

***Ground Target Recognition using KNN, Naïve
Baye's and SVM***

A Thesis Report

*submitted in partial fulfillment of the requirements
for the award of degree
of*

Master of Engineering
in
Computer Science and Engineering

Submitted By
Ravinandan Kumar
(801432031)

Under the supervision of:
Mr. Vinod Kumar Bhalla
Assistant Professor



COMPUTER SCIENCE AND ENGINEERING DEPARTMENT

THAPAR UNIVERSITY

PATIALA – 147004

July 2016

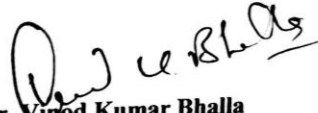
CERTIFICATE

I hereby certify that the work which is being presented in the thesis entitled, "Ground Target Recognition using KNN, Naïve Baye's and SVM", in partial fulfillment of the requirements for the award of degree of Master of Engineering in *Computer Science and Engineering* submitted in Computer Science and Engineering Department of Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of **Mr. Vinod Kumar Bhalla** and refers other researcher's work which are duly listed in the reference section.

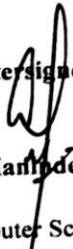
The matter presented in the thesis has not been submitted for award of any other degree of this or any other University.

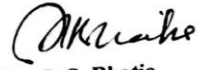

Ravinandan Kumar
801432031
ME (CSE)

This is to certify that the above statement made by the candidate is correct and true to the best of my knowledge.


Mr. Vinod Kumar Bhalla
Assistant Professor
Computer Science and
Engineering Department
Thapar University

Countersigned by


Dr. Maninder Singh
Head
Computer Science and Engineering Department
Thapar University
Patiala


Dr. S. S. Bhatia
Dean (Academic Affairs)
Thapar University
Patiala

ACKNOWLEDGEMENT

I would like to express my most sincere appreciation and deep sense of gratitude and indebtedness to my guide **Mr. Vinod Kumar Bhalla**, Assistant Professor, Computer Science and Engineering Department, Thapar University, Patiala for his continuous indefatigable guidance, which paved me on to the path to carry this work. I am highly indebted to him for his painstaking efforts and invaluable suggestions during the period of work. I would like to thank him for encouraging my research and for being actively involved in my work.

I am also thankful to Dr. Maninder Singh, Head of Department, CSED and Dr. Ashutosh Mishra, P.G. Coordinator, for the motivation and inspiration that triggered me for the thesis work.

I am also very thankful to the entire faculty and staff members for the direct-indirect help, cooperation and support.

Ravinandan Kr.
Ravinandan Kumar
(801432031)

ABSTRACT

Building an effective classification model when the high dimensional data is given that is taken from radar signals is a major challenge to solve this problem for automatic target recognition community (ATR). The problem is severe when pictures have taken from different azimuth angles. To surmount this classification problem and high dimensionality issues in the dataset, we propose a framework that comprises of Principal Component Analysis (PCA), which are used for feature extraction, as well as feature ranker of data. As we also know that principal component analysis is widely used from in various field like space science. The main purposos of using principal component analysis is data compression and feature extraction. This framework is developed using Python language and various Python packages. Then the performance of proposed framework is evaluated and found that proposed framework gives better results than other methods.

Keywords: *Feature Extraction , Radar Signals, ATR, PCA*

TABLE OF CONTENTS

Certificate.....	i
Acknowledgement	ii
Abstract	iii
Table of Contents	iv
List of Figures	vi
List of Tables	vii
List of Abbreviations	viii
CHAPTER 1: INTRODUCTION.....	1-11
1.1 Introduction.....	1
1.2 Synthetic Aperture Radar	3
1.3 Automatic Target Recognition	8
1.4 Organization of the thesis	11
CHAPTER 2: RELATED WORK	12-18
CHAPTER 3: PROBLEM STATEMENT	19-21
3.1 Problem Statement.....	19
3.2 Existing research gaps.....	20
3.3 Objectives	20
CHAPTER 4: PROPOSED FRAMEWORK	21-31
4.1 Proposed Framework	21
4.1.1 Pre-processing Phase	21
4.1.2 Feature extraction phase	23
4.1.3 Classification phase	24
4.2 Implementation of PCA.....	26
4.3 Naïve Baye’s classifier	28
4.4 K-Nearest Neighbor Classifier	29
4.5 Support Vector Machine classifier	30
CHAPTER 5: RESULTS AND DISCUSSIONS	32-37
CHAPTER 6: CONCLUSION AND FUTURE SCOPE	38
6.1 Conclusion	38
6.2 Future Scope	38
REFERENCES.....	39-42

LIST OF PUBLICATIONS	43
VIDEO LINK	44

LIST OF FIGURES

Figure 1.1: Synthetic Aperture Radar	4
Figure 1.2: Goal Azimuth Angle	6
Figure 1.3: Azimuth poses between the Angles.....	7
Figure 1.4: Compression Angle	7
Figure 1.5: Illustration of SAR geometry and automatic target data collection	9
Figure 4.1: Pre-processing phase	22
Figure 4.2: Phases of training and testing in Machine learning.....	23
Figure 4.3: Feature selection procedure.....	24
Figure 4.4: Classification phase.....	25
Figure 4.5: Feature Extraction using PCA.....	27
Figure 4.6: Proposed Framework.....	27
Figure 4.7: Bayesian network	28
Figure 4.8: Implementation steps of Naïve Baye’s.....	29
Figure 4.9: Implementation steps of KNN.....	30
Figure 4.10: Implementation steps of SVM classifier	31
Figure 5.1: Mean value of BTR60	32
Figure 5.2: BTR60 image on the mean value	33
Figure 5.3: Mode value of BTR60.....	34
Figure 5.4: BTR60 image on the mode value	34
Figure 5.5: Mean value of BRDM_2	35
Figure 5.6: BRDM_2 image on the mean value	35
Figure 5.7: Mode value of BRDM_2.....	36
Figure 5.8: BRDM_2 image on the mode value	36

Figure 5.9: Graphical representation of Accuracy37

LIST OF TABLES

Table 1.1: Target images.....	5
Table 5.1: Implementation steps of SVM classifier.....	32
Table 5.2: Comparison analysis of Accuracy	37

LIST OF ABBREVIATIONS

ATR	Automatic Target Recognition
SAR	Synthetic Aperture Radar
PCA	Principal Component Analysis
KNN	K-Nearest Neighbor
SVM	Support Vector Machine
RCS	Radar Cross Section
BCS	Bayesian Cross Sensing
RDA	Range Doppler Algorithm

CHAPTER 1

INTRODUCTION

1.1 Introduction

Radar was invented by different nations at the time before and during World War 2. In 1940, this term Radar was given by the United States Navy. The word Radar stands for Radio Detection and Ranging. The broad uses of radar in the various fields like air traffic control, terrestrial traffic control, marine radars, flight control systems, ground penetrating radar for geographical observations. Fully technical radar systems are linked with digital signal processing, machine learning and it is used to extract the most useful information from high noise levels. Basically it is applied to electronic apparatus to design to detect and track the targets at extensive margins. The working methodology of radar is enormously small bursts of radio energy which is travelling at the velocity of light are carried, sent back off an object and then come back as an echo. This phenomenon we have observed is known as echo principle. To explain this echo principle, suppose we have created a sound near or middle in the sea there is completely vacant space the created noise will disappear but when we create this sound near the any type of object we will get back this reflected sound and it is known as echo and this is known as echo principle. This form of radiometric signal is radiated by radar and it depends on the kind of information you needed about the object. It is an active device and uses its own energy to recognize and track the object. Radar does not depend on the energy created by the object which has to recognize. The main importance of radar is to recognize the object which is at great distances and it also tells the position of that object with high accuracy. These are the two chief attributes of radar. Basically it uses radiofrequency waves and on the basis of this wavelength it is able to tell the position and location of the target.

Two types of radio frequencies are assigned by international standards for using the marine civil radar systems. The first type is the X-band and the wavelength is 3 cm and range of the frequency is between the 9300 to 9500 MHZ. The second type is the S-band which wavelength is 10 cm and range of the frequency is between the 2900 to 3100

MHZ. Occasionally we would like to talk in words of the wavelength rather than in terms of frequency because frequency contains higher value. Radio frequency energy transmitted through pulse modulated radars which consist the equally spaced pulses having durations of 1 microseconds or less but when it relatively goes long there is no energy transmitted. If distance to the target is calculated the measure of time essential for one short bursts travel to target and return as sent back echo. There are different types of factors which are affecting the detection, display and target measurements of the radar systems. To decide these cases it depends on the different factors these are as follows:

1. Factors upsetting the minimum range
2. Factors upsetting the maximum range
3. Factors upsetting the Range Accuracy
4. Factors upsetting the Range Resolution
5. Factors upsetting the Bearing Accuracy
6. Factors upsetting the Bearing Resolution

These are the factors which we take care when we try to detect, display and measure the targets, under these factors there is also lot of attributes which is taken care of some of them are target size, target rate of movement, stabilization of display, range of targets etc. but in the radar technology there is also lot of characteristics of the target components which is also required to take care of that is known as target characteristics. The characteristics of target will able to detect the target at a greater range than other for another goal it create strong echo than other goal of identical size.

Size: Up to fixed restrictions, goal or target which has large reflecting area returns stronger echoes than target or goal which has small reflecting area. The straight up dimension of most goals are less comparing to the straight up beam of the marine navigational radars.

1. Aspect: Aspect of goal is its own direction to the radar beam axis. When we change the aspect, the sent back region can transform, it depends on shape of the target. When the angle between sent back region and the beam is more close to 90 degree, more strength of the echo comes to the antenna.
2. Height: When wave of the radar scattering is line sight, the target height is more important. If the goal is not down the radar perspective, there is chance that radar

beam cannot reflect from the goal. Due to the interference pattern the goal must be above the radar perspective.

