

Soft Computing Based Ground Target Recognition



Vinod Kumar Bhalla, Ravinanda Kumar, Manish Kumar Singla, Parag Nijhawan

Abstract Target recognition from the data obtained from radars poses great challenge to manual analysis of the target with high speed and accuracy. So to overcome this challenge automatic target recognition system is developed using soft computing machine learning tool. The problem becomes more complex when the images are clicked from various angles. An automated classification scheme is proposed in this paper. Principal Component Analysis is used for feature extraction and to reduce the high dominions in the images data. It is known that principal component analysis is widely used from in various fields like space science. Support vector machine is used as a tool. All major kernel functions are applied to gain the maximum accuracy. This framework is evaluated and found effective as compared to results than other methods.

Keyword - Image classification, Feature Extraction, PCA.

I. INTRODUCTION

In modern eras, advancement in radar technology is increasing rapidly. The digital image processing have become more important than ever due to rapidly emerging technological applications like target identification and detection. Several crazy discoveries have been developed in this direction. The ground based target recognition based on the high resolution images taken from the Synthetic Aperture radar mounted on the airborne vehicles for soaring resolution radar pictures is a challenge to manually detect and identify the relevant targets. The electrical signal image processing techniques are generally used to develop the descriptive pictures after the addition of consecutive radar signal reflections. Ground images may be prepared in sever weather conditions and when the optical camera are of no use. The schematic of synthetic aperture radar is shown in Figure 1. These goal recognition technologies require efficient, fast and accurate algorithms. Previously many researchers developed the efficient algorithms. Some of these techniques were efficient and some were not that efficient for target tracking, recognition and classification.

There is a need to develop more efficient, accurate dependable and robust algorithms. There are number of application for such kind of system especially for military applications.

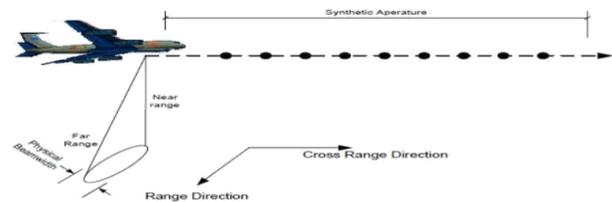


Figure 1 Synthetic aperture radar

The radar pictures data set used in this paper has 128*128 pixels resolution of PCA technique is applied to reduce the size to 96*96 pixels. This helps the radar easily to differentiate between the small to large vehicles. Due to the different class vehicles present in the target area, higher level of consciousness to the radar operator is required. To recognize the military, nonmilitary, enemy and friendly targets with high speed and accuracy is great challenge.

In the radar pictures, the pixel is represented to gray levels. These pictures are subset of whole MSTAR database. In this paper for training and testing purpose vehicles BRDM2 and BTR60 are used for the machine learning classification based models to develop proposed framework. But the technique developed can be used for all type of vehicles presented in the Figure 2.

MSTAR data sets pictures have lot of constraints that can influence the result. These pictures are taken from different goal Azimuth Angle (Figure 3) and the intensity may also vary. The Figure 4 shows different pictures of the T62 with a pose between some angles. The dispersion is important attribute of the synthetic aperture radar images. The sent back of dispersion is dependent on the azimuth of the vehicle.

BRDM2	Truck		
BTR60	Transport		
BTR70	Transport	No Picture Available	
D7	Bulldozer		
T62	Tank		
T72	Tank		
ZIL131	Truck		
ZSU23 4	Gun		

Figure 2 Target images

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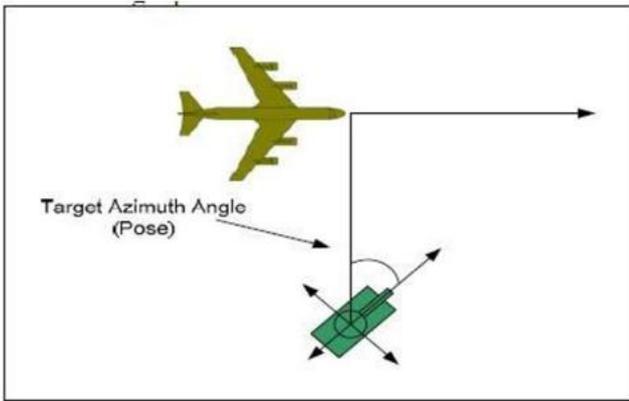


