GENDER CLASSIFICATION BASED ON EYE IMAGES USING K-NEAREST NEIGHBOR, SUPPORT VECTOR MACHINE, AND DECISION TREE ALGORITHM

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Abstract

The orbital cavity serves as a housing for the eyes, functioning as crucial visual organs. Each eye possesses an approximate diameter of 2.5 cm and maintains a round shape. The region between the eye socket and the eye itself contains fatty tissue, contributing to the cushioning effect. Safeguarding the eyes is facilitated by the combined defense of the bony structure and the fatty walls of the orbit. Despite their individual anatomical differences, the two eyes work synergistically. Although one eye can perceive genuine depth, relying solely on one eye can pose challenges, especially in gauging distances. This research is focused on assessing the K-Nearest Neighbor (K-NN), Support Vector Machine (SVM), and Decision Tree algorithm's potential in accurately distinguishing gender using eye images. For this experimental setup, data was sourced from the Kaggle platform, leveraging images of human eyes. The dataset encompasses 11,525 eye photos in JPG format, with 5,202 depicting women and 6,323 depicting men. Accuracy evaluation of the model involved the use of the Confusion Matrix. Upon conducting tests, the model attained its peak accuracy of 78% with the used Support Vector Machine (SVM). This outcome underscores the successful application of the SVM algorithm in eye image classification, leading to optimized accuracy in gender differentiation.

Keywords: Eyes; Gender; Classification; System; K-Nearest Neighbor

Introduction

Identifying a person by their unique physical traits, such as face, fingerprint, iris, and other similar biometrics (Aryanmehr, S., Karimi, M., & Boroujeni, F. Z., 2018). and hand geometry, can reveal interesting insights about their health and lifestyle. Relatively, individuals rely on personal traits or habits such as a certain tone of voice, signature, or handwriting. In terms of seeing, the human eye is the single most important organ of the body. Thus, biometrics that rely on the anatomy and physiology of the eye are becoming increasingly popular. One of the five senses that are most important for human survival is sight. A lot of data can be stored in the eye, which is the organ of vision. The main function of the eye is to detect differences in brightness and darkness (Juniati, D., & Suwanda, A. E., 2022).

In internal features, the eye is the most important and receiving component majority fixation (Sammaknejad, N., Pouretemad, H., Eslahchi, C., Salahirad, A., & Alinejad, A., 2017, Marzoog, Z. S., Hasan, A. D., & Abbas, H. H., 2022). Each component of the human eye has a unique role and mechanism of action, but as a whole, it allows us to see. The orbital cavity houses the eyes, which serve as the visual organs. It measures approximately 2.5 cm and is round (Firdaus, R., Satria, J., & Baidarus, B. 2022, Hasan, B. M. S., & Mstafa, R.,2022). Fat tissue fills the cavity between the orbit and the eye socket. Ocular protection is provided by the bone and fat of the orbital wall. The two eyes have different anatomy but function together. Things One eye access only with true depth perception Has difficulty using one eye, especially for determining distances.

Gender is a grammatical category that groups additional words and terms related to the fact that there are two genders. Gender is also something construction characteristic of culture open to all change (Kurniawan, C., & Irsyad, H., 2022). There is no biological basis for the sex variations that make up sex. Much broader than the case of biological differences, social and cultural forces shape the behavior of men and women (Hasan, B. M. S., & Mstafa, R., 2022). Gender is an operational instrument for measuring the concerns of men and women, especially those related to the

socially imposed division of labor. In recent years, gender has emerged as a hotly debated topic. Visual perception is one of the five senses that play an important role in human existence.

Classification type sex recently developed in a manner outside the ordinary and uncovered different applications, such as biometrics, monitoring supervision, art forensics, disease diagnosis, etc. Information on race and type of sex including "biometrics software" that provides information important about the identity individual (Marzoog, Z. S., Hasan, A. D., & Abbas, H. H., 2022). Gender classification is predicting male and female images that divide into two classes. For people, this is a simple task, but for computers, it becomes very difficult (Aini, N., & Liliana, D. Y., 2022, Irhebhude, M. E., Kolawole, A. O., & Goma, H. K., 2021). Demographic classification based on ethnicity and gender has recently developed tremendously and is revealing different applications, such as biometrics, surveillance monitoring, forensic arts, disease diagnosis, etc. The K-NN, SVM, and DT algorithm were used for searching accuracy and time classification optimal processing type sex. K-NN, SVM, and DT usually use a method for classifying objects based on example the most suitable training in space feature (Sudharshan Duth Amrita Vishwa Vidyapeetham, 2019) Classification is the process of assigning data items to one from several categories that have been determined (Adinata, F. D., & Arifin, J. 2022).