3. Texture: It modifies the effect of aspect and shape of the goal. An easy texture increases the sent back qualities and also the reflection strength, but until the shape and aspect of the goal reflection is focused back on the antenna. Always easy surface gives bad radar echo such thing happen because energy is reflected in another direction.
4. Shape: Same targets shape can give echoes of various strength, it actually depends on the aspect. Actually we will get strong echoes when the steep cliff along the shore is at right angles to the radar beam.
5. Composition: It tells about which type of substance is good reflectors of the radar pulses. Actually the capability of various substances to sent back it depends on the inherent electrical properties of those substances. The poor reflectors are wood and fiber glass boats.

1.2 Synthetic Aperture Radar

Synthetic Aperture radar is picturing technology which produces the soaring quality resolution 2 dimensional pictures of goal or target areas. It is used on space based and airborne vehicles for soaring resolution radar pictures. Generally using the electrical signal image processing techniques, the descriptive pictures are made after the addition of consecutive radar signal reflections of the identical goal region. Hence the synthetic aperture radar functions in the microwave range, surface target pictures, may be prepared at the severe weather when the pictures based on the optical systems are not in use. The figure of synthetic aperture radar is shown in Figure 1.1.

The synthetic aperture radar system applies the linear antenna which is climbed to the direction of route of the airplane. The airplane route is said to the cross range direction. The primary body part of antenna points in a perpendicular direction to the azimuth direction. This route is said to be range direction. That's why the synthetic aperture radar system is considered in the form of array of antennas. The high azimuth resolution is achieved due to the use of these arrays which has better beam width.

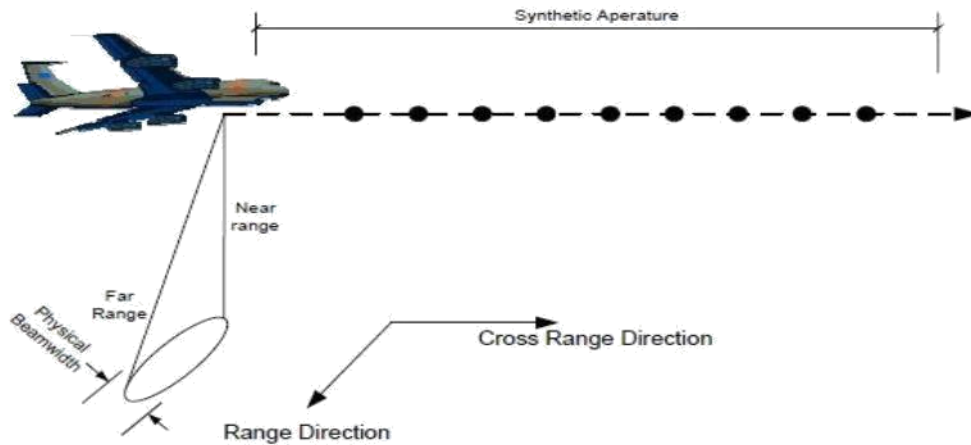






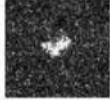

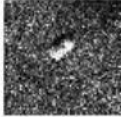



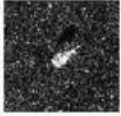

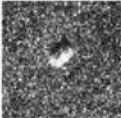


Figure 1.1: Synthetic Aperture Radar

There is difference between synthetic aperture radar and physically phased array. In the physical phased array all elements get energized consecutively while the synthetic aperture radar system has identical antenna. A different array element is combined to make complex from the identical antenna at various locations. When the aircraft moves, the synthetic aperture radar system puts the pulse reflected information in memory unless the all array elements pulses come back. Thus well-equipped processor combines the information to make the soaring resolution picture.

The synthetic aperture radar pictures taken in this thesis has a resolution of 128*128 pixels. This resolution size is reduced to 96*96 pixels using the principal component analysis techniques which helps the radar easily to differentiate between the small to large vehicles. Right now this can be particularly useful for military applications but if someone wants to extend this we can use it for another application also. Due to the soaring resolution of a vehicle gives the magnitude of a picture which consist high pixel values. That's why synthetic aperture radar picture gives more information than goal or target location. Due to the difference between the particular classes of vehicles gives higher level of consciousness to the radar operator. Being able to exactly differentiate between friendly, enemy and nonmilitary and military goals is understandable.

Table 1.1: Target images

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

The Moving and Stationary Target Acquisition and Recognition (MSTAR) data set is synthetic aperture radar pictures which are taken of Russia made vehicles. The US air force released this data set publicly for research purpose. Every picture in this dataset is single goal vehicle. Every picture is kept in particular file. This file keeps information about the goal constraints: goal model number; vehicle type (tank, land cleaner, transport, truck), goal pose angle (azimuth), various different constraints. Vehicle type, visual image of the goal and radar pictures of the goal is presented in Table 1.1.

This radar pictures, the pixel is represented to gray levels. The display allows that user can exactly see the goal vehicle in radar picture. These pictures are subset of whole MSTAR database. In this thesis the clutter and slicy pictures are not taken. In this thesis for training and testing purpose of my machine learning classification models basically used to vehicles BRDM2 and BTR60 but proposed framework can work for all type of vehicles which is represented in the Table 1.1.

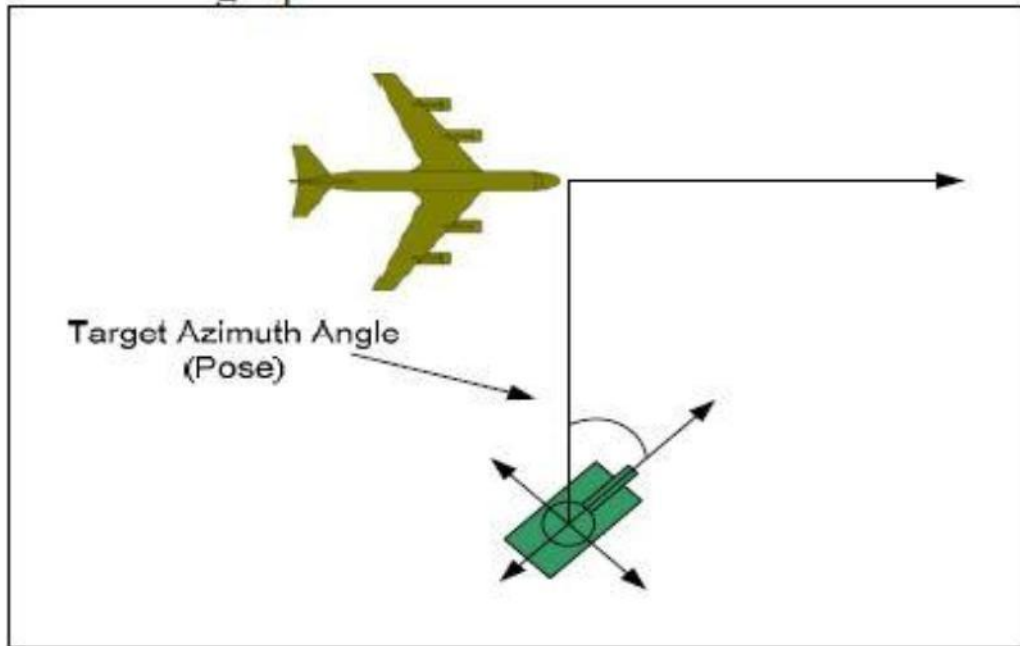


Figure 1.2: Goal Azimuth Angle

There is lot of picture constraints can influence the appearance of the goal in the MSTAR data sets. The important constraints are goal pose angle or azimuth angle. An azimuth angle is an angle between the frontward directions of vehicle relative to the incidence angle of the radar pulse. Figure 1.2 shows of the goal pose or target pose.

The sent back magnitude picture from the identical goal may be dissimilar at dissimilar azimuth or pose angle due to the character of radar disperse. Basically, peak does not carry on a rotation of some degree. This property introduces a major problem in categorization of the pictures. Because of the difference of dispersions, one class of goal is measured as collection of various subclasses presenting the goal at different pose or pose angles. The figures 1.3 show different pictures of the T62 with a pose between some

angles. The intensity of each goal picture is displayed using multi color map. The color map presents the pictures using different classes like small as blue, medium as yellow and green, high as red. The major part of the goal has low intensity. There is some where no continuous points on the goal that has high intensity. These are known as dispersion centers. This dispersion is important attribute of the synthetic aperture radar images. The sent back of dispersion is dependent on the azimuth of the vehicle.

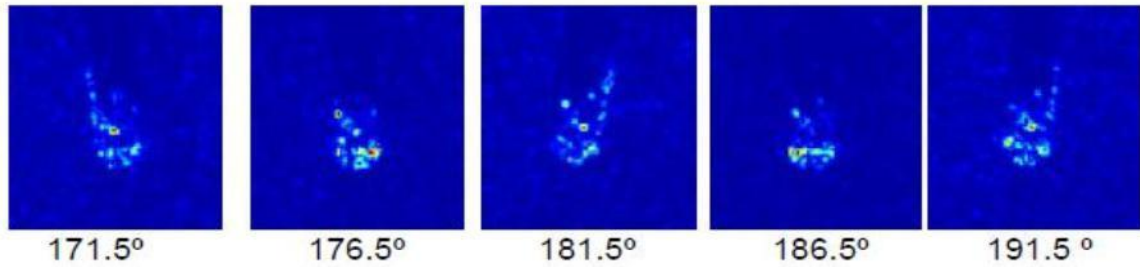


Figure 1.3: Azimuth poses between the Angles

The other constraint that influences the synthetic aperture radar image outward show is the compression angle. A compression angle is defined as the angle between surface of the surface and line between the radar and goal is vertical to the path flight of the radar. Figure 1.4 represents the compression angle. When compression angle becomes less, the shadow image of the goal rises longer.