Figure 3 Goal azimuth angle

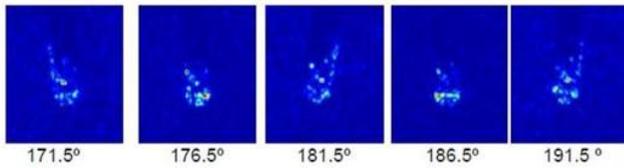


Figure 4 Azimuth poses between the angles

II. RELATED FRAMEWORK

A diversity of high-level attributes are able to provide the important information about a goal set. The pose of the goal has been huge impact on the partition accuracy of an automatic target recognition system [1-4]. Still the poses are not perfect, then use in the automatic target recognition system reduces the complexity and increases the performance [5]. Generally the highest level feature considered as length and width of the goal. The specific feature sometime considered as average radar cross section (RCS) and log standard deviation (LSD). The entire reflectivity is related to the average radar cross section. The log standard measures pixels changes strength in the goal section. Sometimes need to take the optical features like edges and corners [6-7]. One studies focus on the shape of goal area. This type of set features can be figured out the shape of area is Hu moments [8]. The advantage of Hu moments is that it is rotation and scale invariant.

Gronwall, Gustafsson and Millnert et al. [9] suggested about the ground target recognition using rectangle estimation method. In this paper they recognize the ground targets using 3D laser radar data. match the target with CAD models. The performance of this method is calculated statically on computer-generated data.

J.Kurty, F.Nebus and Z.Kus et al [12] discuss the feature extraction method. In this paper the preferred technique is DFT which is implemented using hanning window function. Here assumption is that vehicles are classified into two classes. They are the wheeled vehicles and tracked vehicles. Sun Yijun, Zhipeng Liu, Sinisa Todorovic and Jian Li et al [5] proposed a novel approach for classification of automatic target recognition. In this synthetic aperture radar picture is presented as raw feature vector where raw feature reimburse the pose estimation error that corrupts best picture features. Classification is done using the adaptive boosting algorithm with the help of radial basis function (RBF) RBF network result is added using the AdaBoost.

Zhang, Wu, Liu, Qin and Song et al. [13] worked on high range resolution (HRR) profiles non-negative sparse

coding(NNSC). They projected HRR profile matrix to low dimensional space and used support vector machine and nearest neighbor algorithm to classify the target.

Qiu, Ren, Zou and Zhou et al. [14] discuss the feature extraction technique which is important for automatic target recognition in synthetic aperture radar images. For this they have used principal component analysis. But the drawback with principal component analysis is that we have managed the two dimensional picture into observation vector. So in this paper they have used the two dimensional principal component analysis which can directly extract features from two dimensional principal component analysis. They have also told that two dimensional principal component analysis represents original data with high variance values by linear transformation. Basically this also compares the performance of principal component analysis and two dimensional principal component analysis.

Ismail A.S, Gao Xinbo and Deng Cheng et al. [15] suggested the procedure for feature extraction and recognition of the synthetic aperture radar pictures. The suggested approach consists the three steps. First take the two different types of texture feature which are extracted. These two different types are gray level co-occurrence matrix (GLCM) and Gabor filters (GFs). After getting the two different type of feature vectors we fused it using the canonical correlation analysis (CCA) to reduce the feature space. The last step is the classification of the synthetic aperture radar picture using the support vector machine. In this paper it is also told that we get good classification performance and canonical correlation analysis leads high efficiency dimensionality reduction techniques.

Hafez Alaa El-Din, Hu Wiedo and Gharyb Ahmed et al. [16] in their article suggests the ground targets recognition for flying vehicles using camera or synthetic aperture radar picturing systems. In this paper the proposed technique is image processing which is used to improve the exactness for detecting and tracking the ground goals from flying vehicles. The used method is template matching for detecting and tracking. Vigorous and dependable ground object detection is important and little bit hard step of recognition of object. The main focus is on flying systems with camera to capture the pictures for ground and objects to recognize it. It is a type of picturing radar in which movement of antenna with respect to goal is utilized. The processing of radar reflections on the revolving of antenna using the Range Doppler Algorithm (RDA). The suggested method is not dependent on the height or the direction of the object.

Zhang, Qin and Li et al. [17] has given a new approach for based on bayesian compressive sensing is used to design goal classifiers. The calculation of the performance is compared with different type of discussed state of the art methods. Actually the state of the art methods are BP, SRC and SVM using synthetic aperture radar picture amplitude values and dispersing centers features simultaneously.

