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Early Gender Identification of Date Palm Using Machine Learning

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Abstract: Date palm is a tree grown for its sweet edible fruit by the palm family. Palm's long-life cycle and heterozygous nature, date palm breeding is challenging. So, sex identification at seedlings is essential to overcome the cost and tidy effort of the growers. Our study proposes an efficient technique for the sex identification of Date palms at the seedling stage. We aim to use supervised Machine Learning Techniques (KNN, SVM, Naive Byes, and AdaBoost) for the sex identification of date palms. We use the feature extraction technique before classification to represent the exciting part of the image. Results indicated that the SVM algorithm is the most accurate for sex identification, with 97% accuracy. When given information about the shape of a Date palm's leaves, machine learning models can be used to figure out what the palm is. This study gives us a fast and accurate way to test for DNA markers, and it has the potential to significantly improve the selection efficiencies of date growers. Because male and female date palm genotypes can be identified before maturation, breeders' costs and time commitment are reduced. Deep learning and other methods should be evaluated for their utility in answering additional date palm sex questions. A more comprehensive database of Date palm genotype biodiversity could be created and used to support the findings presented.

Keywords: Date Palm; Machine Learning; Sex Identification; Feature Extraction.

1. Introduction

One of the oldest fruits in the Arab world is the date. Dates are said to be healthy food. Phoenix dactylifera L., the date palm, is essential to Middle Eastern and North African agriculture. These are the top countries, according to the Food and Agriculture Organization, in terms of producing data globally [1]. A dioecious monocotyledonous fruit crop, such as the date palm, has separate male and female plants and seeds with only one cotyledon. Phoenix is intriguing in comparison to other genera in the family since men and females have various reproductive strategies [2]. The palm tree has fronds, leaves, and a single trunk. A

date palm tree's crown is covered in long, pinnate leaves. These leaves typically have a length of 4 m, but this might vary depending on the weather and how old the tree is. The height of a date palm tree can reach 15 to 25 metres [3]. At around seven years old, palms start to produce fruit, which is a sort of berry known as a "drupe." One firm seed is present. A fully developed palm can provide a total yield of 60–100 kg from 5–10 fruit bunches, each with hundreds of strands and thousands of dates. Some plants can generate up to 180 kg per tree on average. The fruit is 25-75 mm (1-3 inches) long, has a huge seed, and has tasty flesh depending on the cultivar [4].

Since only female date palm trees bear fruit, the date palm tree is the same type of tree as both male and female plants, making planting more cost-effective and increasing production. Only female trees are capable of producing dates, hence it is extremely difficult for breeders to distinguish between the sexes at the early seedling stage so that female trees may be planted. Additionally, it's crucial to choose exceptional males. Because it is highly challenging for breeders to identify sex until it reaches the age of five, or its reproductive age, sex determination at the early seedling stage is crucial. Because of the slow growth of this species, early sex determination is necessary to speed up breeding initiatives [5]. Our main problem is to early gender identification of date palms is critical to determine. The date palm has XX/XY gender determination system where the male is heterogametic. The heterozygous genotype is common to all males, whereas all the females have a common homozygous genotype so early gender identification of date palm is critical to determine [6]. The primary goal of our research is to develop an efficient technique for the sex identification of Date palm seedlings using fully automatic machine learning methods. These techniques used RGB images as input and were trained using image analysis in a supervised manner to classify the gender of a Date palm seedling. We used Seedling morphological characteristics such as palmtop shape, trunk diameter, leaf (length and leaf bent), pinnae, and spines to identify gender early on. Using these morphological features, we trained the classifier and evaluated the results. The objectives of this paper are as follows.

1. To acquire Date palm seedlings images.
2. To recognize the gender of Date palms based on Morphological features.
3. To develop a system that automatically identifies gender at the seedling level

This work is organized as follows: Section 2 contains the literature review. Section 3 presents the methodology of the study. Section 4 discusses the results. In last, the conclusion and future work is described in the section.

