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Efficient Iris Image Recognition System Based on Machine Learning Approach

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Abstract— *Iris identification is a well- known technology used to detect striking biometric identification techniques for recognizing human beings based on physical behavior. The texture of the iris is essential and its anatomy varies from individual to individual. Humans have distinctive physical characteristics that never change. This has resulted in a considerable advancement in the field of iris identification, which inherits the random variation of the data and is often a dependable technological area. This research proposes three algorithms to examine the classifications in machine learning approaches using feature extraction for the iris image. The applied recognition system used many methods to enhance the input images for iris recognition using the Multimedia University (MMU) database. Linear Discriminant Analysis (LDA) feature extraction method is applied as an input of three algorithms of machine learning approaches that are OneR, J48, and JRip classifiers. The result indicates that the OneR classifier with LDA achieves the highest performance with 94.387 % accuracy, while J48 and JRip reached to 90.151% and 86.885% respectively.*

Index Terms*— Iris recognition, LDA, OneR, J48, JRip.*

I. INTRODUCTION

Biometrics and image classification have gained the interest of many researchers due to their vast range of important practical applications in security and classifications. They feature distinguishing physical traits that can be used for recognition systems such as item classification, facial recognition, and personal identity. To construct effective authentication systems, computer vision-based biometrics such as facial recognition, fingerprints, and iris scanning are used [1], [2]. Iris identification is one of the best methods for providing individuals with unique authentication based on their iris structure. It has been verified to be one of the most accurate and reliable biometrics authentications [3]. The most effective and trustworthy approach for verifying authenticity is iris recognition. The reason for this is because each person's iris is different, even across siblings or twins, and that the human iris is constant over time (i.e., it doesn't change with aging). As a result, this approach of recognition is thought to be safer and less susceptible to spoofing assaults [4]. Iris detection is widely used in a variety of security applications, including the bank, restricted-area access control, and other modern uses [3]. Due to the variety of uses and promise of this technology, several top businesses, notably those in the security industry, are anticipating the future of the iris [5]. Several researchers have implemented iris recognition with different feature extraction and classification using different databases for iris [2], [3]. Some proposed iris recognition by using the Chinese Academy of Sciences Institute of Automation (CASIA) database, adapting a lot of feature extraction methods such as Gray Level Co-Occurrence Matrix (GLCM), variable length black hole optimization (VLBHO), with classification methods such as

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support vector machine (SVM), k-Nearest Neighbor (k-NN) [6], [7], and [8]. Other researchers applying for Multimedia University (MMU) database adapting Gabor wavelet filters, Principle Component Analysis, and Linear Discriminant Analysis (LDA) for features extractions, with a Multilayer Feed Forward neural network (MFNN), to perform classification, as well as applying the Convolutional neural network (CNN) [9], [10], [11], and [12]. Traditional iris recognition systems have limitations in terms of the quality of iris images captured and the computational required. In this research, it is believed that the latter trend the MMU database has wide applications with vast distributions, and adopted in proposing three algorithms to examine the classifications in machine learning is the novelty of this research that achieve high accuracy. Therefore, this research aims to propose three algorithms that implemented iris image recognition with different feature extraction to examine the classifications in machine learning approaches. The proposed algorithms are OneR, J48, and JRip, depending on LDA feature extraction for the iris recognition system. As well as, comparing these algorithms by applying Performance Measures that are designed for evaluating systems such as the Precision, Recall, and F-measure to achieve the highest accuracy algorithm.

II. LITERATURE SURVEY

Here is a survey of some researchers have implemented iris recognition systems with different feature extraction and classification methods using CASIA and MMU databases.

Baqar et al. [6] proposed Multilayer Feed Forward Neural Network (MFNN)-based iris recognition based on dual boundary (Pupil-Iris & Sclera-Iris) detection and classification. Dual iris borders' localization characteristics are employed as a feature vector for classification. The system has been tested on images taken from MMU iris database with additive noise for various signal-to-noise ratio values (SNR). The strategy outperforms the single border method in experiments for percentage recognition. The system employs a version of the back-propagation algorithm which uses a time varying learning rate compared to the conventional fixed learning rate back-propagation algorithm.

