)\varphi(x_i) \qquad (2)$$

$$f(x_i) = \sum_{n=1}^{N} a_n y_n K(x_n, x_i) + b \qquad (3)$$

Thus the modified hyperplane function written as in Equation (3). where, xn is support vector data [17], an is Lagrange image into the gray scale image. After that the proposed system converts the gray image, the segmentation using GVF based active contours were implemented and results are shown Figures 11,12. Feature vectors are selected after feature reduction using PCA for feature extraction. Hence [17]

- Geometric characteristics including area, perimeter and centroid.
- Statistical characteristics including Mean, Standard Deviation, Variance, Smoothness, Skewness, Curtosis, Root Mean Square, and In- verse Difference Movement.
- Textural Features: Energy, Correlation, Contrast, and Homogeneity.
- Classification algorithm using Bag of Words with the aid of supporting vector machine (SVM) using MATLAB with different kernels are implemented with parameters as shown in table I. The distribution of data diversely is the main hurdle in the classification [3] [10].
- Hence it will not be easy for linear separation [18,19]. In this case, SVM has the kernel function [20] , K(xn,xi), which transforms [17] the original data space into any other space with a higher dimension. This process includes the transformation function with dot product φ(x). By using the kernel function, the data can have upgraded into a high dimension and separated easily.

In this work the comparison of classification [20] using the four kernel functions at the SVM algorithm, i.e., the linear kernel, the RBF kernel, the sigmoid and the polynomial kernel. The coding of SVM classification using different kernels has done in this paper using MATLAB software in GUI environment by implementing the Bagging of Words features (BoW Model).

TABLE I: DIFFERENT TYPES OF KERNELS IN SVM

No	Kernal Function	Formula	Optimization Parameter
1	Linear	$K(x_n, x_i) = (x_n, x_i)$	C and γ
2	RBF	$K(x_n, x_i) = \exp(\gamma (x_n, x_i) + C$	C and γ
3	Sigmoid	$K(x_n, x_i) = \tanh(\gamma(x_n, x_i) + r$	C, γ and r
4	Polynomial	$K(x_n, x_i) = (\gamma(x_n, x_i) + r)d$	γ, r and d

Evaluate classifier performance: Classifier performance validation can be done by initially test the image classification using 5-fold cross validation by training images. Then produce the confusion matrix that is the elements in diagonal by using the MATLAB code evaluate. After that the testing data or validation data which was not used in training cab be used to evaluate confusion matrix and hence calculate the performance indices like precision, Recall, Sensitivity and specificity.

III. EXPERIMENTAL RESULTS

Graphical user interface (GUI) using MATLAB has implemented in the proposed work as shown in figure 1. The first step is the image acquisition, here the images are captured in jpg format. After the data acquisition process, the images are undergone some image preprocessing like noise reduction, contrast enhancement, edge clearing etc. Thus the modified hyperplane function written as in Equation (1). where, xn is support vector data[20], an is Lagrange multiplier and ynis the label of membership class (+1, -1) with n = 1,2, 3, . . , N as shown in Table 1.The results are compared and found that the accuracy is high when SVM with polynomial kernel is used. Performance indices like precision, Recall, F Measure has measured and found GVF based segmentation got high performance. Also classification using WEKA software is also implemented and found the accuracy is high about 88.89 percent shown in figure 5,6. The comparisons of different classifiers are shown in table II. Here the different classifiers like Naive Bayes, J48, Random Forest, Zero R, PART are compared with LibSVM classifiers Figure 11,12 shows the simulation results of Bag of Words(BoW) using MATLAB GUI with Supporting Vector machines(SVM) with different kernels like linear, polynomial and RBF kernels are compared and found polynomial kernel has highest accuracy.

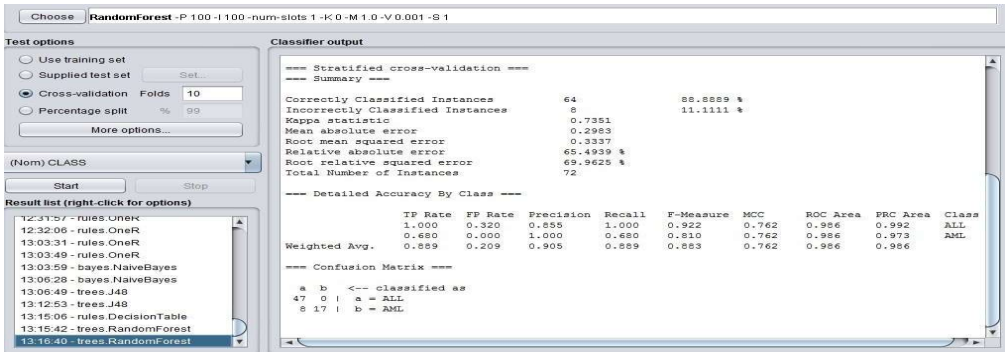

Figure 11. Classification with J48 Classifier in WEKA

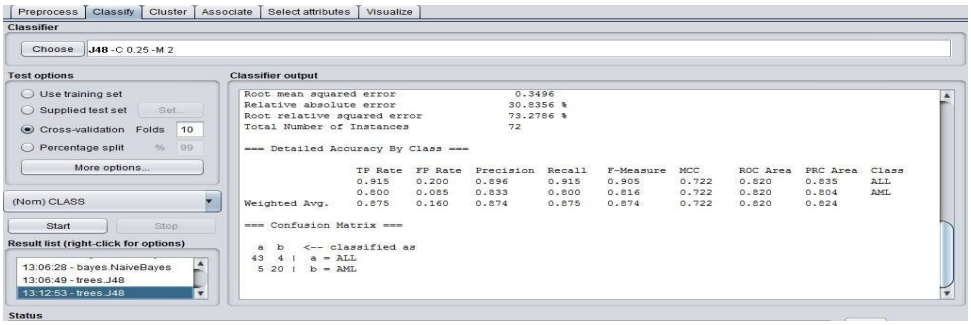

Figure 12. Classification with Random Forest Classifier in WEKA

The results using WEKA with different classifiers are shown in figure 11 and 12. The table II shows the detailed comparison of different classifier using WEKA and it shows the LibSVM has highest accuracy.