K-Nearest Neighbor (K-NN) is a simple and non-linear classifier used in case a sample class is disturbed in a room problem. This is a classifier that stores all available cases and classifies gender-based_distance between Euclidean and Manhattan. The K-NN algorithm is appropriate for problem multiclass tag classification and has the ability for good generalization (Güvenç, E., Çetin, G., & Koçak, H., 2021). A case classified based on the voice of the majority of K neighbors. Many sizes, different similarities or distances can be used to handle it. Related research shows that size similarities/different distances can affect the performance system (Pangestu, M. S., & Fitriani, M. A. 2022).

Support Vector Machine (SVM) is a powerful and effective classification method in handling disrupted class distributions by creating optimal decision limits. SVM uses support vectors to define a hyperplane that maximizes class separation. SVM is able to solve multiclass problems through strategies such as One-vs-One or One-vs-All, and its kernel functions, such as linear kernels and RBF, allow non-linear data handling. SVM's ability to generalize and perform well on new data is crucial, and kernel choice and parameter tuning have a significant influence on its performance, as revealed by previous studies (T. Mantoro, R. T. Handayanto, M. A. Ayu, J. (2020).

Decision Tree is an intuitive and efficient classification method, suitable for overcoming situations where class distribution is disrupted. This method works by dividing the dataset into subsets based on relevant features, with the aim of minimizing uncertainty in classification. Decision Tree can easily handle multiclass and non-linear problems. In each branch, a selection is made based on the features that have the best ability to separate classes. Another plus is the ability of the Decision Tree to handle data that has irrelevant features or ignores noise. However, its tendency to overfitting can be overcome by pruning techniques and parameter setting. Related research shows that adjustments to tree depth and feature selection criteria can affect model performance (Wijaya, S. S., Ayu, M. A., &; Mantoro, T. 2019).

Materials and Methods

This research categorization method was developed in two stages: training and testing. Images are used in the first stage of testing to obtain a model to be used in the second round of testing. In the second phase, called "system testing", the trained model is tested to determine system classification and performance.

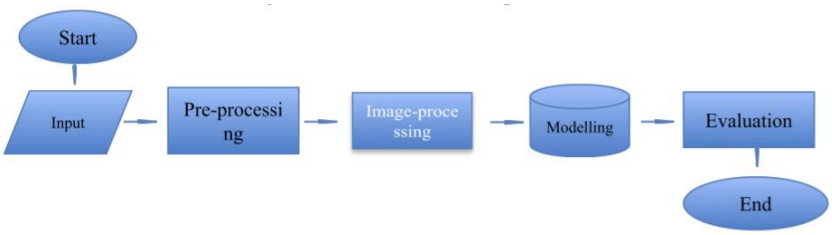

Figure 1. Generic Flowchart

2.1.1 Input Datasets

Data from the website kaggle.com was used for this investigation, and the images are those of the human eye. Overall, 5,202 female and 6,323 male JPG eye photos were used.

Figure 2. Image of eye's woman'

Figure 3. Image of eye's man

2.1.2 Preprocessing

A. Process for K-Nearest Neighbor

This is the first step in processing the image and is necessary because the image needs to be refined in several different ways before it can be processed by the model. The images are separated into training and test sets, the latter being compared to the former under various conditions. The next steps depend heavily on the accuracy method used to measure _ the degree to which the two data sets are similar or different, so important to evaluate various options popular that as distance *Euclidean* and *Manhattan* (Pangestu, M. S., & Fitriani, M. A., 2022).

1. Euclidean
   Euclidean distance formula measures the degree of similarity between data sets. Below is the formula that can be used in the calculation:

$$dx,y=i=1n(xi-yi)2 \quad (1)$$

Where :
d(x,y): Distance between x and y
i: Index of data
n: Number of data
x_i: Data on the center of cluster *i*
y_i: Data on each cluster *i*

2. Manhattan
   Manhattan distance measure is used to determine the highest precision between two coordinates (Nishom, M., 2019). This is the formula used:

$$dx,y=i=1n|xi-yi| \quad (2)$$

Where:
d(x,y): Distance between x and y
i: Index of data
n: Number of data
x_i: Data on the center of cluster *i*
y_i: Data on each cluster *i*

B. Process for Support Vector Machine

Support Vector Machine (SVM) is a machine learning algorithm used for classification. In the context of this study, SVM will be used to classify gender based on eye images. The process that will be carried out first is Data Collection, using the same dataset as described in the previous algorithm. The next step is to divide the dataset into Train data and Test data. SVM model training on a subset of training by optimizing hyperparameters (such as kernel, C, and gamma) to improve performance (Ben Rahman, Boy Subirosa Sabarguna, Harco Leslie Hendric Spits Warnars, and Widodo Budiharto, 2023, E. Irawan, T. Mantoro, M. A. Ayu, J. Asian, 2020).