Uhl and Wild [7] proposed iris texture was located and mapped into Daugman's doubly dimensionless polar coordinates using a two-stage technique which was applied with the CASIA database. To establish the approximate location of the iris center, an adaptive Hough transform was used with different resolutions and an ellipsopolar transform to detect the boundaries of the iris, which make it more complexity for implementation and optimize for some application.

Swati and Deepak [8] proposed an Iris Code classifier, built from phase features used three different methods for feature extraction namely principal component analysis, independent component analysis and two-Dimensional (2D) gabor wavelet. A weighted contribution of weak classifiers using the separation between the phase vectors of the individual iris images makes up the final iris classifier.

Acar [9] proposed a system for identifying an individual from their iris photos using local texture features. The CASIA database was used to create the digital iris images. Using the Gray Level Co-occurrence Matrix (GLCM), the texture characteristics were recovered from the four local iris areas of the segmented picture. Then, the k-Nearest Neighbor (k-NN) classifier was used to categorize the collected feature but the vectors factors may affect its performance in real-world applications. The average performance among the system architectures was observed as 85 % in k=1 neighbor structure of k-NN classifier.

Danlami et al. [10] Proposed four steps in iris recognition system which includes: iris image acquisition, preprocessing, feature extraction and matching. Used the Gabor filter, and the Legendre wavelet filters. Applied them on the two different databases: CASIA and MMU. The result

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demonstrates a significant improvement in the Legendre wavelet filter's recognition accuracy when compared to the Gabor filter.

Saraf et al. [11] proposed iris recognition system that covers the steps of feature selection and iris feature extraction and coding. By modifying variable length black hole optimization, it makes it possible to choose a variable length of features for iris recognition (VLBHO). Based on the CASIA iris database, the method has been assessed. They employed the support vector machine (SVM) and the logical model for categorization.

Karthika and Ramkumarb [12] proposed two separate machine learning algorithms in an uncontrolled environment image dataset, presented the radical segmentation of human iris. Support vector machine (SVM) and convolutional neural network (CNN) models were used to segment the iris in an image taken in an uncontrolled setting. The MMU iris database was used to develop the method. Mean accuracy of iris segmentation of sample images using CNN is 93.9% and by using SVM is reached to 71.6%.

Szymkowski et al., [13] proposed a discrete fast Fourier transform (DFFT) system for iris-based human identification recognition using principal component analysis technique. K-nearest neighbors, support vector machines (SVM), and artificial neural networks were the three techniques employed for categorization. UPOL, MMU, and CASIA-IrisV4 databases were utilized to assess algorithm accuracy. During the experiments, they tested different splits as 50:50 (50% testing set and 50% training set, respectively) as well as 25:75, 75:25 and even 90:10. The most precise results were obtained with SVM algorithm.

III. METHODOLOGY

The Multimedia University (MMU) iris database is adapted in this research. The iris patterns for the process-based biometric identification models are collected for the MMU iris database from a publicly accessible source and contains high-resolution images of iris patterns [14]. This collection consists of 460 photos for 46 individuals, 5 images for the left and right eyes, respectively [3]. The iris images are color, each measuring 320 x 240 pixels, and have three channels or dimensions for depth [15]. Samples of the MMU iris database are presented in *Fig. 1*.

FIG. 1. SAMPLE IMAGES OF MMU DATABASE.

Every image in the dataset has been through a preprocessing techniques, which takes 70% for the training and 30% for the testing model. The LDA feature extraction is used. Classification model based on machine learning classification are utilized. *Fig. 2* shows the system methodology process.

