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Amalgamated Approach of Instance and Probability Based Classification for Alzheimer Detection

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Abstract: The Alzheimer disorder discernment is one of the paramount concerns of machine learning and image processing. The Alzheimer detection has the numerous phases named as pre-processing, segmentation, feature extraction and classification. The method of Grey-Level Co-occurrence Matrix (GLCM) is implemented to pull out attributes. The amalgamated procedure of k-nearest neighbor and Naïve Bayes is used for classification. The performance is scrutinized with regard to accuracy, precision and recall. The proposed method is accomplished in MATLAB and upshot is ameliorating for Alzheimer detection.

Keywords: GLCM, KNN, Naïve Bayes, Alzheimer

1. Introduction

Alzheimer's disease (AD) is a retrogressive disease and that brain malady which is irremediable. This disease is the principal reason of dementia in sexagenarians, septuagenarians, octogenarians and nonagenarian all over the world. In recent times, approximate 90 million people throughout the world have been diagnosed with this disease. According to a survey, the number of people affected by this disease will reach 300 million by 2050. Alzheimer's disease is intensifying and escalating syndrome. This malady starts a process in brain that result into brain cells to degraded and vitiated [1]. This disease leads to continuous decay in rational, logical, behavioral and gregarious skills which in turn disturbs a person's capability to work self-reliantly. Disremembering recent events or discussions may be the early symptoms of this disease. With the growth of this disease, an Alzheimer patient will develop serious memory loss and lose the potential to perform daily chores. The existing therapies of this disease may momentarily improve signs or slow the rate of decay. Up to now, no treatment is developed that can cures Alzheimer's disease or varies the disease progression in the brain. This disease in its advanced stage can create several complications. These complications may range from the severe loss of brain function (e.g. dehydration, malnutrition or infection) even to the death.

Digital images consist of individual pixels. The discrete brightness or colour levels are assigned to these pixels. These images can be competently processed, accurately assessed and made accessible at various locations simultaneously by suitable communication networks and protocols. For example, Digital Imaging and Communications in Medicine (DICOM) protocol, correspondingly [2]. The whole range of digital image processing is now appropriate to the study of medication with the help of

digital imaging tools. MIP (Medical image processing) includes five main fields. The first field of image formation is composed of a variety of steps from image capturing to the generation of a digital image matrix. Image visualization denotes the all sorts of operation of this matrix. This step generates an improved image as output. All processing methods employed for quantitative measurements and abstract readings of medical images are included in the image analysis approach. A priori knowledge on the nature and image content are required by these methods. Therefore, the image analysis procedure is extremely precise. Also, this process hardly transfers designed algorithms into other application fields in direct manner. Image management includes all the methods providing effective storage, communication, transmission, archiving and extraction of image data. Image management also includes telemedicine techniques. Image enhancement is also known as low level processing. This process refers to manual or computerized methods [3]. This process can be interpreted without a-priori knowledge on the particular image content. In image processing, MRI image can be employed for estimating the possibility of detection of Alzheimer disease in early stage. Some prevailing Image processing approaches are embraced in MRI are intensity adjustment, K-means clustering [13,14] and Region growing algorithm. These techniques are used to extract the white matter and grey matter of input brain MRI scan. The use of MRI is quite popular for the detection of brain maladies by means of imaging. MRI generates the full image of the individual physique organs. MRI is as well as referred as magnetic resonance imaging. This approach makes use of Radio waves and strong magnetic field to visualize the inner body organs. The use of image processing for AD (Alzheimer Disease) detection includes several steps [4]. These steps are MRI image acquisition, preprocessing, segmentation, classification etc. In the first step of image acquisition, brain MRI scan is used as input image. In pre-processing stage, the processing of brain MRI is carried out using an appropriate image segmentation approach. The use of image segmentation improves the image characteristics at lowest level. There is no need to insert extra feature suing this approach. Also, this approach eliminates the redundant image features. This process involves image resizing, image translation and contrast adjustment of images. In image segmentation, the interrelated and correlated location of region of interest (ROI) is detected and the cropping and zooming of chosen area is carried out [5]. Further, this cropped image is employed to adjust the brightness of image pixels. The classification of pixels is carried out on the basis of their brightness as one and zero for the trimmed picture. The zero pixel values region in image signifies the active tissue while the black region refers to the lifeless tissues. The number of white and black pixels is counted. A person is declared as healthy if the number of black pixels is extremely low than the white pixels. The patient is classified as Alzheimer Disease (AD) or fit one on the basis of the figure of the occurrence of the black pixel. The classification of the brain MRI images is carried out using various available classification algorithms. Naive Bayes Classifier is a classification algorithm. This classifier depends on the assumption of independence between predictors, also known as Bayes' theorem. In other words, a Naive Bayes classifier makes assumption regarding the occurrence a specific feature in a class that does not relate to the occurrence of any other feature [6,15]. One more classification algorithm known as Logistic Regression (LR) refers to a statistical approach. This algorithm scrutinized the data assortment where 1 or more unrelated variables generate an outcome. The logistic regression aims to discover optimal fitting model for describing association betwixt the dichotomous feature of needed one and group of autonomous called predictor or explanatory variables. Decision tree classification algorithm assembles classification or regression models similar to a tree. This algorithm partitions a data assortment into minor subunit while an associated decision tree is gradually generated simultaneously. The decider output is a tree having conclusion nodes and leaf nodes. A decision node consists of 2 or greater than 2 branches. A leaf node refers to as classification or decision. The highest decision node in a tree is the pre-eminent prognosticator. This is also known as root node. Decision trees (DTs) are able to control both categorical and mathematical data.

