International Journal of Advanced Computer Research (ISSN (print): 2249-7277 ISSN (online): 2277-7970)
Volume-4 Number-1 Issue-14 March-2014

A Bayes fusion method based ensemble classification approach for Brown cloud application

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Abstract

Classification is a recurrent task of determining a target function that maps each attribute set to one of the predefined class labels. Ensemble fusion is one of the suitable classifier model fusion techniques which combine the multiple classifiers to perform high classification accuracy than individual classifiers. The main objective of this paper is to combine base classifiers using ensemble fusion methods namely Decision Template, Dempster-Shafer and Bayes to compare the accuracy of the each fusion methods on the brown cloud dataset. The base classifiers like KNN, MLP and SVM have been considered in ensemble classification in which each classifier with four different function parameters. From the experimental study it is proved, that the Bayes fusion method performs better classification accuracy of 95% than Decision Template of 80%, Dempster-Shaferof 85%, in a Brown Cloud image dataset.

Keywords

Ensemble classifier, Fusion method, Bayes, Brown cloud

1. Introduction

Ensemble classification is a classification process applied to better the functioning of the single classifiers by fusing the output of the individual classifier models. Research in ensemble methods has largely revolved around designing ensemble consisting of single classifier models. An ensemble classification is known as a supervised learning algorithm because it trains the class belongs to their labels and then use to produce predictions.

This work was supported in part by the Department of Computer Science, Avinashilingam Institute for Home Science and Higher Education for Women.

Manuscript received February 18, 2014.

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Ensemble combination is of two types namely, classifier selection and classifier fusion. In classifier selection, each classifier is trained to become an expert in some local or area of total feature space but in classifier fusion all models are trained over the entire feature space [1]. Classifier fusion provides an extra degree of freedom in the classical bias or variance tradeoff. Because of these advantages, fusion classification has been applied to difficult real-world problems [2].

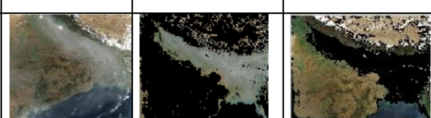
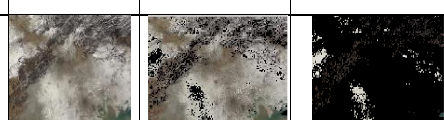
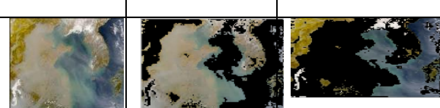
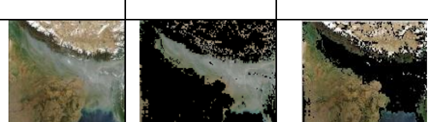
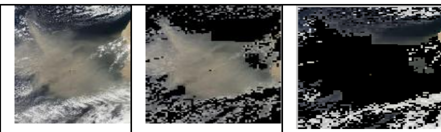
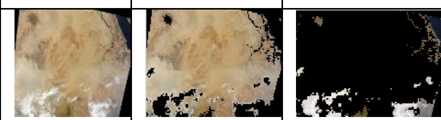
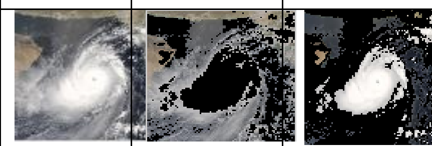
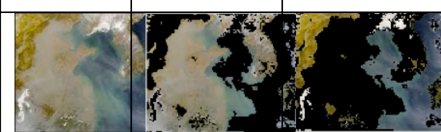
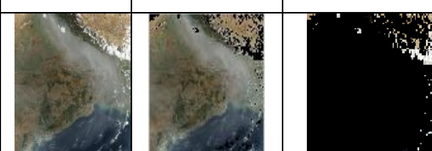
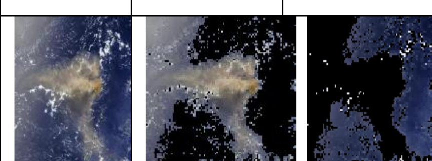
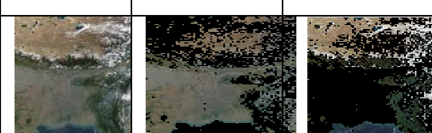
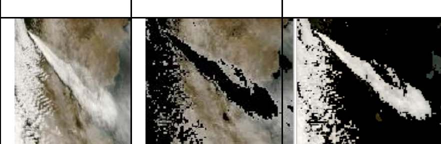
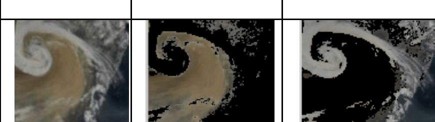
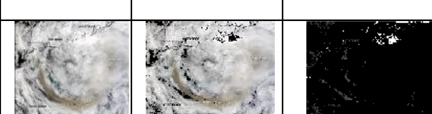
The earliest work on ensemble systems is by Tukeys Twicing, which first proposed an ensemble of two linear regression model to the original data and the second linear model to the residual [2].It is used in many fields as a successful application, such as finance, bioinformatics, medicine, cheminformatics, manufacturing, geography and image retrieval[4].
In this paper, experiment study is carried out in brown cloud image dataset. Moderate Resolution Imaging Spectroradiometer (MODIS) of NASA's Terra satellite images covered brown cloud images. The main impact of brown clouds is towards climate change, temperature and Agriculture. The U.N Environment Program commission declares brown clouds are composed of the dangerous mix of soot and they have been linked to melting of Himalayan glaciers and impact agriculture product. It incorporates a mixture of carcinogens, toxic aerosols, and particles including the Particulat Matter (PM) of less than 2.5 microns in width and this lead with a variety of health effects of respiratory disorders and cardiovascular problems. A brown cloud is classified from the normal cloud using classification techniques and gives the awareness to the people about brown cloud, to reduce the pollution control.

