IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Issue-3, March 2019 E-ISSN: 2347-2693

Implementation of ORB and Object Classification using KNN and SVM Classifiers

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DOI: https://doi.org/10.26438/ijcse/v7i3.280285 | Available online at: www.ijcseonline.org

Accepted: 14/Mar/2019, Published: 31/Mar/2019

Abstract**—** Object identification and classification has been topic of interest for researchers in computer vision due to its numerous applications in various domains since decades. But object detection and classification faces certain issues and challenges like scaling variations, rotational variations, occlusion, noise etc. Hence, there is need to design descriptors which are robust, compact and efficient. The extraction of features and the classification process should be done with minimal compromises in the performances. This paper proposes an orientation and rotation invariant feature descriptor named as ORB (Oriented FAST and Rotated BRIEF). This feature vector computes scale, rotation and translation invariant features for the test and trainee images. For matching the computed feature sets we used supervised classification method i.e. K-Nearest Neighbors Algorithm (K-NN) and Support Vector Machine (SVM) for the classification of various object categories in the dataset. Comparative experimental results based on analysis of the SVM and KNN classifiers on the basis of recognition accuracy and execution time is given. Results show that SVM gives better matching score whereas KNN is time efficient in comparison to SVM.

Keywords**—** ORB, K-Nearest Neighbour Classifier, SVM, Object Recognition and Classification

I. INTRODUCTION

Even though a vigorous research is going on in the field of computer vision but to the current time also the recognition of objects in an image is still a difficult task. Human beings have this ability to identify the various objects in the image under various circumstances such as occlusion, different lighting, scaling, rotation etc. But to develop a computer-model for recognizing of objects in the images is still quite a challenging task. Also, the quality of classifying the various objects under various categories can be easily done by the human beings but for a machine to do this task of classification under various categories is tough.

Object classification can be done easily by the machines but for the humans we need various complex algorithms to train the machines for this purpose. A classification purpose includes various steps like image pre-processing, object detection and recognition, extracting features and then classification. There are various techniques for extraction of features.

In this paper implement the feature descriptor ORB (Oriented FAST and Rotated BRIEF) has been implemented. An experimental analysis of the feature detected has been shown. Then these feature vectors are then given to KNN classifier and SVM classifier using the PASCAL 2005 dataset, a classification of the objects has been done using MATLAB. A comparative analysis of the SVM and KNN classifier on the basis of recognition accuracy and the execution time is also given.

The objectives of this paper are

1. Implement one of the binary descriptor named ORB (oriented FAST and Rotated BRIEF).
2. Implement SVM and KNN classifiers for classification using PASCAL 2005 DATASET
3. To analyze the performance of these classifiers (SVM and KNN) on the basis of recognition accuracy and the execution time.

The paper is organized as follows: Section 2 presents the ORB algorithm used for feature descriptors. The classifiers used for feature classifications are presented in Section 3 and 4. Section 5 presents the experimental setup and results obtained after feature detection using ORB and the classification with KNN classifier and SVM classifier. Conclusion is presented in the section 6.

II. RELATED WORK

Various surveys of feature detectors and descriptors are done in literatures like Mikolajczyk and Schmid [1]. Tuytelaars and Mikolajczyk [2] gave the survey of the Local invariant feature detectors and their comparative analysis on the basis of various parameters. In the past years various feature detectors has been studied like Harris Corner detector [3], FAST [4], SIFT [5], SURF [6], PCA-SIFT [7], BRIEF [8], BRISK [9], ALOHA [10], FREAK [11]. FAST, SIFT, SURF, PCA-SIFT, DIASY, HOG etc are the gradient based feature descriptors. But the due to the advancements in the binary feature descriptors the interest and inclination of the researchers is more towards them. The binary feature descriptors are highly discriminant, compact, require less memory space and are efficient [21-23]. Thus they are highly recommended for the real time applications.

III. METHODOLOGY

ORB is a very popular algorithm, proposed by Rublee used for extraction of rotated and oriented feature descriptor [12]. The popularity of this algorithm lies in the fact that is a proficient alternative to SIFT and SURF and is the improved version of Features from Accelerated Segment Test (FAST) algorithm and Binary Robust Independent Elementary Features (BRIEF) algorithm [12]. This algorithm describes and represents the extracted features using the binary string. The interest points of ORB are calculated by the FAST method and then these feature points are described by BRIEF feature descriptor. Feature points using FAST are extracted very fast and BRIEF descriptor assign orientation to these interest points. Thus, the feature points extracted through ORB algorithm are fast and are rotational invariant and are also quite sensitive to noise.