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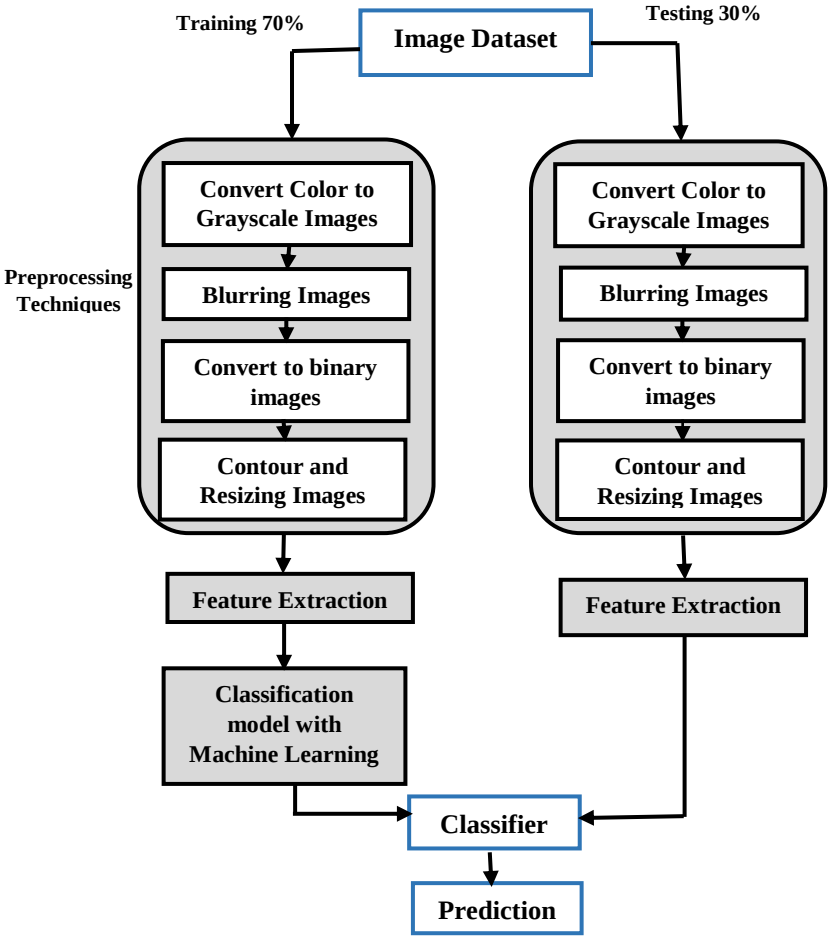

FIG. 2. THE SYSTEM METHODOLOGY PROCESS.

A. Preprocessing Techniques

A preprocessing techniques is recommended to be implemented in the first phase. It used many methods to enhance the input images through applied converting color images to grayscale images, blur images, converting to binary images, contour images and resizing.

1. Convert Color to Grayscale Images

The image domain is a mathematical model with different color components representing color details, and the determination of the color model is important before the analysis process of color image begins. The color models provide color data for each pixel in a particular image [15], [16]. A grayscale image's brightness has been represented using an 8-bit value, but a color image's pixel color is represented using a 24-bit value. [16], [17]. To convert the image into a grayscale, this is brought on by the fact that the three colors: Red (R), Green (G), and Blue (B) should be averaged. Since each of the three kinds has a unique wavelength and contributes differently to the creation of an image, the average must be calculated according to each color's contribution rather than just utilizing the average approach. This has been given by luminosity method. It indicates that the contribution of the color red must be reduced, the contribution of the color green must be increased, and the contribution of the color blue must be placed between these two. Equation (1) shows the converting from color to grey image [15]. *Fig. 3* illustrates samples of the grayscale of the images.

$$\text{New grayscale image} = (0.3 * \text{R}) + (0.59 * \text{G}) + (0.11 * \text{B}) \quad (1)$$

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FIG. 3. SAMPLES OF THE GRAYSCALE IMAGES.

2. Blurring Images

In blurring, an image looks sharper or more detailed to perceive all the objects and their shapes correctly in it. Blurring is the process to reduce the edge content and makes the transition from one color to the other very smooth. For instance, a facial image appears clear when the eyes, ears, nose, lips, and forehead can all be clearly seen [18]. There are several methods for achieving blurring. Median blur is the most typical filter type utilized in this study, which operation is similar to the other averaging strategies. The median of all the pixels in the kernel area serves as the image's new center component. This operation processes the edges while removing the noise. The Median Blur filter broadens color regions in the image [19].

3. Convert to binary images

Binary images can only have two valid pixel values: one (1), which is white, and zero (0), which is black. Binary images are also referred to as 1-Bit images since only the two values necessary to define the image require one bit. [20]. The simplest and most popular way to transform a grayscale image to a binary image, employs thresholding. It chooses a threshold value, and all gray levels that fall below that value are classed as zero, while all gray levels that are equal to or higher than the threshold value are categorized as ones. [21]. See equation (2)

$$g(x,y) = \begin{cases} 1 \text{ if } f(x,y) \geq T \\ 0 \text{ otherwise} \end{cases} \quad (2)$$

Where g (x, y) represents threshold image pixel at (x, y) and f (x, y) represents grayscale image pixel at (x, y).