2. Literature Review

Hiroki Fuse, et.al (2018) in this approach investigated the efficiency of technique for classification of healthy subjects utilizing brain shape information and patients of Alzheimer disease [7]. A P-type Fourier employed as shape information. The analysis of lateral ventricle eliminating the septum pellucid was completed in this work. The mixture of numerous descriptors was used as attributes and support vector machine was employed for the classification. The testing outcome showed that the accuracy of classification was 87.5%. This accuracy was higher than the accuracy received using volume ratio to intracranial volume that was counted as 81.5%. Morphological changes were evaluated conventionally by using this method. The testing results demonstrated that for diagnosis, the shape was more helpful than conventional volume ratio.

Cucun Very Angkoso, et.al (2018) suggested in this work the usage of Grey Matter (GM), White Matter (WM) and Cerebrospinal Fluid (CSF) imagery while determining [8] Alzheimer's identification and the volume of each image with its propositional values. There were three various anatomical plane image acquiring of MRI were employed in this study. The extraction of features was ground on the Kolmogorov-Smirnov distance and Supervised Neural Network Back propagation was utilized for classifier machine. The results were examined on every combination of MRI images and its diverse anatomical plane. At last, it was observed that the individual analysis by using WM or GM were provided better performance as collated to the usage of combination of GM, WM and CSF.

Jun Zhang, et.al (2017) proposed an extraction technique for AD diagnosis that was landmark based [9]. In this method, longitudinal structural MR images were utilized. In the application stage, these images were neither required non-linear registration nor tissue segmentation. These images were also robust among longitudinal scans. It was evaluated in the testing results that the recommended technique achieved finer and efficient performance on the ADNI database. The classification accuracy for AD vs. HC was calculated as 88.30% and for the MCI vs. HC it was calculated as 79.02%.

Samar M. Ismail, et.al (2016) presented a technique for the edge detection [10]. In this method, four fractional order filters were utilized. The addition of random Gaussian noise and inclusion of salt and pepper noise was utilized for the analysis of the noise potential of these filters. In this method, the peak signal of noise ratio had been compared numerically that was taken from the detected images. The mean square error and execution time of the detected images were considered as the evaluation techniques that had been employed for the contrast. In medical edge detection, the visual contrast based on the ability of the filters had been demonstrated. This presentation had proved helpful for the diagnosis of AD by utilizing MRI images.

Lulu Yue, et.al (2018) studied in this approach that the extraction of most valuable features of structural magnetic resonance imaging had been done by applying support vector machine [11]. In the beginning, the pre-processing of structural MRIs was performed by using a strict pipeline and for removing the uninterested portion skull stripping is performed. After that, every volume was re-sliced and the re-sliced images were directly put into the SVM. All the four stages of Alzheimer were recognized, at last. The testing demonstrated the average accuracy of NC vs. AD is found to be 89%. The recommended achieved better performance as compared to existing methods.

Amir Ebrahimi-Ghahnavieh, et.al (2019) made an attempt to detect Alzheimer disease using brain MRI [12]. This work made use of deep learning algorithms for disease detection. A recurrent neural network was used in this work after Convolutional Neural Network (CNN). These approaches

contributed significantly to interpret the association between image series for every subject and performed decision making on the basis of all input slices rather than a particular image slice. The tested outcomes revealed that it was possible to enhance the framework's accuracy by training the Recurrent Neural Network (RNN) on attributes obtained from a CNN.