2. Literature Review

One of the oldest plants that humans have planted is the date palm, and its expansion is crucial for the development of dry places. A dioecious monocot, or tree with both male and female trees, is the date palm. Trees cannot be differentiated until five to eight years after planting. Without taking any physical measures, the six most popular days in Oman were automatically classified using machine learning (ML) techniques. Colour, shape, size, texture, and other crucial classifier criteria were employed to study the effectiveness of the classifier. Automatic classification and qualitative comparison were performed using three different machine learning (ML) techniques: [7] K-Nearest Neighbor, Support Vector Machine, and Artificial Neural Network (KNN). The best level of accuracy is achieved by combining features related to colour, shape, and size. With 99.2% classification accuracy, the ANN classifier exceeds both SVM and KNN [8]. Numerous research has explored using molecular markers to distinguish between male and female date palm cultivars, although the level of bias varies widely. Additionally, Molecular procedures are more expensive, require more meticulous handling, and are more sensitive. However, in this investigation,

employing NIRS and FTIR/ATR (then followed by NMR validation), the PCA model was employed to distinguish between male and female samples. These methods could be utilised by breeders who create explant stocks of various cultivars and tissue culture experts [9]. A database of nuclear magnetic resonance images of adult Araucaria Angustifolia plants has been made to figure out the gender of seedlings [10].

In this work, a novel SCAR marker that can identify a date palm's gender was developed. This SCAR sign has been proven to be a highly accurate method for determining whether a date palm is male or female. The original application of this diagnostic technique was to determine if a date palm plant was male or female[11] [11]. In this work, a novel SCAR marker was developed to identify a date palm's gender [12]. This SCAR sign has been proven to be an accurate indicator of whether a date palm is male or female. The original purpose of this method of diagnosis was to determine if a date palm plant was male or female. To extract DNA from the genomes of 45 date palms (25 female and 20 male) [13]. 100 RAPD and 104 ISSR primers were employed in PCR to increase the size of the essa [14]. To begin, we collected two samples of bulk genomic DNA (each created by pooling DNA from ten male and female plants separately). Then, using a primer that created a band for each sex, the genomic DNA in the bulk samples was multiplied. In samples with only male genotypes, only one RAPD primer, OPA-02, achieved 1.0 kb fragment growth; however, this did not occur in samples with superior female genotypes [15]. Following the cloning of this male-specific fragment, a SCAR primer pair was created to produce a 354-bp fragment only in male genotypes and a 406-bp fragment in both female and male genotypes. To recheck the SCAR marker, 25 female and ten male date palms from various locations were used [16].

Finding a way to distinguish between various varieties of date palm trees by looking at leaflet cross-sections was done using optical techniques and artificial neural networks (ANN). Fluorescence microscopy was used to capture cross-sectional pictures of the leaflets of five cultivars of date palm trees [17]. After extracting features from pictures, the data was loaded into an ANN with a multilayer perceptron and a back propagation learning technique. With an average prediction of 89.1% in tenfold cross-validation and 100% in one of the finest ANNs, the date palm tree cultivars were properly predicted and separated overall [18]. To better understand this database, they experimented with various strategies and classifiers. They were using the original database, in the first set of tests, three classifiers were taught to tell the difference between males and females. In the second round of experiments, the genetic algorithm technique used single-objective and two-objective functions to choose subsets of attributes [19]. After looking at the results, they came up with a new way to use statistical measures to select subsets of points. Several experiments revealed that the proposed choice strategy outperformed the competition, with an accuracy of 80.3 % (AUC = 79.4) [20]. Convolutional Neural Networks were used to sort pictures of date fruits into nine different types. This led to the creation of several models that were 97 % accurate. It is a unique set of 1658 high-quality images taken in a controlled environment [21]. Computer vision and agricultural technology can use these images. Researchers looked at and trained various models with and without adding more data, which led to high classification accuracy [22]. Table 1 explains a detailed summary of recent papers.

Table 1. Explain in detail the Summary of modern literature

References	Objective	Techniques	Accuracy
[23]	sex differentiation in various date palm	PCR-based assays	71%

	cultivars using gender-specific polymorphisms		
[24]	determine the sex of immature date palms	microsatellite markers	68%
[25]	date palm sex identification	SCAR marker	78%
[26]	sex identification of date palm seedlings	SSR markers	79%
[27]	gender of date palm seedlings	RAPD, SCAR, and SSR	80%
[28]	identifying sex in Date palm Seedlings	DNA-based markers (SCAR) markers	81%
[29]	sex identification of date palm seedlings	SCAR marker	79%
[30]	differentiate gender (male/female) at the seedling stage in the Thai date palm cultivar KL1	DNA-based markers	70%

[30]	identify male date palms	SRY-date gene sequences	81%
[31]	distinguish between male and female date palm cultivars	PCA model based on NIRS and FTIR/ATR	90%

3. Materials and Methods

This section contains the methodology of the study.