4. Contour and Resizing Images

Image contouring is a technique for Finding an object's structural outlines in an image and using that information to establish its form. In computational vision, it is common to describe brightness edges as step edges and identify them by placing markers at specific scales that correspond to the maxima of the outputs of odd-symmetric filters [22It should be highlighted, nevertheless, that step edges are a poor model for the visual discontinuities brought on by the projection of depth or orientation discontinuities in the actual scene. To simplify the original image size, the input image is reduced in size to 200x200. This input data format was created by utilizing bicubic interpolation to resize the images [23]. This method is selected because the borders of the result are finer. In bicubic interpolation, a pixel's sixteen nearest neighbors were taken into account. The intensity value assigned to point (x,y) is obtained using the equation (3) [24].

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$$v(x,y) = \sum_{i=0}^{3}\sum_{j=0}^{3} a_{ij}x^i y^j \quad (3)$$

Where $v(x,y)$ represents the estimated value of the function at the point (*x*,*y*), and the coefficients a_{ij} represents the values of the function at the 16 data points in the 4x4 grid.

B. Feature Extraction stage

Which uses a set of rules to identify the valuable feature subset from the original data in order to speed up machine learning and simplify the training environment. The input data is transformed into a set of features during feature extraction, and the resultant reduced representation retains the majority of the pertinent data from the original data. [25].

1. Linear Discriminant Analysis (LDA)

Seeks out the subspace that best distinguishes between several classes [26]. The goal of discriminant analysis is to classify different types of objects, such as people, clients, goods, etc. into one of two or more sets based on a variety of characteristics, such as gender, income, age, preference score, weight, etc. In the underlying space, LDA looks for vectors that can distinguish between the classes with the greatest accuracy [27]. Additionally, the LDA group's photographs that belong to the same class and distinguish between them. Here are the following steps of LDA [28].

- Take samples for class-1 and class-2
- Calculate the class 1 and class 2 means as Mu1 and Mu2.
- Class-1 and class-2 covariance matrices, denoted as C1 and C2, respectively
- Use equation (4) to compute the within-class scatter matrix

$$S_w = \mathrm{C1} + \mathrm{C2} \quad (4)$$

- Equation (5) is used to compute the among-class scatter matrix depending on the classes means which calculated in step 2.

$$S_B = (\mathrm{Mu1} - \mathrm{Mu2}) * (\mathrm{Mu1} - \mathrm{Mu2}) \quad (5)$$

- Compute all the classes means.
- The basic eigenvalue issue is then resolved by the LDA scheme, see equation (6) and (7)

$$S_w^{-1} S_B W = \lambda \mathrm{W} \quad (6)$$

$$W = \mathrm{eig}\left(S_w^{-1} S_B\right) \quad (7)$$

where W is projection vector.

C. Classification model with Machine Learning (ML)

Classification model with ML is the process of creating a class model from a set of records with class labels. A group of algorithms known as "machine learning" use a set of data to learn a model. Machine learning research places a lot of emphasis on developing software that can automatically recognize complicated patterns and draw conclusions from data [28], [29]. OneR, J48, and JRip are used for classification in this study.

1. One Rule (OneR) algorithm

The OneR algorithm is stands for "One Rule," is an easy-to-understand, a precise classification technique that first formulates a rule for each predictor in the data before selecting the rule with the minimum overall error as its "one rule" and only allows level one decision trees [30]. The One Rule

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algorithm has a single parameter, which is the threshold for the minimum frequency of an attribute value. If an attribute value occurs less frequently than the threshold, it is grouped with the most frequent value for that attribute. This helps to reduce the impact of rare values on the decision rule [31]. Algorithm 1 shows the steps of OneR algorithm.

Algorithm 1: OneR Algorithm
Input: Features extracted by LDA **Output:** Build a classifier **Processing steps:** **Step 1:** For each predictor, **Step 2:** the following rule should be created for each value of that predictor; **1.** Calculate each value of target class appearing **2.** Determine the most frequent class **3.** Make the rule gives that class its prediction value. **4.** Compute the overall error for every rule of each predictor. **Step 3:** Choose the predictor with the least overall error.