Huang, C and Lee, K et al. [18] has suggested in his paper that independent component analysis method is implemented to the principal component analysis based automatic goal identification. In this research paper the radar cross section data from goals are accumulated using angular-diversity technique. The angular diversity technique includes dissimilar elevation and azimuth angles. After processing the radar cross section data using principal component analysis try tom reduce the noise and then apply independent component analysis for dependable inequity. Identification of goals is done by comparing the features in independent component analysis region. The authors have also considered the noise effect in this study. Independent component analysis method approach high order statistics and drawn out most important information regarding automatic target recognition. This made the recognition precise and dependable.

R.Vahid, Srinivas Umamahesh and Monga Vishal et al. [19] has mentioned a new approach for the synthetic aperture radar automatic target recognition. In this paper used methodology is Non-negative Matrix Approximations (NNMA) using eigen-vectors using PCA. This method helped for prominent feature selection.

III. PROPOSED FRAMEWORK

A framework is proposed in this research work primarily to focus on the recognition of ground based targets and goal. The images are taken by the radar sensors using electrical signals from different angles and varying intensity. Basic aim of the framework is to solve the real world problems especially faced by the military. The application of this model can be employed in other related fields. The concept of Principal component analysis (PCA) is applied for feature extraction and to classify the objects on the basis of their relevant features as shown in figure 5. It has been previously used in all the area computer graphics, neuroscience and space applications. PCA is based on the practical linear algebra. PCA help in reducing the high dimension problem to low dimension. This attempt removes irrelevant features, reduce the computation cost and enhance the accuracy levels.

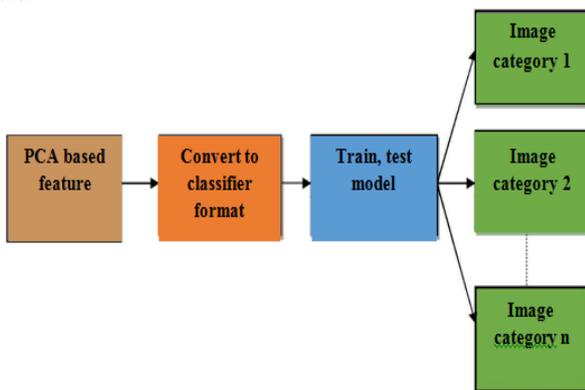


Figure 5 Block diagram of PCA

Support vector machine learning algorithms (SVM) as a machine learning algorithm is applied on the filtered data sets. The following kernel functions are tried to optimize the results- Linear kernel, Radial Bias Kernel, Polynomial Kernel.

The working methodology of work is on the principle of three steps as diagrammatically shown The three phases are as follows:

1. Preprocessing phase
2. Feature Extraction and selection phase
3. Classification phase

In the pre-processing stage, we have taken picture as input and from this picture points we have made picture matrix, after doing this we get vectored picture. After getting the vectored picture we try to mean centered the vectored picture data. That is known as mean centering. Now we make covariance matrix from this data. Then we use another two phase feature extraction and classification phase. One by one will explain these phases.

In the pre-processing stage, from input picture are converted to picture matrix vectored picture. and mean centered the vectored picture data. That is known as mean centering. Then the covariance matrix from this data is generated. The other two phase are employed for feature extraction and classification phase.

Pre-processing Phase

In pre-processing phase shown in Figure 6. The features are extracted and normalized. Data passed through preprocessing phase is divided in the ration of 80-20% and used for training the model with 80% data and testing purpose 20% data respectively. Relative calibration enables the values everywhere in a single image are proportional to geophysical units. Pre-processing phase follows the analysis and classification.