Section 1 provides an introduction to the concepts of ensemble and brown cloud, Section 2 describes about the segmentation, feature extraction of images. Section 3 and 4 explains about base classifier and its fusion method. Finally experimental results are discussed based on brown cloud application. Section 5 presents the conclusion of the paper.

2. Segmentation and Feature Extraction

Segmentation is one of foremost task in image processing and it used to partitions images into distinct two regions containing each pixel with similar attributes. In this paper, Brown cloud satellite images are segmented into two regions namely brown and non brown cloud using pixel segmentation. A Sample of Brown cloud satellite images used for the experiment are listed in Fig 1.

The segmented images are applied to extract feature by using GLCM feature extraction method. The experimented features are namely autocorrelation, contract, correlation, dissimilarity, entropy, energy, sum of square variance, difference variance, difference entropy and information measures of correlation [6].

Image	Original Images	Segmented Brown cloud Images	Segmented Non Brown Images
I 1			
I 2			
I 3			
I 4			
I 5			
I 6			
I 7			
I 8			
I 9			
I10			
I 11			
I 12			
I 13			
I 14			
I 15			

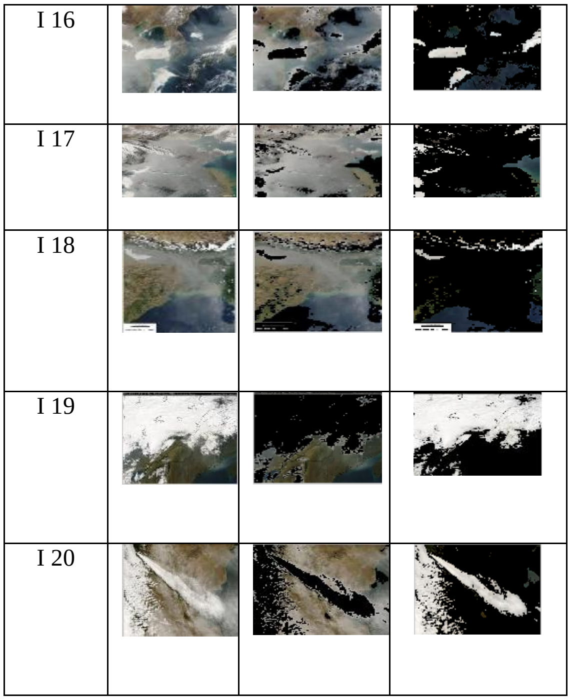


Figure.1: Satellite Brown cloud images for classification

3. Base classifiers for ensemble method

Base models or classifiers are also called as a weak learner because ensemble algorithm is also applicable to boost the weak learner to give much accurate predictions [3].In the proposed ensemble method MLP, KNN and SVM are the three classifiers used as base classifier [13].