FAST is one of the corner detection algorithms proposed by Rosten and Drummond [4] in which the corners can be computed very fast and quickly than many other algorithms like Harris & Stephens's corner detection algorithm [3], Moravec corner detection algorithm, SUSAN corner detector .Due to its computational efficiency it finds great application in real-time visual tracking problems. Once the FAST features are extracted, orientation is assigned using the Intensity Centroid Method. Then the images are smoothened and the BRIEF descriptors are calculated to describe the feature points based on comparisons. The window of size (50×50) pixels is selected for feature extraction. It chooses two points for their intensities comparison and assigned the value '1', if the first point is larger than the second point value else '0' is assigned. The process is repeated for the entire number of pairs and thus a string of Boolean values is constructed. Finally, BRIEF is used to find the binary strings which requires less memory space as compared to SIFT (having dimension of 128) feature descriptor, SURF (256) feature descriptor. However, these feature descriptors can be compressed into binary strings using methods like PCA, LDA or LSH (Locality Sensitive Hashing). But the problem of use of exhaustive memory doesn't really solve as the features are computed and stored well before the size reduction. The steps involved in the ORB algorithm are presented as flowchart in figure 1.

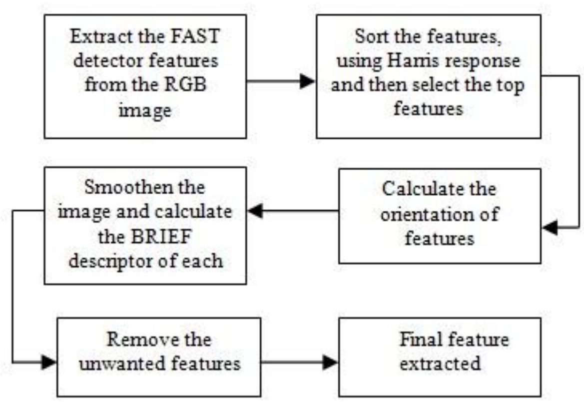

Figure 1. Flowchart of ORB Algorithm

A. KNN Classifier

In a classification problem, the extracted features are mapped to one of the class against the set of classes. Similarity once the ORB features are extracted in the form of template, the classification is carried out using KNN classification to assign the class against the set of available classes. A number of classifiers are available in the literature. However, different classifier performs differently for the types of application they are used.

There are many classifiers which have been studied in the past years. Some of the most commonly used and studied classifiers are Radial Basis Function (RBF) Classifiers [13, 14], decision tree, K-Nearest Neighbours (KNN), Support Vector Machines and Gaussian Mixture Model (GMM).

Classification process includes various steps:

a) *Pre-processing of digital image*-it includes image transformations and noise removal from the image.
b) *Detection and extraction of an object in the digital image*- it includes detection of the object of interest in the image. In this step the data is converted into the classifier acceptable format. In this paper the features are extracted using the ORB feature descriptors.
c) *Training:* It includes the selection of a particular quality which can best describe the pattern.
d) *Object Classification:* In this step the detected object is classified into predefined classes by comparing the database image with the detected pattern.

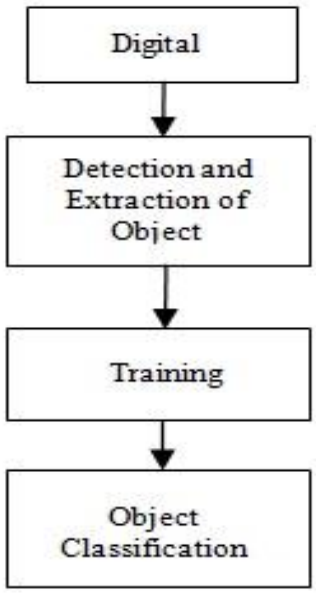

Figure 2. Steps involved in Classification Process

Classification algorithm basically involves two phases:

1. Training phase
2. Testing phase

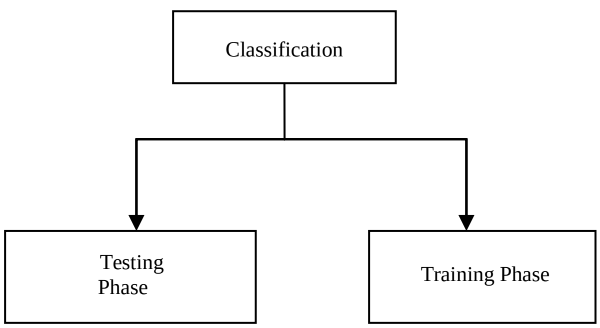

Figure 3. Classification phases

In the training phase, collection of characteristic properties of an image features is done then and using these image features training class is created. In the testing phase, these feature-space partitions are used for the classification of image features.