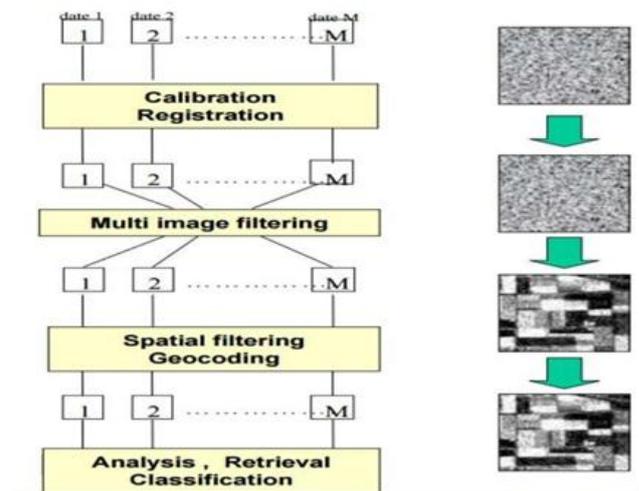


Figure 6 Pre-processing phase

Feature extraction and selection phase

The feature extraction and selection is the most important phase for the success of any machine learning based model. The features convert the raw variables image into a feature space. They are specially designed for particular problem because it is very hard to identify the universal feature set for general purpose usage. The aim for quality feature selection is to identify an informative presentation of the object in the new problem space.

Hidden Markov model, wavelet transform, linear discriminant and principal component analysis are widely used methods for this purpose. In this research work PCA is employed for best features because of high dimensional datasets.

The selected feature through PCA has lowest correlation with other features and highest correlation with the decided function. The aim of the selection of the feature is to comprise means reducing the computational cost, improve prediction performance and make easy data analysis.

Classification phase

There is lot of different machine learning classifiers are available but this work focused on the use of support vector machine with number of kernel functions-linear, polynomial, radial bias with different cost and gamma values. It is a classifier which is one of the best algorithms in SAR-ATR and most beneficial algorithm as per literature. Proposed framework is developed using the python language. PCA-Compact trick is also developed in python. This new concept is faster than singular value decomposition. When number of features is greater for large datasets then singular value decomposition becomes slow while compact trick gives best time complexity or faster than singular value decomposition. After getting the features to classify or recognize the vehicle type the machine learning classification techniques are used in the proposed work.

IV. EXPERIMENTAL RESULTS

To evaluate our feature Extraction method, we choose two dataset and apply important machine learning algorithms for classification purpose. After the implementation of algorithms we can easily recognize our ground targets and also able to distinguish between the different type of vehicles. The used datasets are given below in the Table 1.

Table 1 Summary of data sheets used in experiment

Dataset Name	Samples	Features
BTR60	660	195
BRDM2	850	273

First When principal component analysis is applied on the first dataset named as BTR60 it gives result as follows when we calculate the mean of the data set which is taken in the form of images the mean results are as follows and on the basis of this image is shown in figure 7 and 8.

```

>>> runfile('C:/Users/Ravi/Desktop/untitled0.py', wdir='C:/Users/Ravi/Desktop')
(195, 16384)
PCA - compact trick used
[ 91.97435897  87.41538462  92.1025641 ..., 77.51282051  78.63589744
 83.28205128]
```

Figure 7 Mean value of BTR60

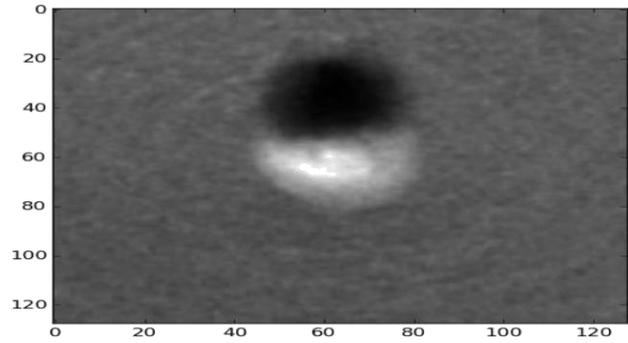


Figure 8 BTR60 image

After calculating the mean value of this dataset. In this it is observed that there is lot of values is repeated. In this finally mode is also calculated for this dataset the another reason to calculate the mode is previous image is not so much focused on the ground target but another image which will given below on the basis of the mode value it will little bit clearer than previous image so mode value and image is shown in figure 9 and 10.. The difference between previous image and current image is that current image is more focused and contains less clutter in the background. It is more focused on the target. It helps easily to recognize the target. The above and below mentioned results are for only one dataset.

```

>>> runfile('C:/Users/Ravi/Desktop/untitled0.py', wdir='C:/Users/Ravi/Desktop')
(195, 16384)
PCA - compact trick used
[[-2113.00446211 -2119.78716394 -2078.9440046 ..., -2169.8863602
 -2193.30538691 -2067.38254375]
 [-2089.20646177 -2176.12539588 -2073.63372104 ..., -2104.58715148
 -2033.0857224 -2059.72402367]
 [-2102.9581471 -2072.59956379 -2074.32122022 ..., -2033.2317522
 -2179.80962345 -2047.78971219]
 ...
 [-2048.76344445 -2019.30596016 -2072.64015923 ..., -2049.51154543
 -2129.07109937 -2151.73374714]
 [-2097.60609298 -2062.63210006 -2032.92523651 ..., -2147.71818991
 -2111.29033156 -2039.04463128]
 [-2089.37343771 -2079.77000388 -2175.17706661 ..., -2076.213397
 -2071.64710779 -2033.50574259]]
```