3.1. Proposed Methodology

In (Figure 1) explain the proposed methodology. The first step we putting data into a category is understanding the problem and thinking of possible labels and features. Features are the things about the title that affect how it works. These traits are called features, they help the model figure out the date palm by its leaf photos and identified its gender. The classification has two parts: learning and judging. The classifier uses a given dataset of date palm of leaf photos during the learning phase to train its model. During the evaluation phase, the model's performance is tested. Image acquisition, image labelling, machine learning model selection, training, validation, and model deployment are the six steps in our method. Image acquisition entails gathering relevant date palm leaf images, whereas labelling entails categorizing each image according to its gender. After some practice, the user can enter a date pam leaf image and determine the gender.

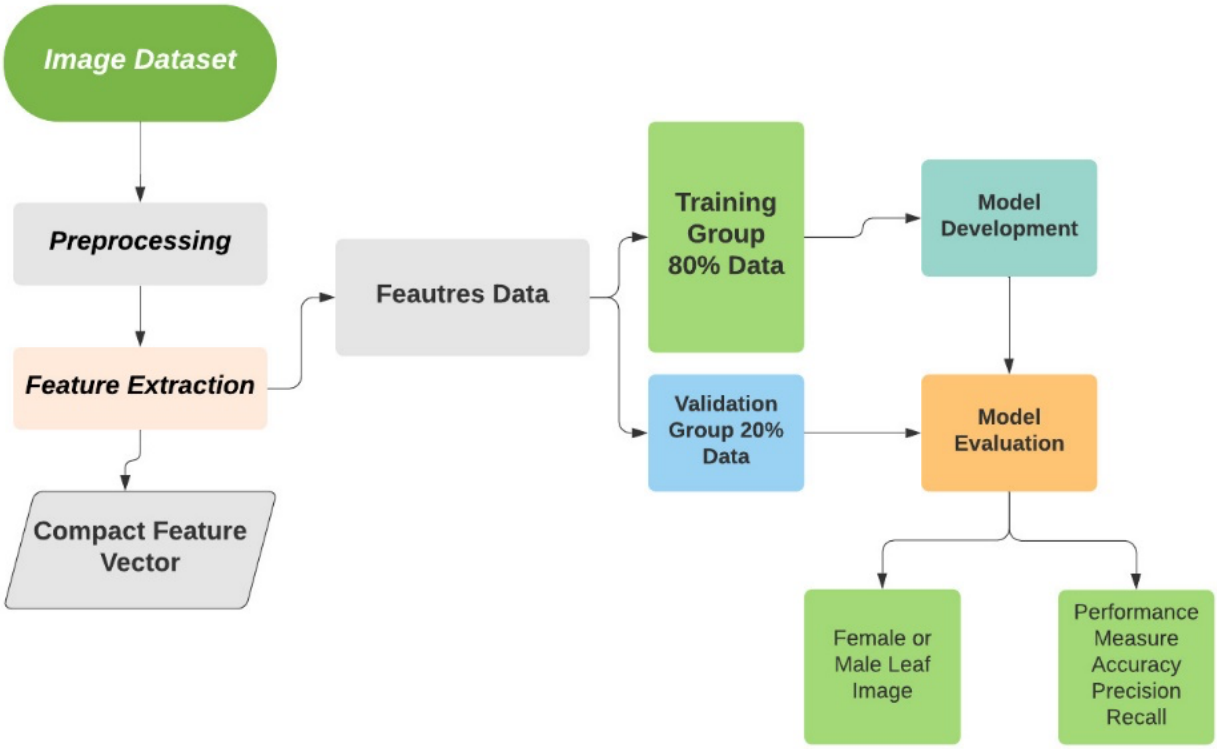

Figure 1. Proposed Methodology.

3.2 Data Collection

Date palm leaf photos were taken into consideration for this investigation. the IUB Date Palm Research Center's collected leaves. The work of capturing images was completed. To regulate camera movement and prevent blurry or fuzzy photos of Date palm leaves, the camera was fixed to a tripod. photos that were taken under controlled circumstances on a white background. The database contains close to 300 images. For training and testing, there are two categories: female leaves and male leaves. The example pictures are displayed in (Figure 2 and Figure 3).

Figure 2. Sample image of Date palm leaf.