3. Research Methodology

Following are the various steps for the proposed methodology:-

1. **Pre-Processing:-** MRI images are taken as an input for the Alzheimer's disease detection. The MRI images are converted into grey scale and reason behind is to solve the problem of storage, for storing single pixel of grey scale only 8-bit needed but for RGB, 24bit needed and another reason is, easier to perform morphological operation on grey scale image and this image is best suited for feature extraction.

2. Segmentation: - There are two type of threshold based segmentation mainly global and local one. First is global one in which single threshold value is sufficient to extract the object and another is local in which more than one threshold value is needed for discriminating pixels and this can be done by investigating pixels, especially the one which are in neighbor. In the segmentation process, we segment non-brain area, cranium and brain tissue like cortex and this process also known as skull disrobing. The approach for threshold based segmentation is applied for the segmentation of MRI image. The Otsu's segmentation is applied in this step which can segment pixels which are below threshold value is segmented into one segment and other in the second segment. Thresholding techniques are the primitive technique for segmentation. In this method image are differentiate on the basis of intensity level. These methods divide the image pixels with respect to their intensity measure.

$$g(x,y) = \begin{cases} 1, & if\ f(x,y) > T \\ 0, & if\ f(x,y) \leq T \end{cases}$$

Where, T is the threshold value which can apply over the whole image and on the basis of T you can discriminate the image. Whose pixels intensity over an image is considerable than threshold value, allot that pixels value 1(white) and those pixels whose intensity estimate is <= to verge evaluation, allot those pixels value 0(black) then extract those attach object whose intensity value is lesser than a particular intensity and after this process, an another image is produced which is a binary image. Minor and insignificant areas are totally removed. Global thresholding provides better result. It is used when the intensity distribution is clear-cut betwixt forefront object and background. For this Otsu's method is used and prerequisite for applying this thresholding is that the histogram of an image is bimodal so that interested object can be easily removed from uninterested object just by comparing with threshold value after apply global thresholding we get an binary image. Otsu's method primarily attempt to lessen within class Variance and simultaneously try to maximise inter-class Variance. After that trivial connected components are extracted then brain portion is find out, this is our region of interest for this firstly a matrix is made and this matrix hold the marker for connected entity mainly eight one, which is found in binary image. Eight connected means that the pixels are said to be connected if their edges is in contact and the condition which tells that two adjacent pixels are belong to same entity if both are connected through horizontal direction, vertical direction and diagonal one then after the area of all region is find out and take that region which has largest area and then using the MATLAB inbuilt function an array is created and with the help of inbuilt function only those values are one in array which is part of brain and other non- interested part value in array is 0 and the

brain region is taken by applying condition and then convert the binary image into grey scale image using function then after all this process an image is produced in grey scale which contain only brain part other, not interested part are totally removed and finally get a skull disrobed image. After that, next step to improve contrast of an image for that adaptive histogram equalization is used as a result another image is formed. Rather than it applied on whole image it is applied over small portion of image which is called as tiles and all the tiles, neighboring one are amalgamated using bilinear interpolation.

3. Feature Extraction: - The approach of textural feature extraction is exercise or employ so that essential features are taken out, these features are further use in classification. GLCM is applied in this step which can extract textural feature of the MRI image for the Alzheimer detection. It is a matrix and matrix has a size m by m and m is a grey levels, an image can have. GLCM is one of the oldest techniques used to examine the image. It tells how frequently the particular combinations of pixels intensity values are transpire in an image. It draws out many characteristics like homogeneity, contrast, correlation and energy.

$$Energy = \sum_{i,j=0}^{N-1} (P)_{i,j}^{2}$$

$$Entropy = \sum_{i,j=0}^{N-1} -In(P)_{i,j}^{\cdot}(P)_{i,j}^{\cdot}$$

$$Contrast = \sum_{i,j=0}^{N-1} (P)_{i,j}^{\cdot}\,(i-j)^{2}$$

$$Homogenetiy = \frac{\sum_{i,j=0}^{N-1}(P)_{i,j}^{2}}{1+(i-j)^{2}}$$

4. Classification: - An amalgamated approach of instance-based and probabilistic method used for classification. The Classification approach is applied in this step which can detect the Alzheimer's disease and its severity. K-Nearest Neighbour (KNN) is an instance-based technique that reserves all the available statistics and details and classify unfamiliar data point on the basis of proximity, means when new data available it categorized efficiently based on the closeness. Following steps should be considered Firstly, take value of k, means number of neighbour but do not take value of k in even number like 2,4,6, because it arises ambiguity in classification then Euclidean distance is calculated for all k neighbour and then those neighbour is taken whose distance is found to be less to that data point which should be classified after this count the data point of each category to which selected neighbour belong and whose count value found to be the largest , assign unfamiliar data point to that category. It is a powerful and vigorous algorithm with regard to space search.