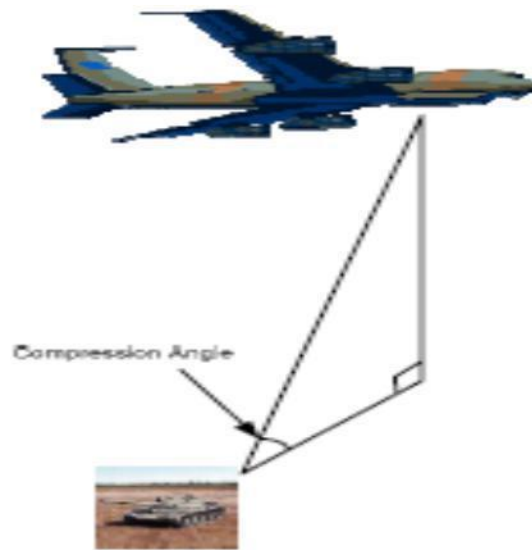


Figure 1.4: Compression Angle

1.3 Automatic Target Recognition

The recognition of target or goal is the procedure of discovering an picture which belongs to a particular kind of vehicle. When computer is use to recognize a goal or target without using human interference is known as automatic target recognition (ATR). The word classification and recognition is sometimes used for each other. The word classification can be defined as the act of providing the input data as one class out of the various pre-defined classes. The job of the classifier is to provide the class to unknown substances described using features, known as attributes. The classifier derives a law from substance which is described by features and for this particular class is known. Basically this classifier model derived this rule using a given data set that is known as learning data set. This classifier model is justified using another part of the data set that is known as testing set. There is also another approach to partition the data set that is known as cross-validation. But it is used when the amount of data is not sufficient to produce training set and testing set that are not dependent, and each contain an adequate quantity of objects. Classification is the component of supervised learning. In this learning approach problem, the object belongs to dissimilar categories known as classes. This learning method goal is deriving the relation between the features of objects. This relation is used to predict the exact true class of the object. This learning approach can be either keep in the category of regression problems or classification problems. The regression problem guess is continuous numerical value, while categorization problem prediction is discrete value.

Various methods are used to ATR from the SAR data has suggested the literature and their performances are described under testing and training scenarios with sample data. The comparative performance of different methods can be unmanageable to measure on these empiric ratings. The existence of this problem is due to execution points which vary from one particular information to other particular information which may or may not attain most favorable results in the study for which it is implemented. The execution points consist of procedures of recognizing targets, procedures of feature extraction, selection of data to use for training and testing of algorithms, and parameterization as angular resolution, azimuth angle.

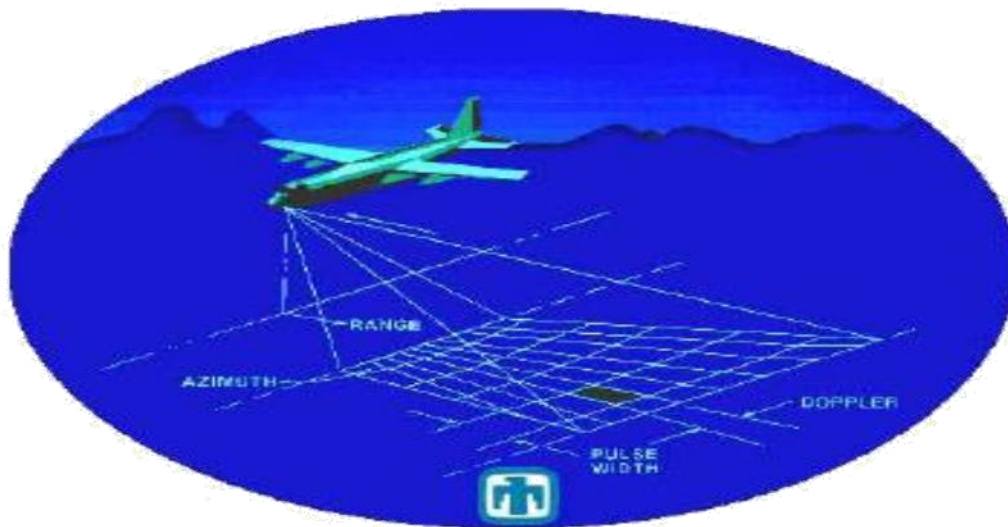


Figure 1.5: Illustration of SAR geometry and automatic target data collection scheme
(Courtesy of Sandia National Laboratories)

The study is proposed to searching the potentiality of models primary the algorithms applied, so the equivalence of methods to automatic target recognition is determined in the logic that algorithm testing is performed only with pictures taken under conditions which were very similar to the training objects.

In this thesis, the proposed algorithm is used to solve the problems of related to recognition of (ground) objects or one of the primary application of this paper is to solve the real world problem. For example, suppose there is a war going between countries or enemies we try to search important artilleries and weapons. The basic problem is how we will accomplish this task. To solve such type of problem, in this paper we are using the concept of Principal component analysis (PCA) for feature extraction and to classify the objects on the basis of their relevant features. PCA is one of the largely important results from the practical linear algebra. It has been used extravagantly in all the classes of analysis from the neuroscience to the computer graphics. Due to its simplicity, non-parametric method of drawing out applicable information from disconcerting data sets. With minimum extra attempt PCA gives a guideline for how to cut a composite data set to a lower dimension to disclose sometimes concealed, altered kinetics that frequently

form the base for it. In the field of pattern recognition, machine learning and picture processing, feature extraction begins from the starting set of measured builds derived values (features) and data destined to the instructive and non-redundant, helping to the consequent generalization and learning steps and in the some area it leads to the better human interpretations. It is also use to reducing the dimensions of the objects. In this when the input data is given to an algorithm is huge to be processed and distrusted to be the redundant then it could be changed into a reduced set of features. It is known as feature selection. In this current paper to extract the features from the SAR pictures we have used the PCA techniques. We have used machine learning algorithms. Basically the algorithms we have used as classifier here are as follows:

1. K-Nearest Neighbors
2. Naïve Baye's
3. SVM

Naive Baye's:

Naive Baye's is the barest example to develop a identical compress delicacy of a high dimensional probability distribution. We have a class variable A that accepts values in some set $\{A^1, \dots, A^k\}$. The model also adds more or less number of features $\{C_1, \dots, C_n\}$ of which values are typically found. The Naive Baye's presumption is that characteristics are conditionally independent contributed the instance class. Regardless of the solid premises that it makes, the naive baye's model is frequently used in, due to. It its ease and the less number of arguments required. The model is used for classification purpous, deciding based on the feature extracted for a given SAR pictures, the class to which the signal is most likely to belong.

K-Nearest Neighbor (KNN):

In field of machine learning and recognition of pattern, the K-Nearest neighbor's algorithm (KNN) is a non-parametric statistic method. It is used for categorization and regression. It is a kind of lazy learning or instance- based learning. To postpone the decision to bring into general or common use beyond the training examples till a new query is find out. When we get a new point to classify, we get that its K- nearest

neighbors from the training data. Actually the distance between the new point and its nearest neighbor is calculated using Euclidean Distance.

Support Vector Machine (SVM)

Support vector machine is founded on the concept of conclusion planes which defines conclusion borders. A conclusion flat surface is one that classifies between a collection of objects having dissimilar class memberships. Support vector machine backs regression and categorization tasks and can handle multiple continuous and categorical variables. Support vector machine can solve the problem which is not linear high dimensional and global optimal problems effectively. It can obtain the unique optimal solution.

1.4 Organization of the thesis

The thesis is organized as:

Chapter 1 presents the introduction section.

Chapter 2 presents the literature review of the research already done so far in this field.

Chapter 3 presents describes the problem statement and its objective.

Chapter 4 explains the methodology and implementation of proposed framework. Chapter 5 shows the results obtained after implementing the proposed work. Chapter 6 concludes the discussion and future scope.

CHAPTER 2

RELATED WORK

2.1 Related work

For this matter, we collected lot of different articles which provide details for many view of automatic target recognition (ATR). We start by concentrating on polar metric synthetic aperture radar picture and the methods used to discover, separate and classify targets found in such picture.

The article by Leslie M. Novak et al. [10] gives a general summary of classical pattern recognition approach. The article by Daniel E. Kreithen et al. [10] talks about the problem of separating targets from the natural clutter objects (e.g. trees and bushes) that gives evidence of radar energy to go across the sensing stage.

Shawn M. Verbour et al. [10] inquires more or less of the problems in discerning three dimensional targets from their two dimensional SAR signatures; and formulates a method for containing three dimensional information in the classification process.

Allen M. Waxman et al. [10] introduces the topic of neural network recognition systems. It talks about some of the motive of neural network architectures that are inferred from biologic vision systems. It also gives the thought that data could be extracted from the modifications in target signature from one view point to the next as a target and a sensing element act by each other. These neural processing concepts are presented on many dissimilar target recognition problems. The subject of neural networks extends in articles by Paul J. Kolodozy and by Murali M. Menon.

Kolodozy [10] gives a description of laser radar picture, which at the equal time catches reflection (reflectivity) information and range information. The article also deals the job of calculating ATR algorithms. On account of the price of gathering training and test picture covering the largeness of existing ATR scenarios, the growth of an electronic terrain board(it is a system that can give synthetic picture with few mistakes and rapidly) for testing and calculating ATR algorithms might be more price efficient.

Menon et al. [10] talks about the use of neural networks to apply an picture enhancement algorithm on markov random fields, for laser radar picture. The consequence of this preprocessing tread on the performance of the target classifier is presented.