3.1 Single Classifier

The single classifier is classifiers which train and test the classifiers separately. The proposed single classifiers are Multi-Layer Perceptron (MLP), K Nearest neighbor (KNN) and Support Vector Machine (SVM).

3.1.1 Multi-Layer Perceptron Classifier

A Multilayer Perceptron (MLP) is also called as multi-layer neural network which is a powerful classifier that may provide superior performance compared with other exiting classifiers. In the proposed MLP classifier, four types of transfer functions namely pure limit, Hard Limit, Log-sigmoid and Tan-sigmoid transfer function are used to make classifiers more powerful [5].

3.1.2 K-Nearest Neighbour Classifier

KNN is the oldest and simplest method that requires a training set of both positive and negative examples and this idea is carried out by taking the k nearest points and assigning the sign of the majority. In the proposed KNN classifier four different distance metric function namely Euclidean, City block, cosine, correlation have been applied, in which accuracy for each metric are calculated [11].

3.1.3 Support Vector Machine (SVM) Classifier

A Support Vector Machine (SVM) is a supervised learning method that analyzes data and recognizes the patterns that are primarily used for classification and regression analysis [12]. In the proposed work SVM classifier experiment with four different kernel function namely Linear, Polynomial, RBF and sigmoid and for each kernel accuracy is calculated.

4. Ensemble classification based on combinational methods

As Fusion classifiers or multiple classifier systems (MCS) have received considerable attention in applied statistics, machine learning and pattern recognition for over a decade [8]. Several studies demonstrate that the practice of combining several base classifier models into one aggregated classifier leads to significant gains in classification performance over its constituent members [9]. The fusion methods used to combine the results of the various classifiers are Decision Template, Dempster-Shafer and Bayes method. By comparing the accuracy among ensemble fusion methods Bayes produce better classification accuracy.

4.1 Decision Template Method

The decision template DTi (Z) of class i is the L × c matrix DTi (Z) = [dti (k, s)(Z)] whose (k, s)th element is computed by

$$dt_i(k,s)(Z) = \frac{\sum_{j=1}^{N} Ind(z_j, i)\, d_{k,s}(z_j)}{\sum_{j=1}^{N} Ind(z_j, i)}, k = 1, \ldots, L, s = 1, \ldots, c, \quad (1.1)$$

Where Ind(z_j , i) is an indicator function with value 1 if z_j has crisp label i, and 0, otherwise. To simplify the notation DT_i (Z) will be denoted by DT_i [10].

4.2 Dempster-Shafer Method

The main idea of using the Dempster-Shafer theory is to combining the base classifiers [7]. This method uses the notion of basic probability assignment defined for a certain class c_i given the instance x

bpa(c_i,x)= $1 - \prod(1 - \hat{P}_{M_k}(y = c_i|x))$ (1.2)

4.3 Bayes Method

The Bayes fusion method the weight associated with each classifier is the posterior probability of the classifier given the training set.

Class(x)= $\underset{c_i \in dom(y)}{argmax} \sum_k P(M_k|S).\hat{P}\, M_k(y = c_i|x)$ (1.3)

Where $P(M_k|S)$ denotes the probability that the classifier M_k is correct given the training set S [7].The estimation of $P(M_k|S)$ depends on the classifier's represent.To estimate this value for decision tree.

5. Experimental Results

Ensemble approach based classifications are constructed, which takes different input features from the images to train and to prove the performance of the ensemble fusion methods. Decision Template, Dempster-Shafer and Bayes most popular methods in ensemble fusion classification and it used to combine outputs of the base classifiers to give the ensemble classification accuracy. Brown cloud images used for experiment are listed in Figure 1.

5.1 Experimental results of Single classifiers

The performances of single classifiers are trained and test individually and accuracy of the single classifiers is compared with ensemble fusion method using accuracy rate. Table 5.1 shows the classification accuracy rate of single classifiers with different function.