There are 150 photos of female date palm leaves in the database, while the number of pictures of male palm leaves is 100. The most famous Pakistani Date Palm Verities Used for the Sex Classification of the date palm are Dhakki, Gulistan, Zaidi, Azadi, Shakri, Basra and Hillwai.

Figure 3. Sample image of Date palm leaf**.**

3.3 Image Preprocessing

Image processing is making changes to an image to improve it or get helpful information from it. Some Preprocessing is also done on the original-captured image to remove extra parts of an image. Some Preprocessing is also done on the original-captured image to remove an extra part of the image as in (Figure 4) the original image size was 1024 x 1012 then the image was resized to remove the unnecessary part of

the image to reduce computational cost. The images acquired were more significant, so before processing, resized them to 150× 150 sizes. To work on the interesting area of an image, need to remove the unwanted areas from the image, known as background elimination. Commonly used algorithms for background elimination are split and merge algorithms, and square window is used for foreground detectionConversion of RGB to greyscale is considered as low-level preprocessing. The average method and weighted method are mainly used for RGB to GRAY conversion (figure 5) show.

Figure 4. Original image.

Figure 5. Processed Image.

3.4 Feature Extraction

When it comes to extracting useful information from an image, features are crucial. Various feature extraction approaches are available, according to the study. Shape, colour, and texture are examples of features that can retrieve to aid in the comprehension of an image. Colour characteristics can be extracted, for example, Color means, hues, saturations, values, and standard deviations can be calculated by changing an image from RGB to HSV and computing the colour mean for each channel Can extract texture features in addition to colour, which aids in extracting the leaf pattern. The grey-level cooccurrence matrix is the method used most often (GLCM). The grey-level co-occurrence matrix is the most common way to texture a surface (GLCM). Can employ Local binary pattern and wavelet transform features in the same way for feature extraction.

3.5 Data Visualization

Data visualization shows data in charts, graphs, maps, and other visual formats to help find patterns and connections in the data. Visualization of a dataset of two categories using a bar chart in figure 6.

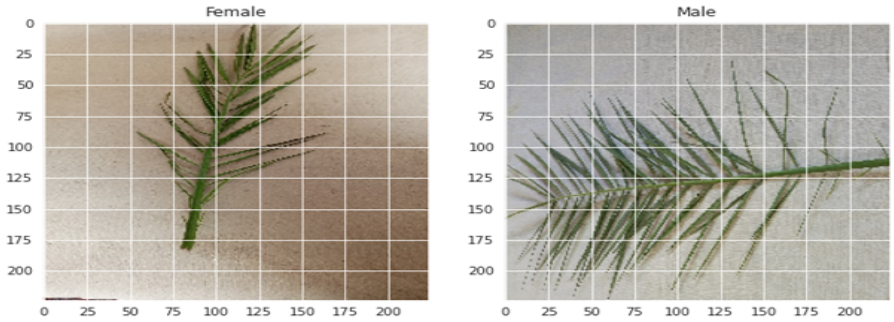

Figure 6. Random Image Visualization Result of Male and Female Date Palm Leaf.

Images of Date palm leaves from a dataset were used in the experiment. The pictures were taken in different places with a 4048-4048 digital camera. Because larger images are more challenging to process, they are reduced to 150 150 pixels. The number of features is used to compare the accuracy of male and female classification using different classifiers. Colour hue, saturation, colour moment, entropy, correlation, energy, contrast, mean, homogeneity, RMS, and standard deviation are all examples of feature attributes.

4. Results and Discussions

We check the performance of various classification techniques on a sex identification dataset, such as NB, KNN, AdaBoost, and SVM, and discover that the KNN and SVM classification techniques outperform the others. This Date palm leaves dataset is split into two parts: training data (90 %) and testing data (10 %). The date palm leaves dataset contains 300 images and two class labels. This experiment shrinks the image from its original size to 150 150 pixels because the pictures of the data set were all different sizes, so each image has a unique dimension. The labelled grayscale photos are converted into Python's cv2 format image processing library. This transformation is repeated indefinitely because the formatted pictures are fed into a pickle. Any of the classification algorithms can now use the pickle file. The models' codes are then implemented, and the data is trained on the model that predicts an image's gender.