Richard L. Delanoy et al. [10] presented the use of laser radar measurements for target recognition, but the authors use a model based approach. Signal detection has done by many algorithms that run in parallel and are keyed to search for several picture features by using a method called functional template correlation. Multiple functional template outputs are joined to build a simple concern picture to concentrate on succeeding processing. Target data is pulled and decayed into features that are corresponded against kept appearance models. The weights used to rule the corresponding procedure could be adaptively discovered on training data.

Delanoy and Seth W.Troxel et al. [10] presents the tractability and ability of functional template correlation. This article talks about how functional templates are used to discover and discern blow faces in weather radar data.

The article by M. D. Devore and J. A. O'Sullivan et al. [10] has mentioned a model which examines resemblances on an yet foothold while reducing the affect of accomplishment points and explains the change in the size of the picture, in angular resolution and in the orientation sizes the windows used for training. Another approach to ATR is qualified in terms of the best accomplishable performance as function of the complexity of the model parameter database.

The article proposed by Amit Kumar Misra and Bernard Mulgrew et al. [2]is that usage of principal component Analysis (PCA) for synthetic aperture radar (SAR) picture classification to automatic target recognition (ATR) community. In this research paper the results are compared on the basis of percentage of true classification, ROC and presentation with least quantity of training data.

M.R.Azimi-Sadzadi , S.Ghaloum and R. Zoughi et al. [8] talks about the improvement of neural network based classifier for arranging three different pictures(urban, park and weather) from various polarized SAR pictures of San Francisco bay area is discussed. Basically they have inquired the relationship between object profile and received

scattering data for the monostatic, or coincident source- receiver tomographic measurement geometry. They have separated the deduced everting schemes as Fourier transform and far field methods and have got that the Fourier transform method gives superior picture quality. Since the execution of this method can be based on the fast Fourier transforms it provides efficient calculation benefit over the far field method. While the application of the fast Fourier transform method is fixed to comparatively deep targets, numerical simulations propose that there is less loss of picture quality related with the application of this approach to shallow targets.

The another proposed article by the Martin Klenke and Volker Hochschild et al. [9] in this article they talk about the SAR pictures of craggy and mountainous area are ruled by the terrain induced back scatter variation. To implement automatic categorization methods as for example land cover unfairness. This effect had to be cut in order to get meaningful results. So basically they have used principal component analysis (PCA) as significant methodological tool for the analysis of picture time series. Finally they used PCA for diminution of radiometric terrain in SAR data. In this article they also mentioned that the accuracy and class variability for a several environmental problems.

The problem of forest/urban unfairness is distinctive for C-band and SAR calculations particularly when the settlements are rural towns with a high percentage of green vegetation. Possible solutions add the analysis of textural data natural in the scenes and coherence analysis of from interferometric processing.

Various procedures of automatic target recognition of the Moving and Stationary Target Acquisition and Recognition data set have been searched. Particularly two were most important that is template matching and high-level feature based region. Here we will discuss these methods.

Template Matching

Templates are reference pictures in the spatial frequency area which is made using the training data. This template has identical number of pixels in the training pictures. Using the frequency area template there should be identical number of coefficients as like as pixels in the training pictures. Various templates are made for every goal class to explain

the deformation because of dissimilarity in pose and clarification. While test picture is divided on the basis of the template that is more closely corresponds it. Here likeness is quantified by selected distance metric. It is easy to implement and provides high accuracy [1][2][3]. The disadvantage of this model tends to be the large and computationally tough. The synthetic aperture radar picture of every goal picture changes with azimuth making the pictures unchangeable to rotation, therefore every goal class must be the parts of a mixture distribution that add models of an particular goal at various routes. It is achieved using filter template and minimum squared error templates.

High-Level Feature-Based Recognition

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] [5]. Still the pose 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. It controls the 3D dispersed data. They have assumed that man made objects of complex figured can be divided into set of rectangles. It contains four steps; first is estimated size and direction of the target, target segmentation into rectangular shape, identify the segment which contain main parts and 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 in the radar target classification using the J frequency band pulse radar. Using the discrete-time Fourier transform (DFT) and Multiple Signal Characterization which are based on the detection of Doppler effect, easily feature extraction is done here. 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) as the base learner. Radial basis function is binary classifier which decomposes the multiclass problem into binary. RBF network result is added using the AdaBoost.

Zhang, Wu, Liu, Qin and Song et al[13] talks about the new approach to classify the synthetic aperture radar goals represented on the basis of high range resolution(HRR) profiles time-frequency matrix non-negative sparse coding(NNSC). First it converts the synthetic aperture radar picture is transformed into HRR profiles. For every profiles the non-negative time-frequency matrix is obtained using the adaptive Gaussian representation. Non-negative sparse coding is implemented to learn goal time-frequency basis of the training set. By projecting every HRR profile time-frequency matrix to low dimensional time-frequency basis space is used to make the feature vectors. In this paper they have 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 synthetic aperture radar goal classification using the Bayesian compressive sensing (BCS) with dispersing centers features. Dispersing centers features is drawn out as L1- norm sparse problem on the basis of synthetic aperture radar observation model which can easily increase the dissimilar ability compare to the original synthetic aperture radar image. Basically

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 radar target recognition. The aim is to recognize the equality between the unknown and known goals. In this research paper automatic radar target recognition accumulates the Radar cross section (RCS) and then treated to help as the features for target recognition. 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). In this method the set of orthogonal eigen-vectors is made using principal component analysis it is very efficient for solidity, and leads to the loss of critical discriminative information in signals. In this using the Non-negative Matrix approximations we create new basis set of synthetic aperture radar pictures.

3.1 Problem Statement

In these modern eras, advancement in multimedia is rapidly increasing. The multimedia equipments and rapidly emerging technological applications like goal detection in digital image processing is the most important than ever. Several sophomore and crazy discovery has come up in the field of goal detection. Approximately several of them needed critical image processing work as it demands lot of efficient goal detection systems. Previously several of efficient algorithms for goal detection has been implemented. Out of them some are efficient and some are not efficient. These are not much efficient algorithms are based on features of the target and estimation of the state for dissimilar regions through dissimilar segmentations procedures.

These goal detection techniques need fast, efficient, accurate, dependable and robust algorithms for goal tracking and classification. The exact challenge is not merely to accumulate the information about objects with much larger faithfulness which is possible now these days, but also required to process the collected information faster and propagate them rapidly in the preferred arrangement. The primary approach for any goal recognition problem is to separate the dissimilar components from a scene and find the one that is of your interest from the rest. Because of the environmental conditions such as amplification changes, gloom etc. In this thesis the main problem definition is that we have tried to recognize or detect the ground targets using the machine learning models or techniques. Previously there is lot of machine learning techniques have implemented but it is not told that which one is more efficient. In this it has suggested that out of the Naïve Baye's, K nearest neighbor and support vector machine which one is more efficient or accurate. These machine learning techniques is implemented on the feature of the objects. Previously there is lot of techniques has implemented for feature extraction but which is more efficient and accurate it is also a problem. So in this thesis the suggested method or approach for feature extraction is also new which is different from other existing algorithms. It is also difficult task to extract feature due to the noise, clutter and distortion

in the received dataset. In this clutter is defined as group of signals or reflections drawn out from spatial consistent reflectors but not related to goal and so it prevents to exact detection and recognition. Thus perceiving goal information from a taken picture or object is completely grounded on the taking apart of background information and target information. In this thesis the detection of ground targets are based on the synthetic aperture radar images.

3.2 Existing research gaps

The following points explains the main theme of research gaps for automatic ground target recognition explained in related work given below as follows :

1. Still after considerable research, noise and clutter regions are major impediment in exact recognition.
2. High degree of isolation of goal from surroundings is yet to be found.
3. There is lot of statistical techniques have been implemented but which one is more efficient it should need to be more elaborated.
4. It is also need to be implement machine learning models and need to find out which classifier give best accuracy out of them.
5. With growing sophistication has not wrongly labeled false goals or targets to be labeled as true goals or targets.
6. Implementation of principal component analysis which uses singular value decomposition need to be once again modified if number of features increases rapidly.

3.3 Objectives

Exclusively this thesis aims at:

1. Pre-processing which is required to reduce noise rejection.
2. Normalization is required to centering the data.
3. Extraction of features from dataset using principal component analysis.
4. Classification of ground targets using machine learning classifiers like Naïve Baye's, K-nearest neighbors, Support vector machine.
5. Performance analysis of these classifiers.

CHAPTER 4

PROPOSED FRAMEWORK

4.1 Proposed Framework

The working methodology of work is diagrammatically shown in the below pages. As we see that there is three phases to solve my problem. The three phases are as follows:

1. Preprocessing phase
2. Feature Extraction 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 centred the vectored picture data. That is known as mean centring. Now we make covariance matrix from this data. Then we use another two phases feature extraction and classification phase. One by one will explain these phases.