TABLE II: COMPARISON OF DIFFERENT CLASSIFIERS USING WEKA

Classifier	Correctly classified instances	Incorrectly classified instances	Time taken	Kappa statistic	Accuracy (%)
Naive Bayes	48	24	0.19	0.5778	67.85
J48	39	33	0.14	0.7821	54.35
Random Forest	64	8	0.12	0.7351	73.89
ZeroR	56	16	0.10	0.4318	74.45
PART	50	22	0.13	0.7812	69.23
LibSVM	57	15	0.17	0.172	75.46

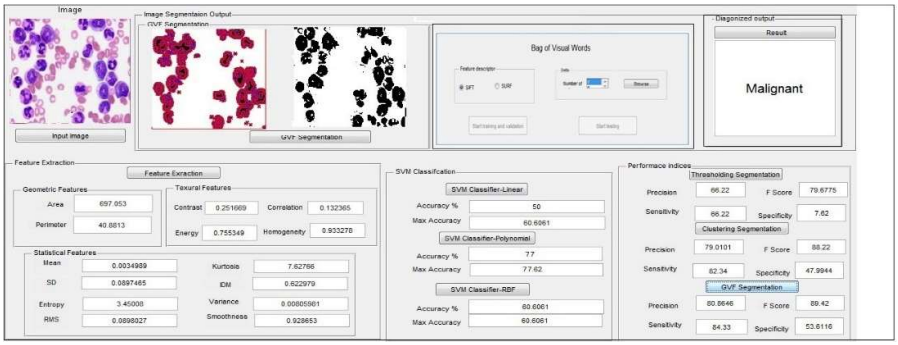

Figure 13. Simulation Results of Image 1

The results in Fig 13, Fig 14 shows the detailed segmentation, feature extraction, classification using Bag of Words in separate frame, classification with different kernels and performance evaluation of different images.

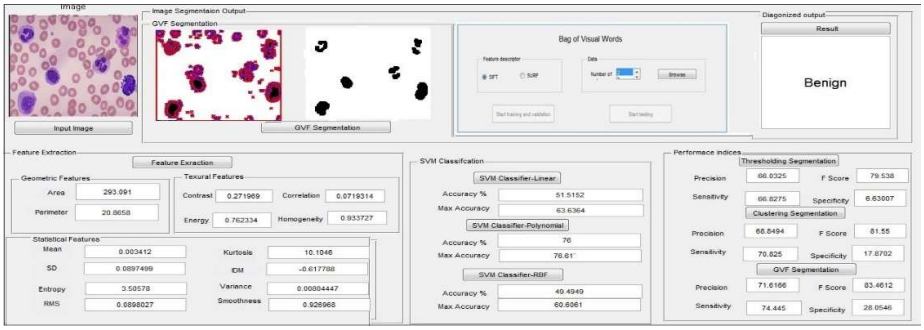

Figure 14. Simulation Results of Image 2

TABLE III: COMPARISON OF DIFFERENT CLASSIFIERS USING WEKA

Classifier	Correctly classified instances	Incorrectly classified instances	Time taken	Kappa statistic	Accuracy (%)
Bag of Words	50	22	0.07	0.65	77.62

The table III shows the results of correctly classified instances out of 72 instances The comparison between the classification using Bag of Words (BoW) model and WEKA classifier are shown below in the table IV

TABLE IV: CLASSIFICATION ACCURACY IN BAG OF WORDS METHOD AND WEKA CLASSIFIER

Model for Classification	Classifier	Classification Accuracy (%)	Precision	F Score	Sensitivity	Selectivity
Bag of Words model	SVM	77.62	79.62	85.56	72.15	54.56
WEKA tool	Lib SVM	75.46	76.54	80.14	71.25	52.34

IV. CONCLUSION

The model explained in the proposed work, which had developed in MATLAB GUI environment for segmentation, feature extraction, feature selection and classification using SVM with different kernels has proposed in this paper. The proposed GUI in figure 1 works well for GVF based segmentation. The Feature reduction using PCA has done for the feature extraction. The Statistical, Textural and geometric features are

extracted. Classification with Bag of Words(BoW) using SVM has successfully done using MATLAB with different kernels like linear, polynomial and RBF. Here found the polynomial kernel with SVM have the good classification results shown in figure 13,14. Also classification using different classifier like J48, Random Forest, Naive Bayes, Zero R, PART and LibSVM has experimented using WEKA. Performance indices like precision, Sensitivity, F Score and selectivity were calculated. The Classification with LibSVM using WEKA gave the best accuracy compared to other classifiers in WEKA model. From the classification accuracy comparison and performance evaluation, classification with Bag of Words using SVM has found better classification accuracy.

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