K-Nearest Neighbour algorithm [15] is one of the simplest machine learning algorithms used for the classification of objects done on the basis of closest training examples in the feature space. In the training process the feature vectors and labels of training images are stored and then the object is classified based on the labels of its k nearest neighbours by majority vote. K is a positive integer. Each image is converted to a vector of fixed-length and then the Euclidean distance function for KNN is used. Also, we can use other distance metrics as well.

K-Nearest Neighbour algorithm (KNN) is an example of supervised learning and has numerous applications in the area of statistical pattern recognition, data mining etc. The major benefits of this algorithm are that it works very well with multi-modal classes because in this case the basis of decision is small neighbourhood of similar objects. Thus, for multi-modal classes the Classifier provides results with very good accuracy. However, the major disadvantage of the KNN algorithm is that it makes use of all the features in computing for similarities equally. This generally leads to classification errors generally in the case of small subset of features.

B. SVM Classifier

"Support Vector Machine" (SVM) is a supervised machine learning algorithm which is used for classification. In this algorithm, each data item is plotted as a point in n-dimensional space (where n is number of features) with the value of each feature being the value of a particular coordinate. Then, we perform classification by finding the hyper-plane that differentiates the two classes very well. Not only can SVM perform well in linear classification but it can also efficiently perform a non-linear classification. Various experimental analyses prove that SVMs helps to achieve significantly good results with higher search accuracy [17-19]. Lin et.al.[20] proposed a very fast converging parallel averaging stochastic gradient descent algorithm for training. It has empirically good performance and has successful applications in many fields (bioinformatics, text, image recognition).

IV. RESULTS AND DISCUSSION

The proposed algorithm involves the pre-processing of the digital image and then the features are extracted using the ORB. The dataset is first separated into the test set images and the training set images. The training set of images will be used to train the SVM/KNN classifiers and the test set images will be used for classification at the end of the training. The feature vectors are constructed for both the test images and the training images. These feature vectors are then passed through the KNN and SVM classifiers to get the output results. In KNN Euclidean distance metric is used whereas in the SVM the polynomial kernel is used for classification. The flowchart of the classification process is given below in the figure.

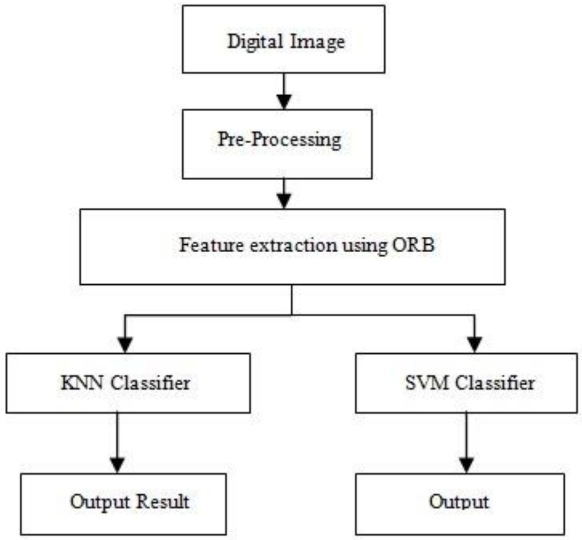

Figure 4. Flow Chart illustrating the Proposed Algorithm

To analyse the classification results PASCAL 2005 dataset [16] is used. This dataset provides standardised image datasets for object classification. The 2005 PASCAL dataset has basically four classes of objects:

1. Bicycle
2. Car
3. Motorbike
4. People

Experiments are carried out on the PASCAL 2005 dataset using MATLAB version 2013 on 8 GB RAM with i7 Intel Processor.

Given below are few sample images from the PASCAL 2005 dataset showing the various classes of objects; cars, Motorbikes, Bicycle etc.