4.1.1 Pre-processing Phase

Several factors influence the success of machine learning on any given task. The presentation and superiority of the object data is main and important. If the dataset is much unbalanced and superfluous information or noisy and not reliable data then discovery of knowledge at the time of training phase is more complex. It is well familiarized concept that data preparation and filtering take proper amount of executing time in machine learning problems. The pre-processing considers data cleaning, normalization, transformation, feature extraction and selection, etc. The final output of this stage is the training dataset. The pre-processing phase for the synthetic aperture radar images is shown as follows in Figure 4.1

1. Calibration: It is used to for the conversion of data to standard geophysical measurement units. Basically it converts the voltages which are measured from the sensor to geophysical units. Calibration is required to allow comparison of data from:
 - i. Different Sensors

- ii. Different times
- iii. Different positions

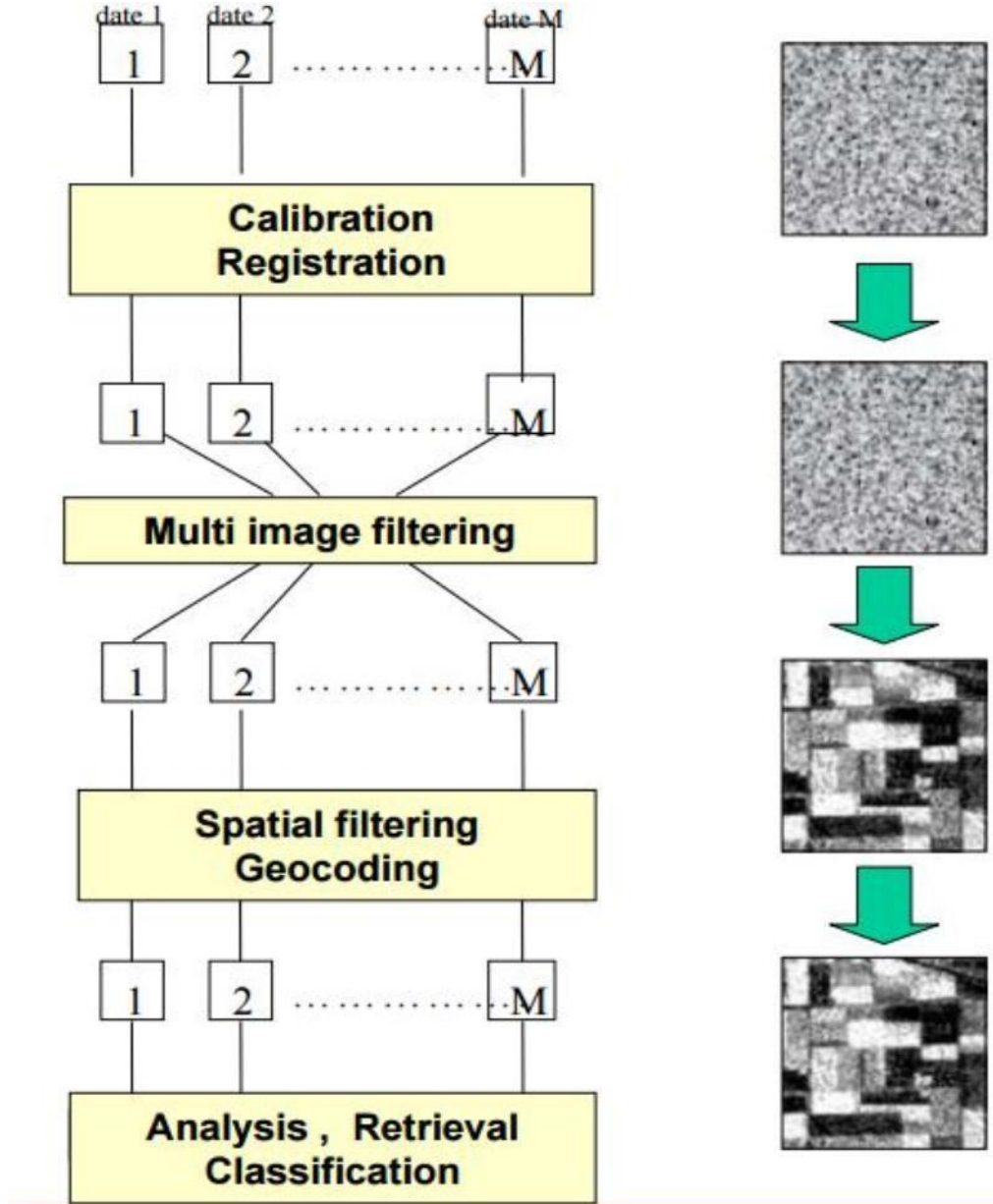


Figure 4.1: Pre-processing phase

Relative calibration tells us that the values everywhere in a single image are proportional to geophysical units.

2. Geocoding: It allows the data to be referenced to map and allow geolocation.

3. Registration: It gives certainty that several pictures can be matched to point to point.

After these step in pre-processing phases we do analysis, retrieval and classification.

4.1.2 Feature extraction phase

Extraction of features and recognition of pattern are the two most important aspects in machine learning. It is a procedure that derives an informative and optimal set from the presentations of the radar signals. Recognition of pattern can be divided into supervised learning and unsupervised learning based on the learning procedures. Training and testing phases in machine learning is done as follows represented in Figure 4.2.

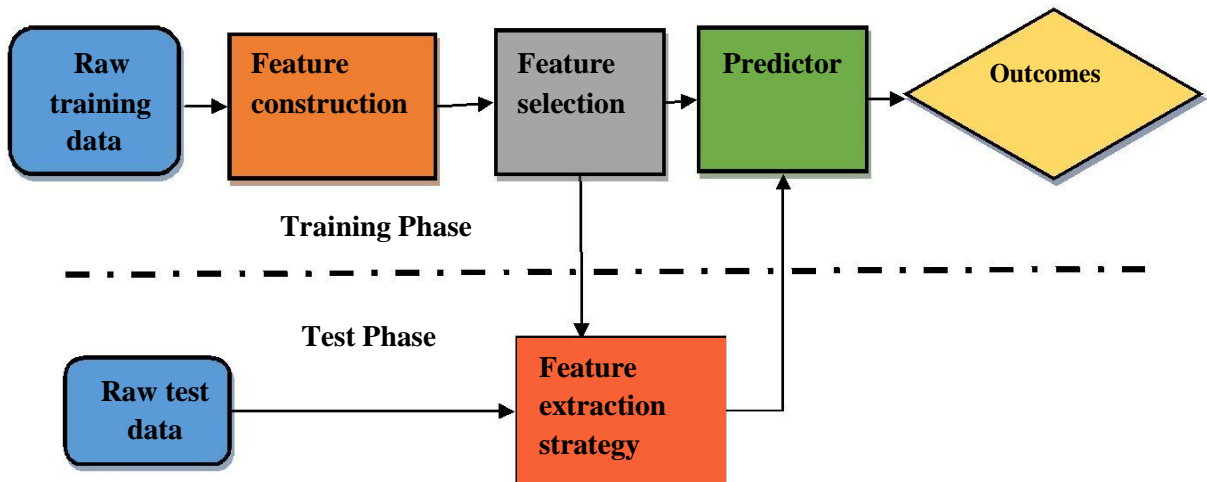


Figure 4.2 Phases of training and testing in Machine learning

In any analysis or learning methodology, every instance is presented by some set of properties known as features. This part will tell includes feature construction and feature selection. The construction of feature changes the raw variables of an image into a feature space. The goal is to find an informative presentation of the object in the new region. For every application there is never possible to find universal features. It is designed on the particular problems , it can be either qualitative or quantitative. There is several methods to extract the features, like as linear discriminant analysis, principal component analysis, hidden Markov model and wavelet transform. Here we have used principal component

analysis. Feature selection looks for an best subset of the constructed features; not relevant and redundant features can be the reason for worst performance of the classifier's. The selected feature should have highest correlation with the decided function and lowest correlation with other features. The aim of the selection of the feature is to comprises means reducing the computational cost, improve prediction performance and make easy data analysis. It consist four main steps as shown in Figure 4.3.

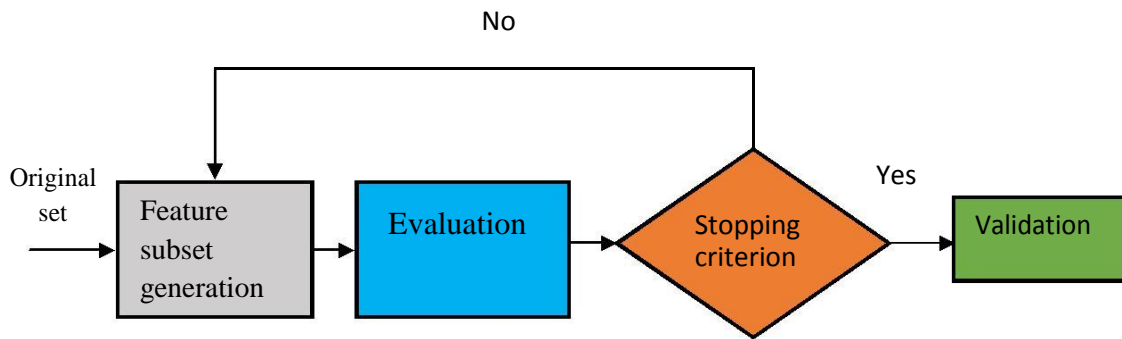


Figure 4.3: Feature selection procedure.

1. Generation: On the basis of search strategy we try to select the feature subset candidates.
2. Evaluation: Try to find out the importance of the feature subset candidate.
3. Stopping criterion: When have to generation and evaluation should stop so we provide conditions.
4. Validation: Validate the selected subset.

4.1.3 Classification phase

There is lot of different machine learning classifiers are available but basically we have used Naïve Baye's, K-nearest neighbour and support vector machine.

Till now the Naïve Baye's is a classifier which is one of the best algorithm in SAR-ATR. Basically Naïve Baye's algorithm is based on the Baye's theorem, which is conditionally independent, Naïve Baye's is the theoretical algorithm which is most beneficial algorithm.