$$d(p,q) = \sqrt{((q_1 - p_1)^2 + (q_2 - p_2)^2)}$$

Where d(p, q) is the Euclidean distance between two points. One point is, which needed to classify and other point, which belong to specific class. Second method is Naïve Bayes, It presume that prophetic features are not depend on each other. It is convenient to use if working on large dataset, provide better result. It basically works on Bayes' theorem. It basically find out a particular event occurring or not with respect to other event which is already happened.

$$P(y|x) = \frac{P(x|y) * P(y)}{P(x)}$$

Naïve Bayes algorithm work very well as compared to other sophisticated algorithms. Main concern of this algorithm is creation of rule set. It is the futuristic method. The amalgamated approach of KNN and Naïve Bayes method can train using the features which are extracted with the GLCM algorithm. This hybrid approach, classify disease accurately and meticulously.

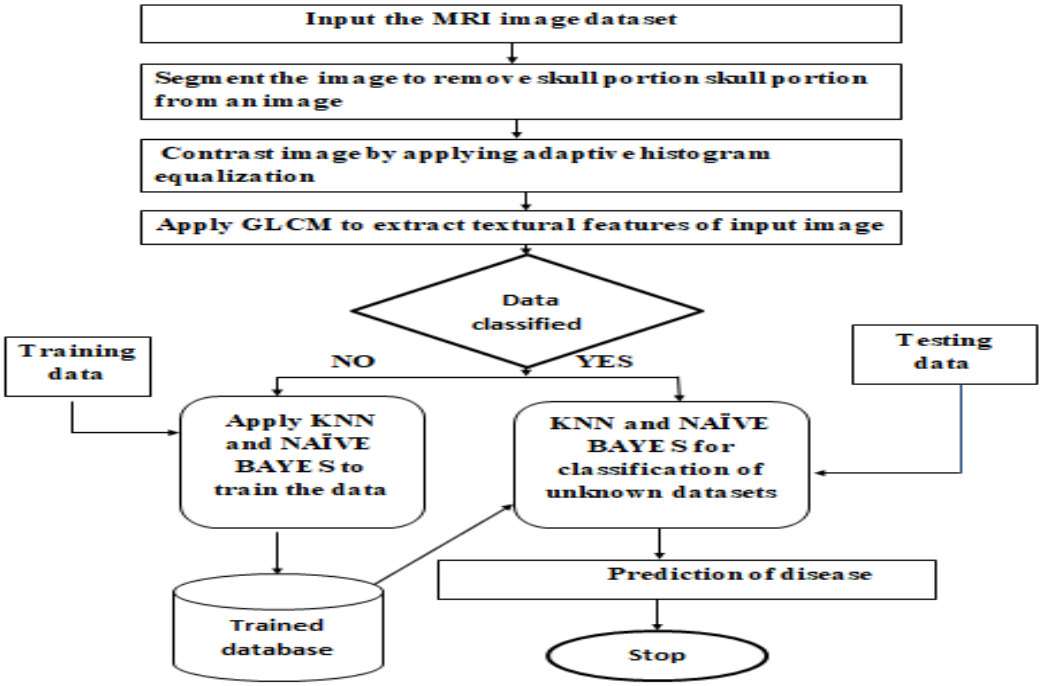


Fig. 1: Proposed Methodology

4. Result and Discussion

The key objective of this work is to discern Alzheimer malady. The proposed course of action is based on the KNN and Naïve Bayes approach for the Alzheimer disease detection. The image is taken from ADNI. It is a dataset repository .The execution of each and every step explained below.

4.1. Input Image

Images are taken from ADNI as display in fig. 2.