After training, SVM models can be used to classify test eye images. Evaluation is the classification result using metrics such as accuracy, precision, recall, and F1-score.

$$f(x)=i=1n\ iyixiT\ x+b \quad (3)$$

Where:
f(x): Vector Machine Value
x_i: Vector machine to i
y_i: Number 1 or -1
α_i: Lagrange Multiplier
b: bias

The mathematical formula for SVM depends on the kernel used (such as linear, RBF, or polynomial kernels). The linear kernel is the simplest, and the formula is like a formula 2.

C. Process for Decision Tree

Decision Tree is a machine learning algorithm used for classification based on a series of decisions made based on features from data. The first step is the same as the previous step, namely data collection using datasets, then the next step is dividing datasets into training data and training data. The next rarity is to build a decision tree from a subset of training by selecting the most informative features to share at each step. Cut trees if needed to avoid overfitting. Classify the test eye image by following the tree branch based on the features of the image. The final step is an evaluation with classification results using metrics such as accuracy, precision, recall, and F1-score.

Decision Tree Formula: The mathematical formula for a Decision Tree using Gini Impurity or Entropy.

Gini=1- p12- p22 (4)

Entropy= - p1* (p1)- p2* p2) (5)

2.1.3 Modeling

At this stage, the researcher tested the data to find the best accuracy so that the system was able to classify gender through eye images. The K used is 1 in the modeling results which are measured using the Confusion Matrix to calculate precision, recall, and accuracy.

2.2 Classification

K-NN, SVM, and Decision Tree are used as a categorization method in this investigation. During the classification phase, the authors compared the test attributes with the training characteristics and divided them into two categories —male and female—using the Formula used of hyperparameters, respectively (Saraswita, E. F., & Sukemi, S., 2019). Accuracy is a metric for how well the system interprets input and uses it to produce the desired result (Kurniadi, D., Sugiyono, A., & Wardaya, L. A., 2021).

$$Accuration = \frac{Number\ of\ true\ data}{Number\ of\ all\ data} x100\% \quad (3)$$

1. K-Nearest Neighbor

Algorithm K-NN is to determine how far the data is from the test image from the data used to create the training image. The attribute values shared by the two data sets are what this distance measures. Closer data has a smaller distance value. In this context, "nearest neighbor" refers to the portion of the training image data closest to the reference image. If the closest neighbor is found in the test image, the data is used in the training image, and so on for k iterations starting with the smallest distance value (Salsabila, H., Rachmawati, E., & Sthevanie, F., 2021). The largest number of classes in the k data will then be used to determine the classification of the test image data (Sujaini, H. 2019, Sari, W. S., & Sari, C. A., 2022).

The K-NN method is used to create a new object classification system based on its attributes and training examples. In cases where most of the K-NN categories can be used to classify new test samples. The distance used is the distance between Euclidean and Manhattan. The commands and program code for implementing the K-NN algorithm are:

Pseudocode of K-NN
Download dataset
Unzip dataset
Split dataset into DATA_TRAIN and DATA_TEST (70:30 ratio)
Normalize dataset (image preprocessing techniques: resizing, feature extraction like HOG)
Import necessary libraries (e.g., numpy, cv2, matplotlib, scikit-learn, etc.)
Preprocess and prepare the data:
- Load and preprocess images

- Extract relevant features (if necessary) - Encode labels (e.g., male as 0, female as 1) Train the KNN model: - Initialize the KNN classifier with hyperparameter k - Train the model on DATA_TRAIN Save the trained KNN model Make predictions on DATA_TEST using the trained model Calculate evaluation metrics (e.g., accuracy, recall, F1-score) for model performance Print and store the evaluation results END

2. Support Vector Machine

In the pseudocode above, you can replace comments like "Set hyperparameters" or "Initialize the SVM classifier" with specific steps according to the programming language used (usually using Python with libraries like scikit-learn or SVM from TensorFlow/Keras). You can also customize SVM hyperparameters according to your project needs.