We usually classify the leaves as female or male so that farmers can act on specific date palm sex as soon as possible. Date palm sex is determined by the morphological characteristics of mature and two-year leaves. (Figure 7) KNN classifier was the most accurate (>93%) during training, but accuracy ranged from 80 to 90% during testing for the four training data set sizes. With the respective arrangements of Naive Byes, AdaBoost, and SVM, training phase accuracy with the 80% data set ranged from 83 to 64%.

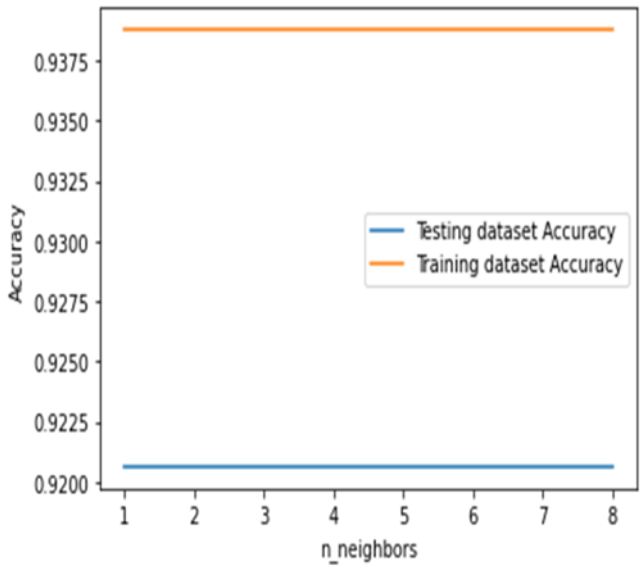

Figure 7. Training and Test Accuracy of the KNN Model

Training and testing accuracy of the KNN classifier is between 90 to 93% accuracy varied from 93.00% (KNN) to 97.00% (SVM). According to our findings, KNN could be used to distinguish between male and female Date palm genotypes reliably. As a result, machine learning models based on leaf features can be used to predict sex in Date palms. Table 2 Comparison of different algorithms Gaussian Naive Bayes, Support Vector Machine (SVM), and K-Nearest Neighbor (KNN). The combination of colour, shape, and size characteristics helps achieve the highest accuracy level. The SVM and KNN in classification accuracy, with 97.0% and 93.0%. According to our findings, KNN could be used to distinguish between male and

female Date palm genotypes reliably. As a result, machine learning models based on leaf features can be used to predict sex in Date palms.

Table 2. Comparison of Accuracy, Precision, Recall and F1 of each class

Ml Model	Class	Accuracy	Precession	Recall	F1 Score	Support
Gaussian Naive	0		0.93	0.62	0.74	21
Bayes	1	0.785	0.71	0.95	0.82	21
AdaBoost	0		0.88	1.00	0.93	21
	1	0.928	1.00	0.86	0.92	21
SVM	0		0.88	1.00	0.93	21
	1	0.97	1.00	0.86	0.92	21
KNN	0		0.95	0.90	0.93	21
	1	0.93	0.91	0.95	0.93	21

4.1 KNN Confusion Matrix

For KNN, we have used the Scikit library and with the help of the KNN Classifier header file, we have achieved an accuracy score of 93%. (Figure 8) show the confusion matrix of the KNN classifier.

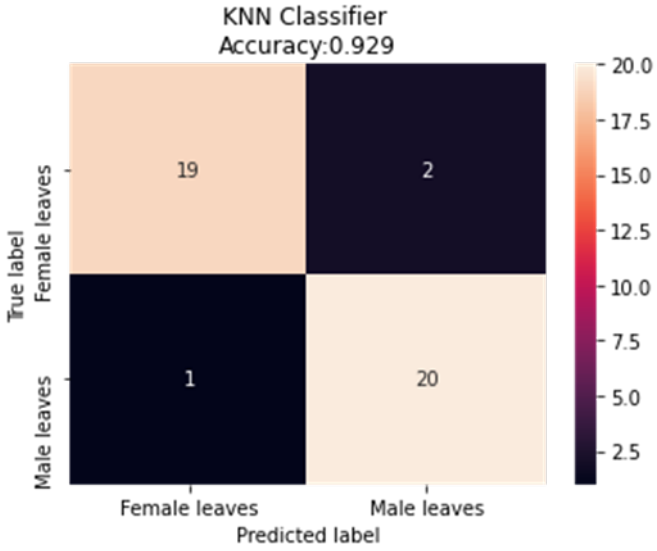

Figure 8 Confusion matrix of KNN Classifier

The classification problem prediction results are summarized in a confusion matrix. The sum of correct and incorrect predictions is divided by class. Figure 4.6 shows the KNN classifier confusion matrix.