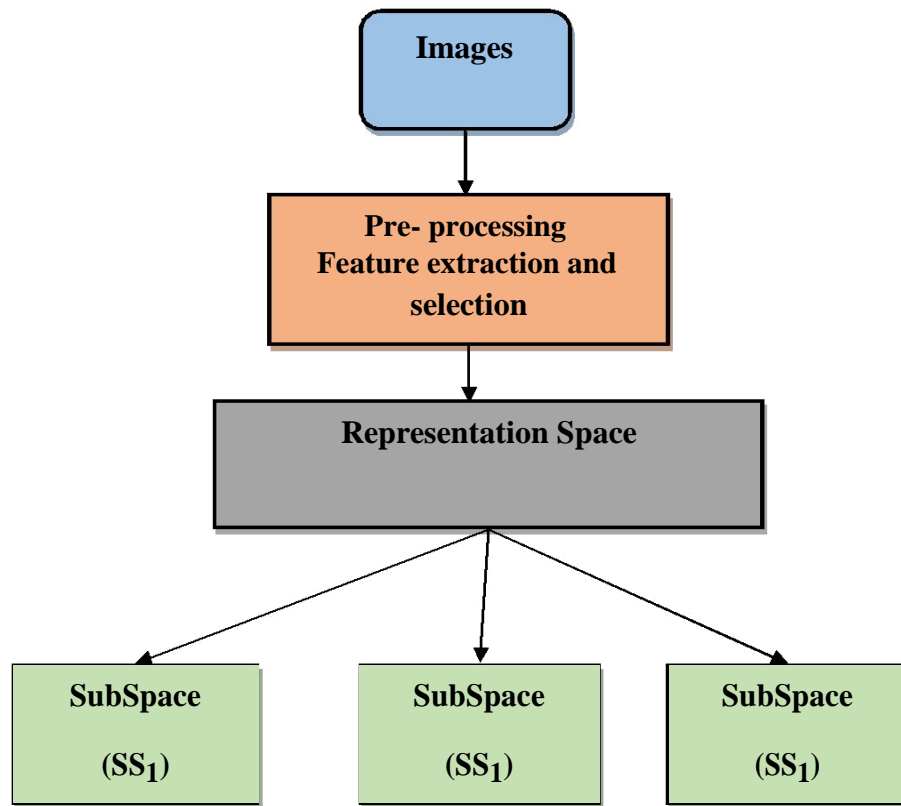


Figure 4.4 Classification phase

Every points of the picture has understood which is from a Gaussian distribution trained or dependent on the type of the goal and pose of the goal represented in Equation 1[20].

$$X=Y (f,b)+K \dots \text{equation (1)}$$

Where X's are the discovered vividnesses of the points sets up the 1-D vector, K's are the noise, Y is the signal put on the f , it is the pose angle of the goal and b the type of the goal. The log-likelihood of discovered X, set (target pose angle, target type) is shown

relative to: Equation 2[20]

$$-\sum_{j=1}^n [\log(\Sigma_j) + ((X_j - \mu_j) / \Sigma_j)^2] \dots \text{equation (2)}$$

Where X_j is the jth point of the test pictures, S_j, M_j is the standard deviation and mean.

We know that Naïve Baye's is based on the Baye's rule so Baye's rule is

$$P(b/X) = P(X/b) \cdot P(b)$$

Where $P(b)$ the probability of every different type of moving objects is presumed to equal. When we use PCA, the picture points are presumed be the practical variables, depends on the type of the goal. Equation 3[20]

$$X=Y(b) + K \dots \text{equation (3)}$$

Where X the determined vividness of the points put in a 1-D vector and K is the noise. Every picture in the training data set is from the equal pinnacle but a different azimuth angle. Points of pictures are presumed as variables, taking unlike declarations with altering azimuth angle.

4.2 Implementation of PCA

Principal component analysis is implemented to data set to cut down the number of practical variables. Using PCA this is used as follows:

1. Every picture, the points are taken into the declaration vector and successive pictures have taken as dissimilar declaration results.
2. The whole subsequent refigured picture point vectors are piled unitedly to make the declaration matrix.
3. Then this declaration matrix is normalized (find the unit variation) and then the whole declaration matrix is made to Zero centered. Assume that the absolute matrix is referred as A .
4. From this declaration matrix, the covariance matrix is detected for the declaration vector.

$$S = A^T A$$

5. Now eigen value operation is implemented on S after getting eigen value we get the eigen vectors.
6. Accompanying to the greatest eigen value, we piled eigen vectors to make matrix B .
7. Using the matrix B , the training data set is reduced.

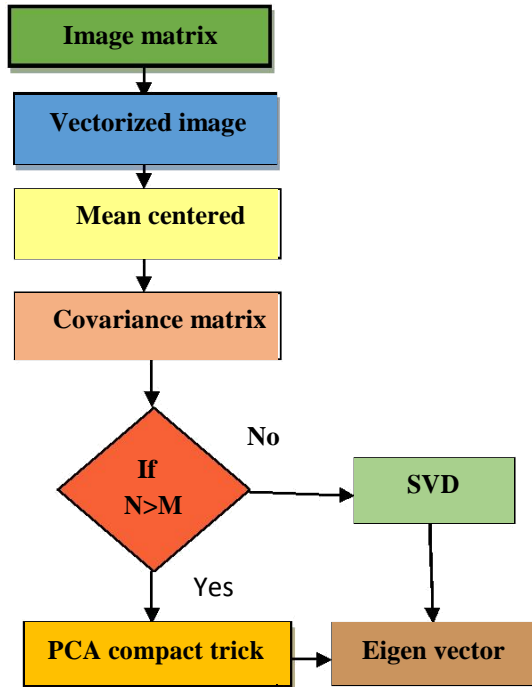


Figure 4.5: Feature Extraction using PCA

Proposed framework is developed using the python language with the help of various python libraries and packages like PIL for picture processing and numpy, glob ,operator etc. To enhance the performance of feature extraction the proposed work used the new concept i.e.

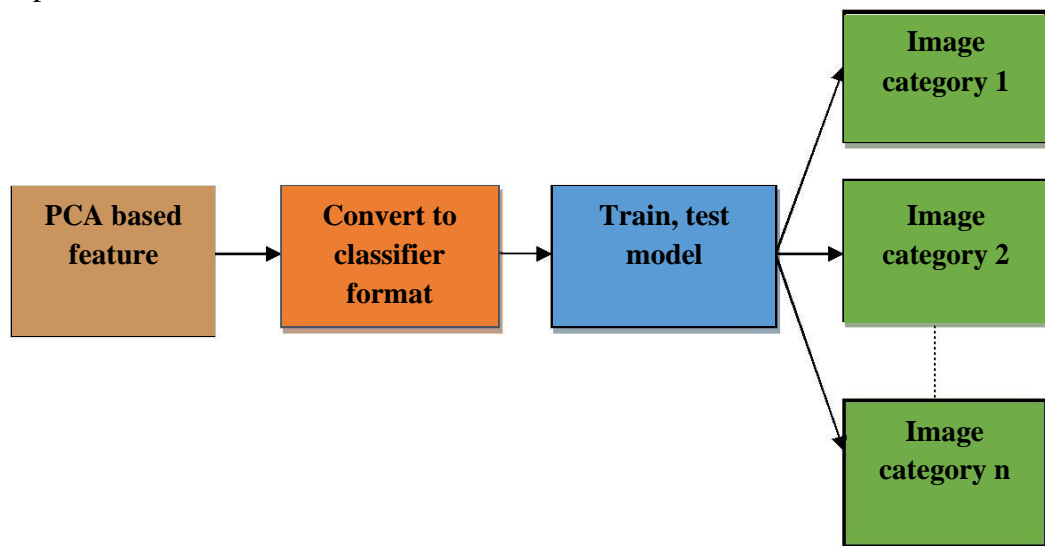


Figure 4.6: Proposed Framework

PCA-Compact trick which is 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.

4.3 Naïve Baye's classifier

It is a probabilistic classifier which is based on the Baye's theorem with strong independence assumptions. It is represented as Bayesian network.

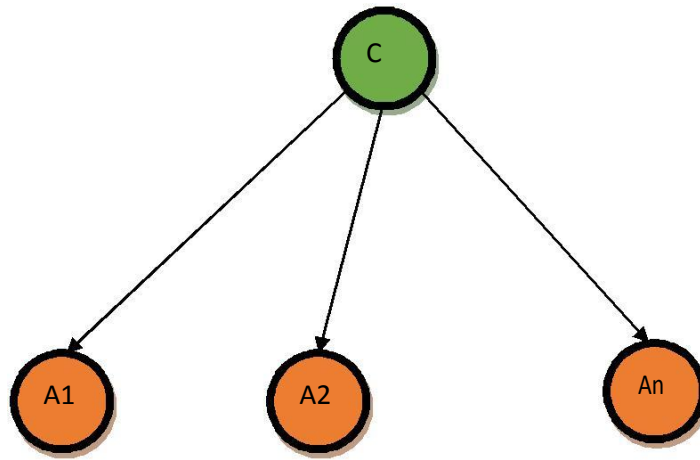


Figure 4.7: Bayesian network

In Naïve Baye's classifier, if feature have continuous or numerical data, we can handle the data in two ways:

- 1) Transform the numerical values to their categorical counterparts.
- 2) Use the distribution of numeral values to find the frequency. To do this we use normal distribution two parameters Mean and Standard deviation.

Implementation steps of Naïve Baye's:

Step 1: Select the input file.

Step 2: Read the input file.

Step 3: Use the split ratio i.e. known as cross validation method in machine learning techniques.

Step 4: Create training set and testing set.

Step 5: Calculate the prior probabilities for training set.

Step 6: Calculate conditional probability for feature values in test data.

Step 7: Calculate posterior probability for each class.

Step 8: Classify to each class.

Step 9: Display classification result.

Step 10: Calculate Accuracy.

Step 11: Display Accuracy.