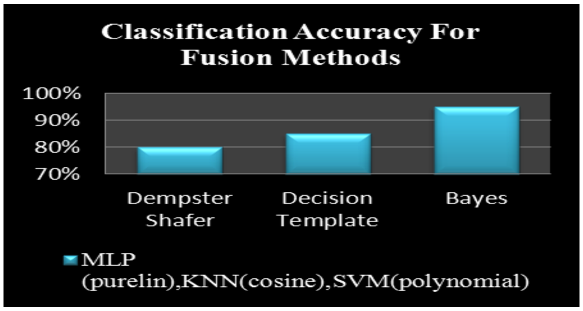


Figure 2: Comparison of classification accuracy with fusion methods

The accuracy rate of single classifier MLP with purline (78%),Tansign(85%),Harlim(40%)and Logsin(80%), KNN with Euclidean (82%), Cityblock(85%),cosine(87%) and correlation(77%), SVM with Linear(80%),RBF (68%),Sigmoid(40%) and Polynomial (90%) are compared with ensemble fusion method Decision Template (80%), Dempster-Shafer(85%) and Bayes(95%). From the experimental results Bayes fusion methods obtain higher accuracy rate compared with other fusion method and single classifiers.

5.2 Performance Metrics

The performance of classification algorithms greatly depends on the characteristics of the data to be classified. The performance of ensemble base classifiers namely Multilayer Perceptron, K-Nearest Neighbour and Support Vector Machine each classifier with four different function are combined to form sixty four combinations to combine base classifier. The performances of the fusion methods are compared to produce a high accuracy. From the experimental results of classifiers with different function MLP with Tan-sigmoid transfer, KNN with cosine distance metric, and SVM with Polynomial kernel perform a better results than other function combinations. From the selected function based classifier, ensemble is been introduced using combinational rules. Among the combinational method bayes takes higher accuracy in classify the brown cloud dataset.

Figure 2 shows results of proposed fusion methods. The Decision Template, Dempster-Shafer and Bayes fusion methods are used to fuse different combinations. The accuracy rate obtain by fusion methods are 80% in Dempster shafer, 85% in Decision Template and 95% in Bayes.Comparing the accuracy rate among the fusion method Bayes produce the highest accuracy rate from the proposed fusion methods and it is clearly evident that the Bayes ensemble fusion method show significant improvement in term of accuracy in the brown cloud dataset.

6. Conclusion

Ensemble classification is an area in machine learning algorithms where the primary goal is to combine output results of various individual classifier models using fusion methods to perform higher accuracy than single classifiers. MLP, KNN and SVM are the base classifier with each classifier consists of three different functions which are lately fuse using combination rules like Decision Template, Dempster-Shafer, Bayes methods. From the experimental results it's proved that MLP with Tansig, KNN with Cosine and SVM with Polynomial perform high accuracy in the single classifiers, the classifier with this function are applied in ensemble fusion methods. From the proposed fusion methods Bayes perform high accuracy rate of 95% than other fusion methods.

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Table 1.1: Feature Vectors of Brown Cloud Images

Images	Aucor *	Cont*	Corre*	Dissim*	Entro*	Ener*	SSV*	DV*	DE*	IMC*
1	1.38	3.44	7.66	7.08	3.83	1.65	1.52	3.44	8	-3.62
2	7.23	1.90	9.17	3.14	2.69	2.12	9.3	3.9	1.07	-2.95
3	2.98	2.05	4.85	4.39	6.72	8.99	3.81	2.05	5.7	-1.97
4	1.38	3.44	7.66	7.08	3.83	1.65	1.52	3.44	8	-3.62
5	8.87	1.19	8.97	3.06	1.86	2.18	5.14	1.19	5.58	-7.08
6	1.49	1.42	7.34	5.35	4.20	2.51	1.58	1.42	9.52	-4.16
7	1.34	1.68	5.87	6.25	1.34	2.46	1.41	1.68	1.06	-3.15
8	1.41	1.27	5.40	5.11	1.40	2.48	1.48	1.27	9.2	-3.69
9	7.05	1.93	7.15	3.61	3.25	2.16	7.57	1.91	6.39	-4.76
10	9.41	1.36	7.66	5.34	2.22	2.14	1	1.36	9.44	-3.53
11	1.91	2.20	5.19	8.19	8.54	2.83	2.03	2.2	1.22	-2.46
12	2.23	1.20	5.38	2.301	8.62	4.58	2.86	1.2	3.03	-2.36
13	3.69	1	4.96	3.76	2.7	1.75	4.11	1	7.39	-3.95
14	1.35	1.7	7.74	3.1	3.22	1.78	1.48	1.7	6.27	-5.91
15	7.72	3.41	5.48	9.56	2.23	2.5	9.35	3.41	1.24	-2.29
16	1.47	1.17	8.03	3.94	2.26	1.85	2.52	1.17	7.15	-4.34
17	1.45	2.8	5.31	8.81	1.07	2.66	1.57	2.8	1.22	-2.75
18	1.26	2.19	5.13	7.94	1.8	2.09	8.99	2.19	1.13	-1.98
19	1.38	1.22	8.43	3.5	2.68	1.73	1.45	1.22	6.63	-5.71
20	1.91	2.2	5.19	8.19	8.54	2.83	2.03	2.2	1.22	-2.46