4.2 KNN Classification Report

The classification report of KNN in terms of precision-recall, f1-score shows the ratio of the number of correctly predicted positive samples to the total number of predicted positive samples. Which reduces the overall accuracy of the algorithm to **0.93**. Below (Figure 9) shows the classification report of KNN.

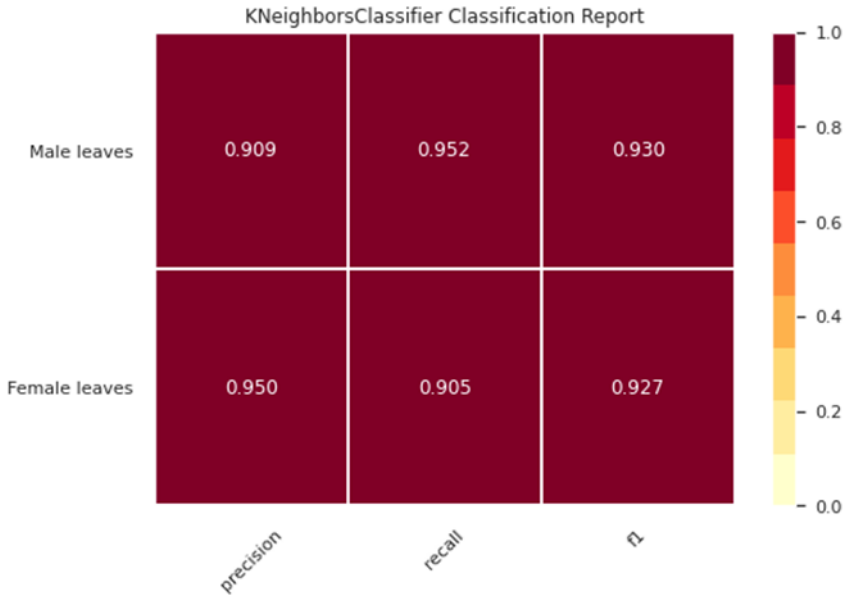

Figure 9. Classification report of KNN Classifier

4.3 Evaluating the Result

For a dioecious tree like the date palm, it is hard for growers and breeders to tell the sex of the tree when it is still young. Males and females cannot be distinguished until they reach maturity and begin producing inflorescences or until DNA tests are done, which are expensive and take a long time. Four different machine learning methods were used in this study to classify date palm sex using only leaf shapes from the early stages of growth were used as input data. KNN, SVM, AdaBoost, Gaussian, and naive Bayes were used to sort the data. The optimal values for each classifier's parameters were computed and evaluated to get a more accurate estimate of how well the classifier works. The generalizability of each classifier was tested with different sets of training data (20, 40, 60, and 80%). The size of the training data set can affect how well and how accurately each classification method works, the findings show. The chosen parameters have a significant effect on how well each classifier works. The KNN classifier showed the most crucial ability for training in figuring out the sex of a date palm. Organizing the training abilities of the remaining classifiers can be done with SVM, AdaBoost, and Naive Bayes. Classifiers have to show that they are good at testing and can train well. How well these methods work in the real world depends directly on how well the testing phase is done. With an 80 % training data set, the five ways had the following overall classification accuracy: KNN (93 %), SVM (97 %), Naive Byes (78 %), and AddaBost (78 %) (78 %). As a result, KNN and SVM were the best of the four classifiers in our experience for determining Date palm sex Despite KNN's superior training capability, SVM won 92 %. The test accuracy for classifying and the training accuracy for organizing are 88.33 %. When given information about the shape of a Date palm's leaves, Machine learning models can be used to figure out what the palm is.

This study gives us a fast and accurate way to test for DNA markers, and it has the potential to significantly improve the selection efficiencies of date growers. Because male and female date palm genotypes can be identified before maturation, breeders' costs and time commitment are reduced. Deep learning and other methods should be evaluated for their utility in answering additional Date palm sex questions. A more comprehensive database of Date palm genotype biodiversity could be created and used to support the findings presented. The outcomes of our research are as follows:

- Early identification of Date Palm Gender.

- A predictive model that automatically identifies the gender of date palms.
- Help formers to early identify the gender of date palms.