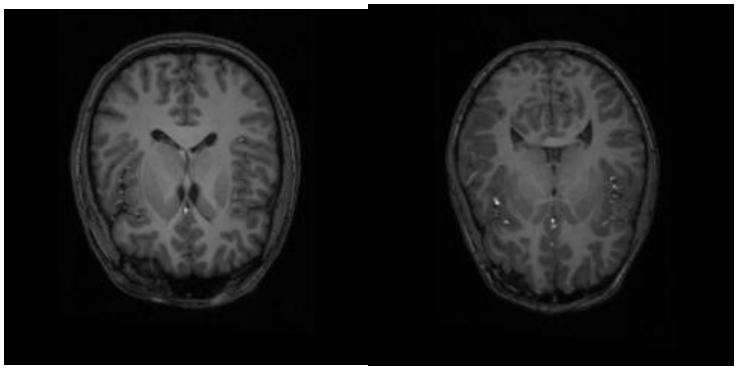


Fig. 2: Specimen

As depicted in fig. 2, these samples are taken from ADNI and all step are performed on it like segmentation to remove skull and non-tissue part and GLCM after that classification which is final and foremost step to descry the disease.

4.2. Segmentation

In this skull disrobing is carried out to find out the interested portion.

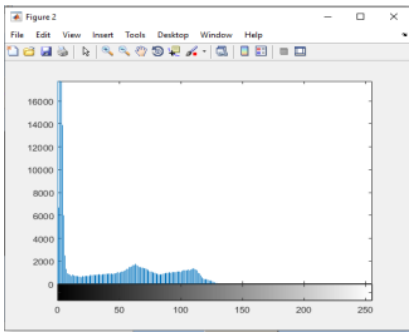
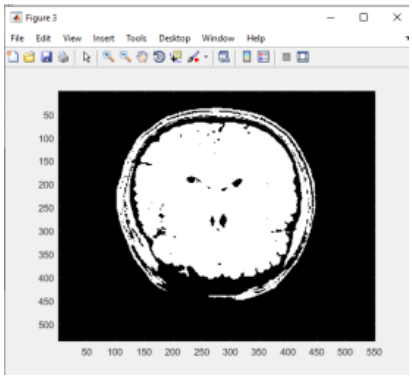
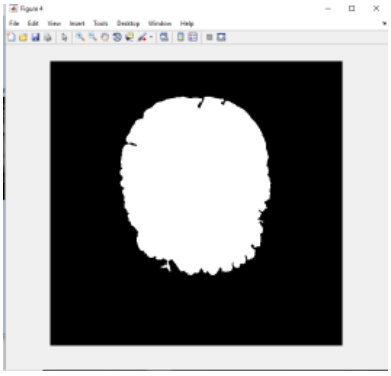


Fig. 3: Histogram

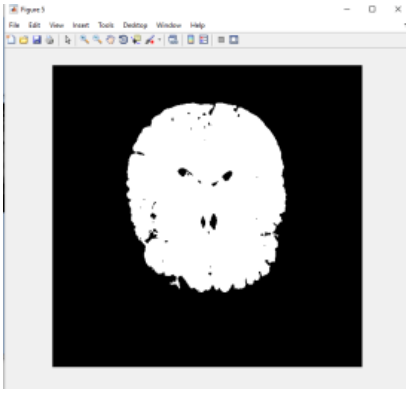
As shown in fig. 3, this is histogram of an image. In an image different intensity values pixels are available, histogram is a way through which we can find out number of pixels available for each intensity levels.



a. Clean Image



b. Outer Portion



c. Indispensable Section

Fig. 4: Segmentation

As shown in fig. 4, these 3 images a, b, c are segmented images. C is the final one and after that converts the binary image into gray image.

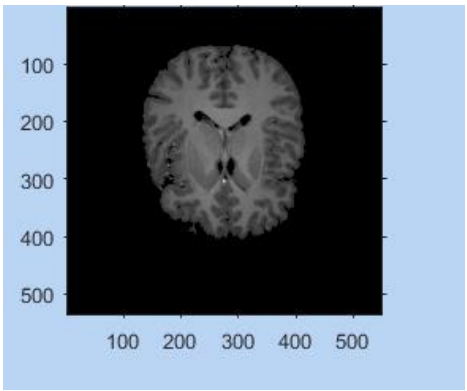


Fig. 5: Skull Disrobing

As shown in fig. 5, this is final gray scale image after segmentation.