Figure 4.8: Implementation steps of Naïve Baye's

4.4 K-Nearest Neighbor Classifier

It is part of supervised learning that is used in several fields like mining of data and recognition of pattern. It is method of classifying the instances on the basis of nearest training examples in the feature vector. It is decided by majority vote of the neighbor. The value of k will always nonnegative. To calculate the distance we will use Euclidean distance formula between the neighbors

Implementation steps of

KNN:-Step 1:- Select the data.

Step 2:- Split the data.

Step 3:- Create training set and testing

set. Step 4:- Determine the value of k.

Step 5:- Evaluate the distance between the test object and all the training objects.

Step 6:- For all the training samples sort the distance and evaluate the nearest neighbor on the basis of k-th minimum distance value.

Step 7:- Get all the variety of training data for sorted value which are under k.

Step 8:- use the nearest neighbor as prediction value.

Step 9:- Find the accuracy.

Figure 4.9: Implementation steps of KNN

4.3 Support Vector Machine classifier

It is currently gained recognition in the area of machine learning and classification of the pattern. Classification is done using linear or non-linear separable surface in the input region. In this the separating function can be shown as linear combination of kernels related with the support vectors. We find the hyperplane that separates the data by maximal margin.

Implementation steps of SVM classifier

Step1:- Select data.

Step2:- Create training set and testing set.

Step3:- Obtain feature vectors using PCA.

Step4:- Classify the input data i.e. images.

Step5:- Train the SVM classifier.

Step6:- Test the each images using the trained SVM classifier.

Step7:- Output the final class to each image.

Step8:- Find the accuracy.

Figure 4.10: Implementation steps of SVM classifier

CHAPTER 5

RESULTS AND DISCUSSIONS

To evaluate our feature Extraction method, we choose two dataset and apply important machine learning algorithms for classification purpous. 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 5.1.

Table5.1: Summary of Datasets Used in Experiment

Dataset Name	Samples	Features
BTR60	660	195
BRDM2	850	273

First of all on the above mentioned dataset to extract the feature in this thesis the implemented methodology is principal component analysis using the compact trick concept. 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 also presented below.

```
>>> 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 5.1 Mean value of BTR60

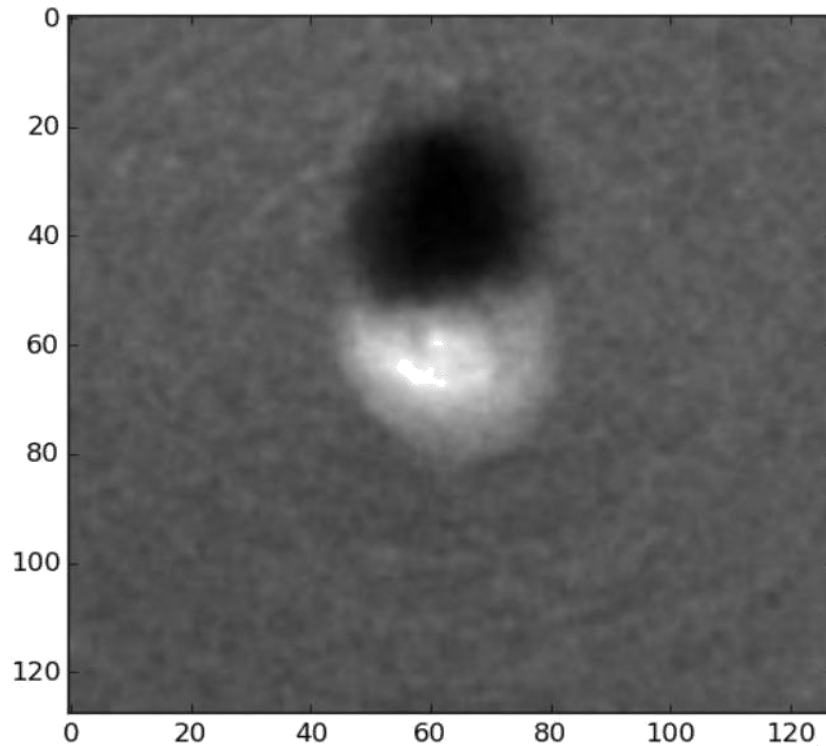


Figure 5.2 BTR60 image on the mean value.

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 given below. 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=r'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 5.3 Mode value of BTR60

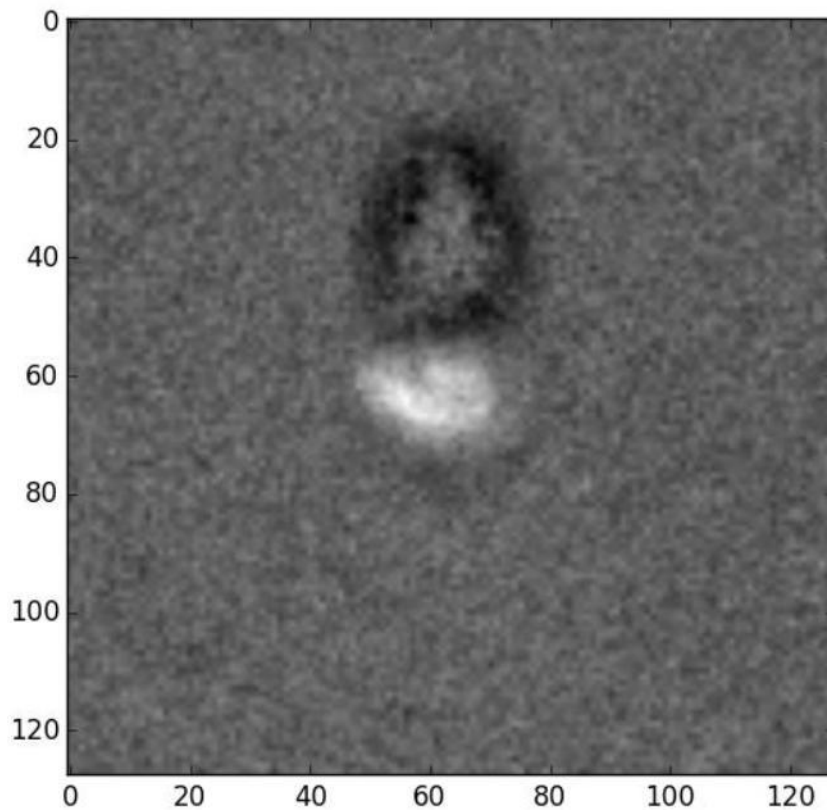


Figure 5.4 BTR60 image on the mode value

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 mentioned below as follows.

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

Figure5.5 Mean value of BRDM_2

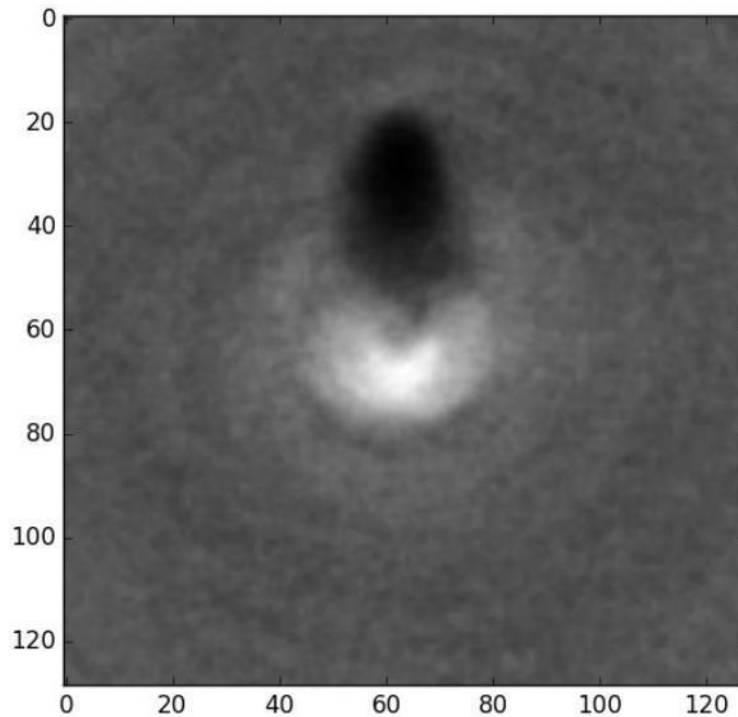


Figure5.6 BRDM_2 image on the mean value