Following are the output of images that are unseen to the model. (Figure 10) Shows that the input image gives the accuracy for the female leaf class at 84 % and the male class at 15%. So the predicted image belongs to the female class because the accuracy of the female class is greater than the male class.

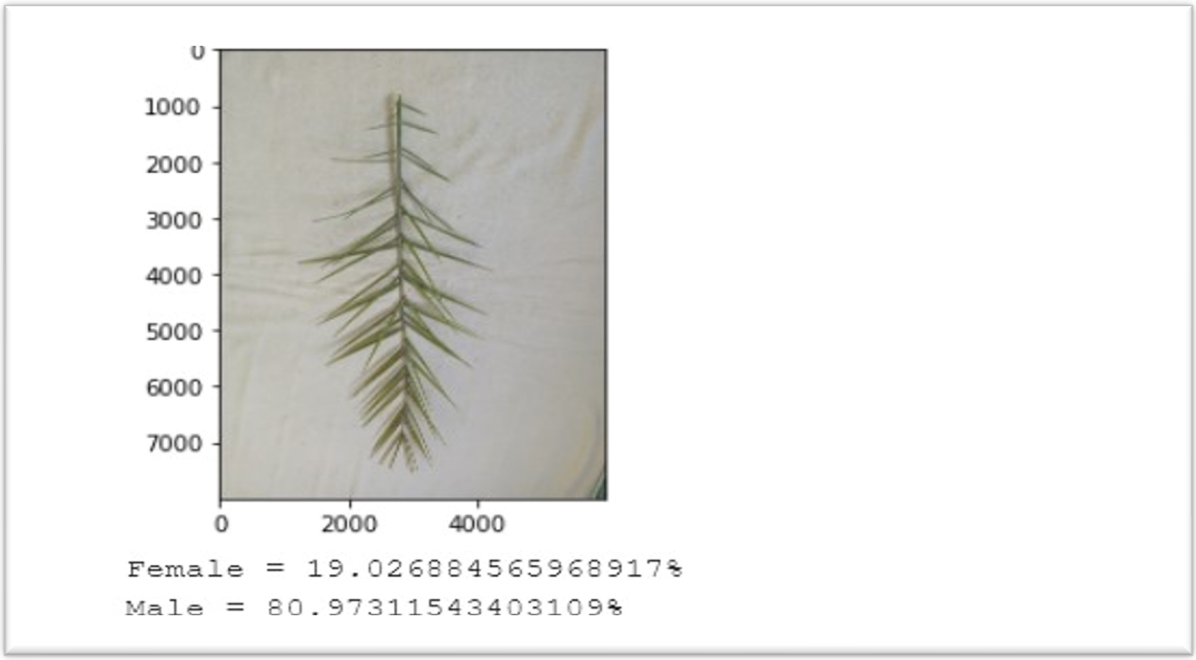

Figure 10. Identification results of female date palm leaf

Following are the output of images that are unseen to the model. (Figure 11) shows that the input image gives the accuracy for the female leaf class at 17 % and the male class at 82%. So the predicted image belongs to the male class because the accuracy of the male class is greater than the female class.

Figure 11. Identification Results of Male Date palm leaves

5. Conclusion and Future Work

We have concluded and summarised our research work and presented ideas for further extending the research in future. Female plants are economically valuable as they bear fruit, so early-date palm sex

characterization is critical for commercial production. Female plants are more valuable because they bear fruit, so identifying the sex of date palms in the early stage is essential for commercial production. To determine the Sex of Date palms, supervised machine learning algorithms such as KNN, SVM, Gaussian Naive Byes, and AdaBoost classifier were used. The proposed methodology was used to train the classification model using picture data. SVM classifiers had the highest accuracy of the other classification models for sex identification in picture data testing. With an 80 % training data set, the five ways had the following overall classification accuracy: KNN (93 %), SVM (97 %), Naive Byes (78 %), and AddaBost (78 %) (78 %). As a result, KNN and SVM were the best of the four classifiers in our experience for determining Date palm sex Despite KNN's superior training capability, SVM won 92 %. The test accuracy for classifying and the training accuracy for organizing are 88.33 %. Farmers can take the necessary actions depending on the identified Sex as soon as possible. However, each model in the classification process has its own set of dangers that may or may not apply to all datasets. We can implement models in the future by combining various high-dimensional data sets with a variety of classification methods.

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Conflicts of Interest: The authors declare no conflict of interest.

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