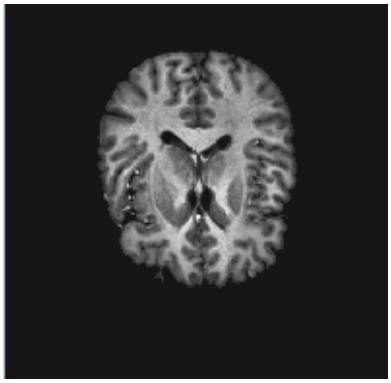


Fig. 6: Contrast Image

It is needed to expand the contrast of an image for this adaptive histogram equalization is applied. After applying it, a contrast image is obtained as shown in fig. 6

4.3. Feature Extraction

For extracting textual feature, GLCM is applied

4.4. Classification

This is most essential phase for detection; in this step final prediction is carried out. The accomplishment of proposed technique is analyzed in semblance of accuracy, precision & recall.

Table 1: Notation Used

Serial Number	Terms	Description
1	Lm1	True Positive
2	Lm2	True Negative
3	Lm3	False Positive
4	Lm4	False Negative

a. Accuracy: Accuracy is explicated as the ratio of entities which are exactly designated to the total entity.

$$Accuracy = \frac{Lm1 + Lm2}{Lm1 + Lm2 + Lm3 + Lm4}$$

b. Precision: It's a correlation that notifies how many entities are precisely categorized to the aggregate of positive meticulously categorized and positive erroneous one.

$$Precision = \frac{Lm1}{Lm1 + Lm3}$$

c. Recall: Recall is expounded as the ratio of exactly categorized to all positive entity in factual.

$$Recall = \frac{Lm1}{Lm1 + Lm4}$$

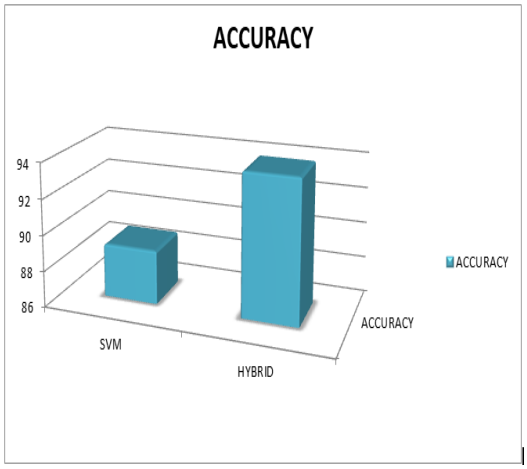


Fig. 7: Accuracy Analysis

As shown in fig. 7, the accuracy of proposed hybrid system is collated with existing SVM classification method for Alzheimer detection. In the former technique accuracy come out to be 89% and in proposed technique the accuracy is 94%. It is crystal clear that proposed one respond better as compared to former one.

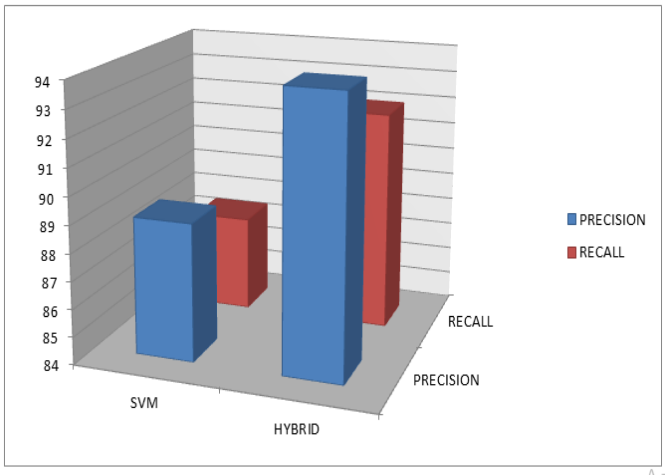


Fig. 8: Precision Scrutiny & Recall Scrutiny

As shown in fig. 8, the precision, recall of proposed hybrid technique is collated with the existing SVM classification for Alzheimer detection. The proposed strategy is come up with better recall and precision as compared to former one strategy. Precision and recall of SVM is 88%, 87% respectively and for proposed hybrid method precision and recall is 94%and 92% respectively.

Conclusion

It is deduced that Alzheimer Malady discernment is considerable matter of image processing and machine learning. The Alzheimer is the brain disorder which is difficult to detect from the MRI images. In this work, the technique of Alzheimer disorder is proposed based on the KNN and Naïve Bayes technique. The accuracy with the proposed technique is achieved up to 94 percent. In future, work will be done on sagittal plane dataset.

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