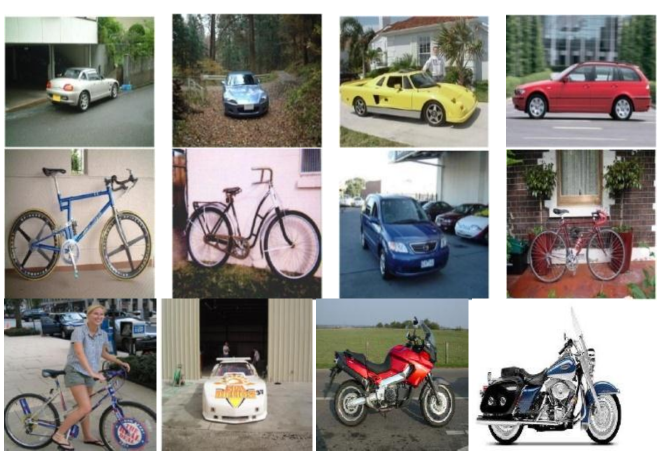

Figure 5. Sample Images from the PASCAL 2005 dataset for feature Vector Construction

The images from the dataset are divided into two sets: Training and testing dataset. The figure given below shows the features that are extracted using ORB and the feature vectors are formed.

Figure 6. Features extracted using ORB for the Bicycle category

Figure 7. Features extracted using ORB for the car category

Once the feature vectors are formed, these are then given to the classifiers. The table 1 given below shows the performance analysis of the SVM and KNN classifier in terms of recognition accuracy and the time taken for execution. The table 2 gives the PASCAL 2005 dataset. Number of training images taken are 364 and the number of testing images taken are 156.

Table 1: Results showing the comparison between the SVM and KNN classifiers on the basis of Recognition Accuracy and Execution Time.

Method	Recognition Accuracy (%)	Execution Time(Sec)
SVM	90.47	0.85
KNN	88.33	0.212

Table 2: PASCAL database Images used for training

PASCAL Database Images of Analysis	
Number of training images	364
Number of testing images	156
Total number of images	520

The figure below gives the analysis of execution time of SVM and KNN classifiers.

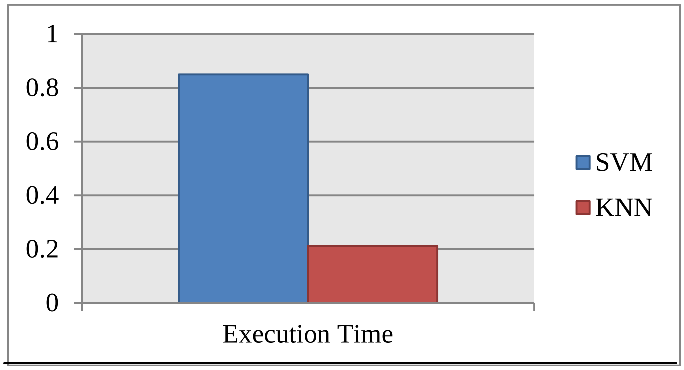

Figure 8. Execution time for the SVM and KNN classifier

The figure below gives the analysis of the recognition accuracy of the SVM and KNN classifiers.

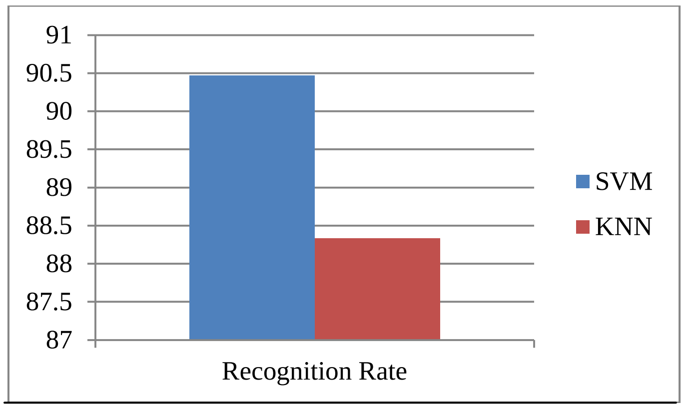

Figure 9. Recognition Accuracy for the SVM and KNN classifier

V. CONCLUSION AND FUTURE SCOPE

ORB descriptor is one of the feature descriptors which help in finding the features which are scale and rotation Invariant. Since, the corners are extracted using FAST so the algorithm is quite fast and tolerant to noise as well. ORB is a better alternative as compared to SIFT and SURF. To test the efficiency of the SVM and KNN classifiers an attempt has been made to classify the objects in the PASCAL 2005 dataset using SVM and KNN classifier on MATLAB. The experimental analysis shows that the recognition accuracy using SVM is better than KNN. SVM gives and recognition accuracy of 90.47% as compared to KNN. SVM outperforms the KNN classifier though the execution time of SVM is more than the KNN. Thus SVM is a supervised machine learning method which gives great results in pattern recognition and classification. Further work could include the use of modified ORB as feature descriptor and the use of hybrid classifiers.

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