Note: *AU-Auto correlation, *Cont-Contract, *Corre-Correlation, *Dissim-Dissimilarity,*Entro- Entropy, * Ener-Energy, *SSV-Sum of Square Variance,*DV- Difference variance,*DE- Difference Entropy, *IMC-Information Measures of Correlation

Table 1.2: Feature Vectors of Non-Brown Cloud Images

Images	Aucor *	Cont*	Corre*	Dissim*	Entro*	Ener*	SSV*	DV*	DE*	IMC*
1	3.61	2.04	4.88	7.46	1.27	2.59	3.68	2.04	1.14	-1.81
2	1.34	2.19	6.60	6.82	1.41	2.41	1.43	2.19	1.02	-3.7
3	1.05	1.02	7.88	3.79	2.48	1.83	1.09	1.02	7.67	-4.88
4	1.4	2.67	6.78	8.18	1.46	2.46	1.54	2.67	1.13	-3.1
5	1.15	1.16	8.33	3.33	2.97	1.64	1.3	1.48	6.88	-5.78
6	1.19	2.42	6.32	3.35	4.74	2.18	1.3	1.42	6.01	-3.28
7	7.6	7.16	7.73	3.33	2.97	1.64	9.57	1.15	4.92	-6.56
8	4.42	1.67	6.93	3.55	6.79	1.91	5.4	1.67	4.89	-4.34
9	2.98	2.05	4.85	4.39	6.72	8.99	3.81	2.05	5.7	-1.97
10	3.61	2.04	4.88	7.46	1.27	2.59	3.68	2.04	1.14	-1.81
11	5.22	3.79	4.64	7.84	4.13	1.67	7.08	3.79	8.83	-2.9
12	3.49	2.18	5.21	4.43	5.84	1.17	4.27	2.18	6.12	-3.47
13	1.15	1.18	7.89	3.62	4.07	1.37	1.24	1.18	6.53	-4.83
14	1.87	1.26	9.24	2.34	4.5	1.05	1.94	1.26	6.35	-7.26
15	8.94	1.29	8.33	3.79	3.5	1.72	9.33	1.29	6.45	-5.43
16	5.57	1.65	7.48	3.74	5.17	1.3	6.07	1.65	5.68	-4.56
17	7.6	1.15	7.36	3.2	3.26	1.78	7.97	1.15	5.75	-6.02
18	1.2	2.44	7.98	6.27	2.75	2.08	1.31	2.44	8.99	-4.48
19	9.08	1.67	9.17	4.28	2.41	1.88	9.15	1.67	7.15	-5.37
20	7.72	3.41	5.48	9.56	2.23	2.5	9.35	3.41	1.24	-2.29

Note: *AU-Auto correlation, *Cont-Contract, *Corre-Correlation, *Dissim-Dissimilarity,*Entro- Entropy, * Ener-Energy, *SSV-Sum of Square Variance,*DV- Difference variance,*DE- Difference Entropy, *IMC-Information Measures of Correlation

Table 5.1: Classification accuracy of MLP ,KNN and SVM classifier for brown cloud dataset

Applications	MLP				KNN				SVM			
	Pur	Tan	Har	Log	Euc	Cibl	Cos	Cor	Lin	RBF	Sig	Poly
Brown Cloud Dataset	78%	85%	40%	80%	82%	85%	87%	77%	80%	68%	40%	90%

Note:*Pur-Purelin,*Tan- Tansign,*Har- Harlim *Log- Logsin *Euc- Euclidean *Cibl- Cityblock *Cos- cosine *Cor- correlation *Lin-Linear *RBF- RBF *Sig- Sigmoid *poly- Polynomial