2. J48 decision tree algorithm

The J48 decision tree algorithm is used to determine how the characteristics vector acts in various situations. The classes for the newly produced instances are also being found based on the training instances [25]. This algorithm was picked since it is well-liked and utilized in ML. In cases of potential over-fitting, pruning can be used as a tool for précising. Some methods classify the data in a recursive manner until every leaf is pure, ensuring the classification is as accurate as feasible [22]. This algorithm generates the rules from which the particular identity of that data is generated. The goal is to gradually generalize a decision tree until it achieves balance between flexibility and accuracy [30]. J48 has several default parameters that can be adjusted to optimize its performance which are: confidence factor that controls the degree of pruning, minimum number of instances, binary splits specify whether the algorithm should use binary splits or multiway splits, and subtree raising specify whether the algorithm should raise the subtree of a pruned node to replace the pruned node [23], [30]. Algorithm 2 shows the steps of J48 algorithm.

Algorithm 2: J48 Algorithm
Input: Features extracted by LDA **Output:** Build a classifier **Processing steps:** **Step 1:** The leaf is identified by a comparable class. if the objects belong to the same class. **Step 2**: For each attribute, the potential data will be generated and the gain in the data will be derived from the test on the attribute. **Step 3:** Using the current selection parameter, the best characteristic will be selected..

3. JRip algorithm

JRip algorithm was implemented a propositional rule learner, Repeated Incremental Pruning to Produce Error Reduction (RIPPER), by altering or updating certain rules. Reduce error pruning was used to select when to stop adding new conditions to a rule after isolating some data for training [31]. By employing the minimum description length heuristic as a stopping condition. The induction rule's post-processing phases revise the rules for the estimates produced by the global pruning technique, which increases accuracy. Algorithm 3 shows the steps of JRip algorithm.

Algorithm 3: JRip algorithm
Input: Features extracted by LDA **Output:** Build a classifier **Processing steps:** **Step 1:**

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For each class, initialize a set of rules called RS = {},
Step 2:
Building phase: repeated step 3 and step 4 until reaching a stopping criterion, at which point the entire set of rules are optimized.
Step 3:
Grow a rule: Grow one rule by greedily adding antecedents (or conditions) to the rule until the rule is perfect. Every conceivable value for each attribute is tested, and the condition with the greatest information gain is chosen by the method.
Step 4:
Prune a rule: Incrementally prune each rule and allow the pruning of any final sequences of the antecedents.
Step 5:
Optimization: Optimize the rule set

D. Performance Measures

The system employs a number of metrics that are intended to measure system performance.

1. **Precision:** is the total of the true positives that are separated by total number of true positive cases and the total number of the false positives [16], [33].

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}} \tag{8}$$

Where: -
TP: True Positives
FP: False Positives

2. **Recall:** The capability of Finding all examples that are relevant within a data collection; precision is the proportion of data points that this model says are relevant that are actually relevant [17] [32]

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}} \tag{9}$$

Where: -
TP: True Positives
FN: False Negatives

3. **F-measure:** The harmonic medium value of recall and accuracy, where F1 is best at one and worst at zero. [32], [33]

$$\text{F}_1 = \frac{1}{\frac{1}{\text{recall}} + \frac{1}{\text{precision}}} = 2 * \frac{\text{precision} * \text{recall}}{\text{precision} + \text{recall}} \tag{10}$$

IV. RESULTS AND DISCUSSION

OneR, J48, and JRip classification algorithms that applied to the data. These methods are proposed depending on MMU database that is believed to be good for efficient iris recognition system. OneR algorithm used to create a rule for a predictor, it would produce a frequency table for each predictor against the objective. J48 algorithm creates the rules for the target variable's prediction. The data's crucial distribution can be understood with the use of the tree classification technique. While JRip algorithm employing the minimum description length heuristic as a stopping condition. The classification accuracy results will be compared of the three algorithms in order to choose the best between them. It has been shown that OneR generates rules that are intuitive to people and just slightly accurate than state-of-the-art classification algorithms. Table I shows the experimental results of each algorithm depending on the performance measures.