```
>>> runfile('C:/Users/Ravi/Desktop/untitled0.py', wdir=r'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]]
>>>
```

Figure5.7 Mode value of BRDM_2

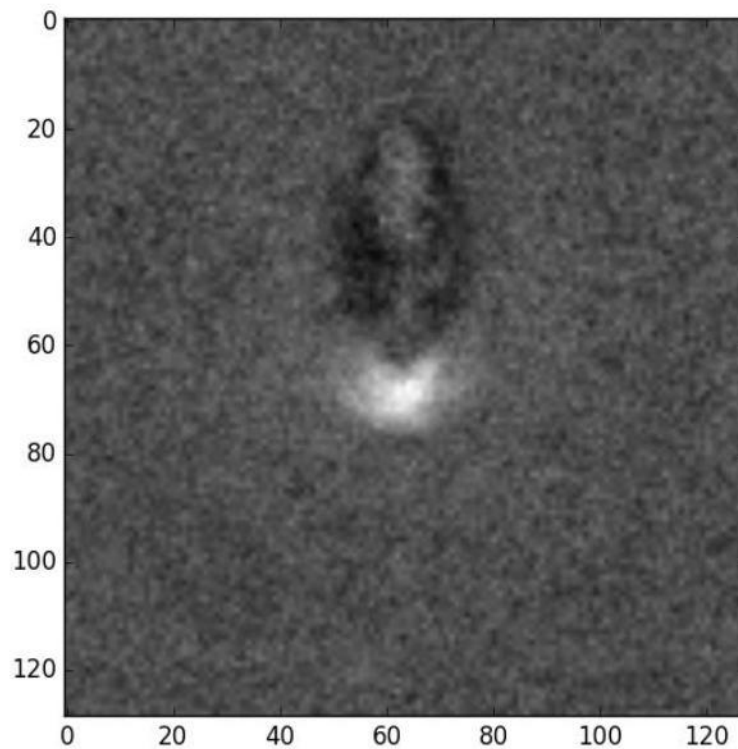


Figure5.8 BRDM_2 image on the mode value

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

Table 5.2: Accuracy in Table Format

Model Name	Accuracy(Mix dataset)
Naïve Baye's	58%
KNN	79%
SVM	68%

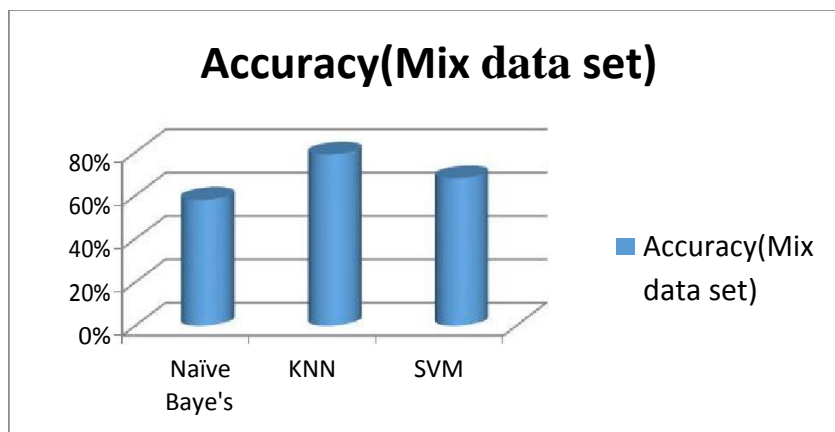


Figure 5.1: Graphical representation of Accuracy

6.1 Conclusion

In this thesis, a new framework is proposed, called PCA Compact trick (feature extraction). It is employed as a pre-processing and feature selection step to train Naïve Baye's, KNN and SVM on SAR picture dataset. When compared with experimental results derived using PCA Compact trick which is used for feature extraction. Along with feature Extraction it is concluded that the performance improvement of K- Nearest Neighbour algorithm is better than Naïve Baye's and Support Vector Machine. It can be concluded that classification of data can be improved significantly to key out the rare events from the datasets by applying Feature Extraction. Finally it is concluded that proposed framework gives better performance results than other techniques.

6.2 Future work

Future work will involve conducting additional empirical studies with different type of machine learning algorithms and different possibilities of datasets. More comparative study using other sampling approaches and rankers will also be considered in the future.

REFERENCES

- [1] M. Devore and J.O'Sullivan, "A Performance complexity study of several approaches to automatic target recognition from synthetic aperture radar images." *IEEE Transactions on Aerospace and Electronic Systems*, vol.38, No. 2, pp 632-648,2002.
- [2] M. Kaplan, "Analysis of multiplicative speckle models for template based SAR ATR." *IEEE Transactions on Aerospace Electronic Systems*, vol.37, No. 4, pp.1424-1432, 2001.
- [3] R. Patnaik and D.Casasent, "MINACE filter classification algorithms for ATR using MSTAR data. " *Proceedings of the SPIE, Automatic target recognition XV*, vol.5807, pp.100-111, 2005.
- [4] Mahalanosis, Abhijit, D.W.Carlson and B.V.Kumar, "Evaluation of Mach and DCCF correlation filters for SAR-ATR using the MSTAR public database." *Proceedings of SPIE, Algorithms for synthetic aperture radar imagery V*, vol.3370, pp.460-468, 1998
- [5] Sun,Yijun,Liu.Zhipeng, Todorovic and Li.Jian, "Synthetic aperture radar automatic target recognition using adaptive boosting." *Proceedings of SPIE, Algorithms for synthetic aperture radar imagery XII*, vol.5808, pp.282-293.
- [6] J.Sagri and C.Guilas, "Hausdorff Probabilistic feature analysis in SAR image recognition. " *Proceeding of SPIE, Applications of digital image processing XXVII*, vol.5909, pp.21-32,2005.
- [7] Kraweic, Krzysztof and B.Bhanu, "Visual Learning by co-evolutionary feature synthesis. " *IEEE Transactions on systems, man and cybernetics-part B: cybernetics*, vol.35, No.3, pp.409-425, 2005.
- [8] Yang, Yinan, Qiu.Yuxia and Lu. Chau, "Automatic target recognition classification experiments on the MSTAR SAR images. " *Proceedings of the sixth International conference on software engineering, AI, Networking and parallel computing first ACIS*

international workshop on self assembling wireless networks, Towson, MD, USA, May. 2005. pp. 2-7.

[9] Gronwall, Christina, Gustafsson, Fredrik and Fu.Qiang, “Ground target recognition using rectangle estimation. “*IEEE transactions on image processing*,vol.15, No. 11, pp.3400-3408, 2006.

[10] Dan. Dudgeon and T. Lacoss, “An Overview of automatic target recognition.” *The Lincoln laboratory journal*, vol. 6, 1993.

[11] Fan, Yingrui, Liu, Song and and Qiang.Fu, “Simulation and experimental verification of ground target recognition based on HRRP.” *5th International conference on information engineering for mechanics and materials*, 2015.

[12] J.Kurty, F.Nebus and Z.Kus, “ Feature extraction in radar target classification,” *Radioengineering* Vol.8, No. 3, 1999.

[13] Zhang. Xinzheng, Wu. Qizheng, Liu. Shujun, Qin. Jianhong and Wei.Song, “HRR profiles time- frequency non-negative sparse coding for SAR target classification,” *Progress in electromagnetics research B*,vol.60,pp.63-77, 2014.

[14] C. Qiu, H. Ren, H. Zou and S.Zhou, “Performance comparison of target classification in SAR images on PCA and 2D-PCA features,” *Synthetic aperture radar, 2nd Asian-Pacific conference*, Xian, Oct 2009. pp. 868-871.

[15] AS. Ismail, X.Gao and C. Deng, “SAR image classification based on texture feature fusion,” *IEEE china summit and international conference on signal and information processing*, Xian, July 2014. pp. 153-156.

[16] AEDS. Hafez, W.Hu and AM. Gharyb, “Ground target recognition from flying vehicles using camera/SAR imaging systems,” *International journal of machine learning and computing*, vol.1, No.5, pp.427, 2011.

[17] X.Zhang, J.Qin and G.Li, “SAR target classification using Bayesian Compressive sensing with scattering centers features,” *Progress in Electromagnetic research*, vol.136, pp.385-407, 2013.

- [18] CW.Huang and KC.Lee, "Application of ICA technique to PCA based radar target recognition," *Progress in Electromagnetics research*, vol.105, pp.157-170, 2010.
- [19] V. Riasati, U.srinivas and V.Monga, "SAR automatic target recognition via non-negative matrix approximations," *SPIE Defense, Security and Sensing, International society for optics and photonics*, 2012.
- [20] Mishra. Amit and M.Bernard, "Radar signal classification using PCA based features," *IEEE International Conference on Acoustics Speech and Signal Processing and Proceedings*, Toulouse, May 2006.
- [21] T.Feingersh, BGH,Gorte and HJC.Vanleeuwen, "Fusion of SAR and SPOT picture data for crop mapping," *IEEE Geoscience and Remote Sensing Symposium*, vol.2, pp.873-875, 2001.
- [22] Mishra. Amit and M.Bernard, "SAR-ATR using one and 2D PCA," *International radar symposium(India),Banglore*, pp.19-22, 2005.
- [23] Y.Pu, W.Jin, M.Zhu and L.Hu, "Classification of radar emitter signals using cascade feature extractions and hierarchical decision technique," *IEEE 8th International conference on signal processing*, Beijing, Nov 2006.
- [24] Y.Guo and X.Zhang, "Radar signal classification based on cascade of STFT,PCA and Naïve Baye's," 2016.
- [25] H.Zhang, N.M. Nasrabadi, Y.Zhang and T.S.Huang, "Multiview automatic target recognition using joint sparse representation," *IEEE Transaction on Aerospace and electronic systems*, vol.48, No.3, pp.2481-2497, 2012.
- [26] M.R.Azimi-Sadjadi and S.Ghaloum and R.Zoughi, "Terrain classification in SAR bimages using principal component analysis and neural networks," *IEEE Transactions on Geoscience and Remote sensing*, vol.31, No.2, pp.511-515, 1993.
- [27] M. Klenke and V.Hochschild, " Reducing the radiometric terrain effect in SAR imagery by means of principal component analysis," *IEEE Geoscience and Remote Sensing Symposium*, Hamburg, vol.2, pp.1288-1290, 1999.

[28] H. Chaabouni-Chouayakh and M.Datcu, "PCA vs ICA decomposition of high resolution SAR images: Application to urban structures recognition," *Remote sensing, International society for optics and photonics*, 2007.

[29] I.T. Jolliffe, "Principle component analysis," 2nd edition, Springer press, 2002.

[30] D.Koller and N. Friedman, "Probabilistic graphical models: principles and techniques," MIT Press, 2009.

[31] [https:// www.sdms.afrl.af.mil](https://www.sdms.afrl.af.mil).

LIST OF PUBLICATIONS

Ravinandan Kumar and Mr.Vinod Kumar Bhalla, “Ground Target Recognition Using KNN,Naïve Baye’s and SVM” International Conference on *Inventive Computation Technologies*.(ICICT- 2016) [Accepted].

VIDEO LINK

<https://www.youtube.com/channel/UCwLthIZKdUGZNJkzjZmWQ8A>