Figure 9 Mode value of BTR60

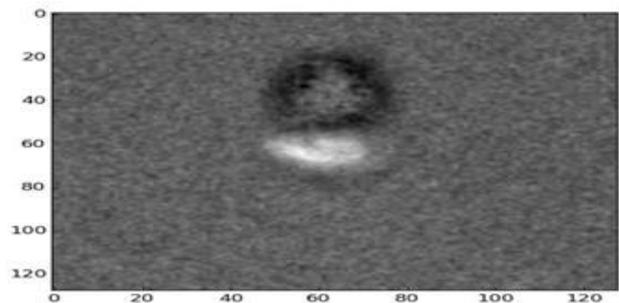


Figure 10 BTR60 image

Now the same concept is also implemented for the another dataset BRDM_2 which is another type of vehicle taken as target and the results are as follows according to the mean and mode these are shown in figure 11-14.

```

>>> runfile('C:/Users/Ravi/Desktop/untitled0.py', wdir='C:/Users/Ravi/Desktop')
(274, 16512)
PCA - compact trick used
[ 81.36131387  87.71167883  85.20072993 ..., 83.02189781  81.55474453
 79.04014599]
```

Figure 11 Mean value of BRDM_2

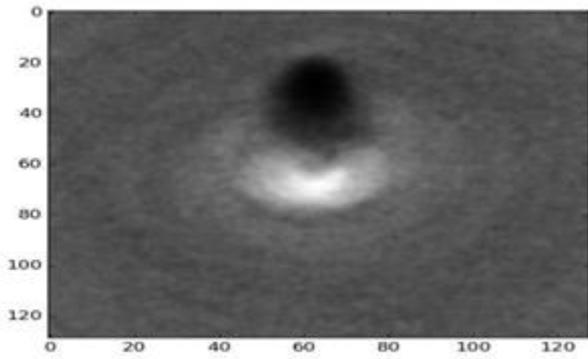


Figure 12 BRDM_2 image

```
>>> runfile('C:/Users/Ravi/Desktop/untitled0.py', wdir='C:/Users/Ravi/Desktop')
(274, 16512)
PCA - compact trick used
[[-2565.25130182 -2399.3684158 -2456.04405265 ..., -2514.26955897
-2458.01457288 -2472.43727906]
[-2517.18896831 -2591.7235533 -2495.74596217 ..., -2513.87308749
-2502.95865555 -2624.24793464]
[-2503.53099151 -2697.32047864 -2557.65681196 ..., -2460.27323853
-2459.84427299 -2552.91907009]
...,
[-2588.38452764 -2510.040333 -2507.4362536 ..., -2448.2226842
-2538.64391685 -2554.42878353]
[-2531.62086678 -2465.88502062 -2513.3027302 ..., -2522.96006496
-2465.73104495 -2346.16890319]
[-2576.79212881 -2655.58489236 -2466.36229911 ..., -2420.67809321
-2533.24389879 -2497.26325369]]
>>>
```

Figure 13 Mode value of BRDM_2

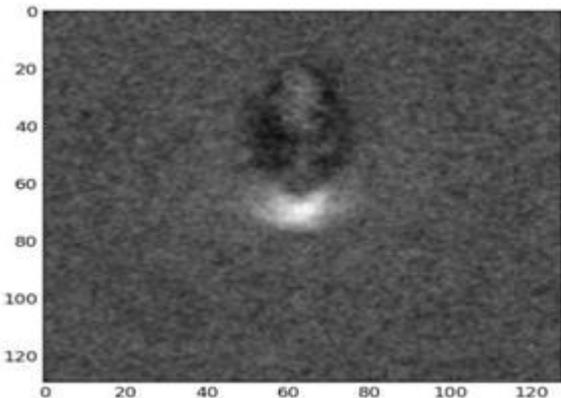


Figure 14 BRDM_2 image

An experimental result of proposed framework is presented below in figures. Each table contains outcome of 3 classifiers kernels along with the value of Accuracy. The suggested framework is applied to MSTAR (Moving and Stationary Target Acquisition and Recognition) data sets.