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TABLE I. THE EXPERIMENTAL RESULTS OF ONER, J48, AND JRIP CLASSIFICATIONS

classification algorithms	Precision	Recall	F-measure
OneR	94.387 %	94.895 %	94.527 %
J48	90.151 %	89.559 %	89.465 %
JRip	86.885 %	79.118 %	80.768 %

The results show the accuracy of these classifications depending on the performance meseares is typically evaluated in order to assess the effectiveness of these algorithms. It is evident from the table 1 that the implemented OneR with LDA feature extraction has the highest classification accuracy where the precision is (94.387%), the (recall is 94.895%), and the F-measure is (94.527%). The Second highest classification accuracy for J48 with LDA feature extraction algorithm where the precision is (90.151%), the (recall is 89.559%), and the F-measure is (89.465%). Moreover, the JRip algorithm showed the lowest classification accuracy of other algorithms that the precision is (86.885%), recall is (79.118%), and the F-measure is (80.768%). So the OneR algorithm outperforms the other state-of-the-art classification methods in terms of classification accuracy. Several researchers have implemented iris recognition sytem with different feature extraction and classification methods with different databases. Many researchers used CASIA database with good accuracy and some of them that used the MMU databases. Table II shows the comparison between results obtained by this proposed system and some previous related works used MMU database. Though in comparison with other researchers that used the same dataset of this proposed system using MMU. In Baqar et al. [6] used a Multilayer Feed Forward neural network (MFNN) to perform a classification obtained good accuracy which reached to (93%). While Danlami et al [10] used the Gabor wavelet filter (GWF), and the Legendre wavelet filter (LWF) obtained good accuracy (93.00%, and 93.80%) respectively. Karthika and Ramkumarb [12] used CNN model and Support Vector Machine (SVM) model and reached accuracy to (93.9% and 71.6%) respectively. In this proposed system the higher accuracy is (94.38749%) by using LDA feature extraction and OneR classifier so it considered the higher accuracy for the proposed system that overtakes the other comparisons works in case of using the MMU databases.

TABLE II. COMPARISON BETWEEN PROPOSED SYSTEM AND SOME PREVIOUS WORKS

Methods of previous works	Feature Extraction	Classifier	Accuracy
Baqar et al. [6]	-	MFNN	93.00%
Danlami et al [10]	GWF	-	93.00%
	LWF		93.80%
Karthika and Ramkumarb [12]	-	CNN model	93.90%
		SVM	71.60
Proposed work	**LDA**	**OneR**	**94.387 %**

V. CONCLUSIONS

Three algorithms proposed to examine the classifications in machine learning approaches with feature extraction for the iris image recognition system are proposed, which include the selection of appropriate features, the design of an efficient classification model, and the optimization of the recognition system to achieve high accuracy. Implementing the Multimedia University (MMU) database which consists of iris patterns and is intended to be utilized with process-based biometric identification models. The LDA feature extraction is used for dimension reduction. Classification Models based on Machine Learning classification are utilized. The Decision Tree Algorithm is used to determine how the characteristics vector acts in various situations. Understanding the data's crucial distribution is accomplished with the use of the tree classification technique and generates rules that are

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easy to understand. Reduce Error Pruning was used to select when to stop adding new conditions to a rule after isolating data for training. OneR J48, and JRip classification algorithms are applied to the data. The classification accuracy results will be compared with the three algorithms. The implemented OneR with LDA feature extraction has the highest classification accuracy (94.387% precision, 94.895% recall, and 94.527% F-measure). The Second highest classification accuracy for J48 with LDA feature extraction algorithm (90.151% precision, 89.559% recall, and 89.465% F-measure). The lowest classification accuracy is the JRip algorithm (86.885% precision, 79.118% recall, and 80.768% F-measure). The results of the experiments indicate that the OneR classifier with LDA achieves the best performance with 94.387% accuracy, which overtakes the other classifiers J48, and JRip. Comparing the results with other researchers that used the same databases depending on performance measures indicated that the proposed system is a higher accuracy with 94.387% by using LDA feature extraction and OneR classifier. It is recommended to apply the OneR classifier with LDA for many other databases to get the best benefit and application of the algorithm. Machine learning classifiers have been used in various industries and real life applications to improve the recognition performance to predict customer behavior including finance, healthcare that classify medical conditions, and analyze large datasets to gain insights and make better business decisions.

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