Table 2 Single data set accuracy

SVM Model Name	Accuracy (Single dataset)
Linear Kernel	84%
Radial Kernel	93%
Polynomial Kernel	86%

Table 3 Mix data sheet accuracy

SVM Model Name	Accuracy (Mix dataset)
Linear Kernel	78%
Radial Kernel	87%
Polynomial Kernel	83%

In single data set Table 2 linear kernel accuracy is 84%, polynomial kernel achieved 86%. But RBF kernel yield very satisfactory results in terms of 93% accuracy levels. Trough this data it has been concluded that RBF kernel outperformed the performance and accurately recognizes the ground targets quite efficiently. Further in experiment Mix dataset is applied to the trained models. In this case linear kernel accuracy is 78%, polynomial kernel achieved 83%. But RBF kernel yield very satisfactory results in terms of 87% accuracy levels. Trough this data it has been concluded that RBF kernel outperformed the performance and accurately recognizes the ground targets quite efficiently. Difference in the performance accuracy is due to nature of test data collected from single data set where as in Table 3 mixed vehicle picture data set is chosen to increase the confidence of model.

The graphical representation is shown in figure 15 of single and mix data sheet. The data feature obtained by applying PCA are scaled in the range of [-1 1]. Further data is processed to convert in SVM data format. In case of single data set maximum accuracy obtained through trained model is maximum in case of RBF kernel i.e. 93% and in case of mixed data set again RBF kernel produced maximum accuracy in comparison to other kernel functions and it came out to be 87%. In the opinion proposed framework SVM-RBF kernel function is fine tune with low cost, gamma and mse error along with PCA extracted features, the results are very promising.

V. CONCLUSIONS

The proposed method is used to accurately classify and recognize the ground target images obtained by the high performance radar. To reduce the high dimensionality involved in the data set due to the images take from different angle, a well known technique called principle component analysis (PCA) is used to extract and reduce the irrelevant feature. This significantly increased the speed of training and increased the performance. Support vector machine (SVM) is implied to train the model on the training dataset. Linear, polynomial and Radial (RBF) kernel functions are tried by varying the cost and gamma values. It is concluded that the result obtained through all the optimized kernel functions produced the promising results. But out of the entire three Radial kernel function produced the best results. It is also evident from the results that PCA proved to be better choice for feature extraction. In future other machine learning approaches will be tried like KNN, Naïve Baye’s and decision tree. Researcher will try different other data sets and try to further improve the accuracy.



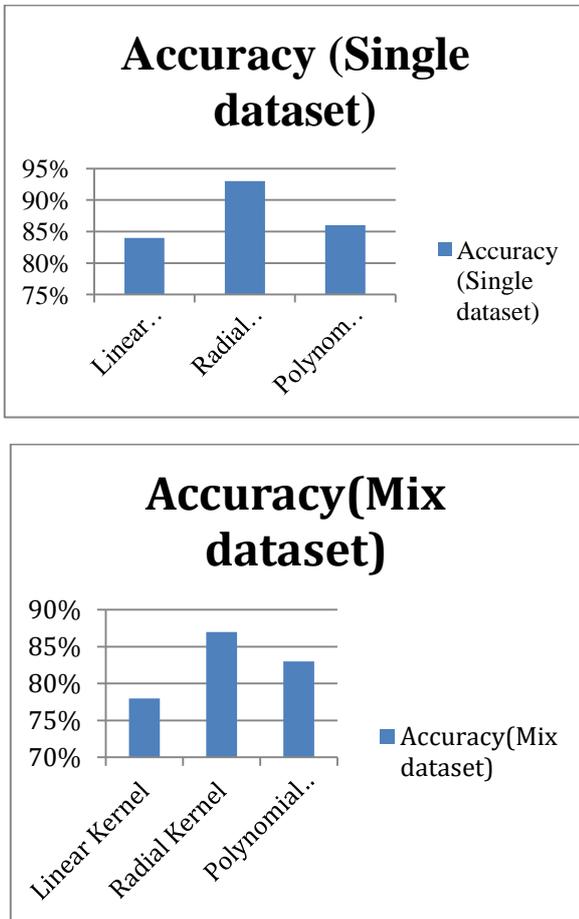


Figure 15 Graphical representation of accuracy

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