Pseudocode of SVM
Download dataset Unzip dataset Split dataset into DATA_TRAIN and DATA_TEST (70:30 ratio) Normalize dataset (image preprocessing techniques: resizing, feature extraction like HOG) Import necessary libraries (e.g., numpy, cv2, matplotlib, scikit-learn, etc.) Preprocess and prepare the data: - Load and preprocess images - Extract relevant features (if necessary) - Encode labels (e.g., male as 0, female as 1) Train the SVM model: - Initialize the SVM classifier (e.g., linear SVM or other kernel) - Set hyperparameters (if applicable) - Train the model on DATA_TRAIN Save the trained SVM model

3. Decision Tree

In the pseudocode above, you can replace comments like "Set hyperparameters" or "Initialize the Decision Tree classifier" with specific steps according to the programming language used (usually using Python with libraries like scikit-learn). You can also customize the Decision Tree hyperparameters according to your project needs.

Pseudocode of Decision Tree
Download dataset Unzip dataset Split dataset into DATA_TRAIN and DATA_TEST (70:30 ratio) Normalize dataset (image preprocessing techniques: resizing, feature extraction like HOG) Import necessary libraries (e.g., numpy, cv2, matplotlib, scikit-learn, etc.) Preprocess and prepare the data: - Load and preprocess images - Extract relevant features (if necessary) - Encode labels (e.g., male as 0, female as 1) Train the Decision Tree model: - Initialize the Decision Tree classifier - Set hyperparameters (if applicable) - Train the model on DATA_TRAIN Save the trained Decision Tree model

Make predictions on DATA_TEST using the trained model
Calculate evaluation metrics (e.g., accuracy, recall, F1-score) for model performance
Print and store the evaluation results
Visualize the Decision Tree (optional)
END

Results

3. 1 Use of K-NN, SVM, and Decision Tree Methods

Inspection begins i.e. comparison of the volume of data to determine accuracy system. There are three data sets to compare: one with the same amount of training and test data (5,764 photos train and 5,761 test images), one with 70% training data and 30% test data (8,069 images train and 3,456 test images), and one with 80% training data and 20% test data (9,223 images train and 2,302 test images). K=1 in the K-NN model means that is the parameter for distance Euclidean and Manhattan used.

In addition to using the K-NN model, we also ran experiments with the Support Vector Machine (SVM) method to compare the performance of the two models. SVM is a machine learning algorithm that can be used for classification problems.

These experiments were ran using Decision Tree as an alternative method to compare its performance with K-NN and SVM models. Decision Tree is a machine learning algorithm that models decisions in the form of a tree, which can help in classification problems.

Table 1. Test results based on the amount of data

Comparison of Total Data	Accuracy		SVM	Decisision Tree
	Euclidean	Manhattan		
30% training data and 70% test data	55%	55%	66%	59%
45% training data and 55% test data	60%	61%	71%	70%
50% training data and 50% test data	68%	71%	74%	72%
70% training data and 30% test data	77%	77%	78%	72%
80% training data and 20% test data	73%	73%	77%	73%

Table 1 shows that the optimal accuracy, 78%, is achieved by comparing 70% of the training data with 30% of the test data. However, scenarios where the data is training and testing produce the lowest accuracy, an average of 55 % with this test image experiencing underfitting for K-NN, 66% for SVM, and 59% for Decision Tree.

2. Accuracy Testing

3.2.1 K-Nearest Neighbor

In this study, testing was carried out with the K-NN algorithm, using random eye image data as many as 11,525 and testing the level of data accuracy in the study starting with the value of K = 1 to K = 15. The number of K values indicates that the nearest neighbor to an object with the K-NN algorithm is able to distinguish a male eye image or a female eye image based on the increased accuracy of testing hyperparameter values.

Table 2. Displays the results evaluation performance K-NN approach.

K value	Manhattan				Euclidean			
	F1 Score	Recall	Precision	Accuracy	F1 Score	Recall	Precision	Accuracy
1	69%	63%	77%	69%	68%	63%	74%	67%
2	57%	42%	85%	64%	56%	43%	82%	63%

3	73%	66%	81%	73%	72%	68%	77%	71%
4	64%	52%	85%	68%	65%	54%	82%	68%
5	74%	67%	82%	74%	74%	69%	79%	73%
6	69%	57%	85%	71%	69%	59%	83%	71%
7	76%	70%	83%	76%	75%	72%	80%	74%
8	71%	61%	86%	73%	72%	63%	82%	72%
9	76%	70%	83%	76%	76%	73%	80%	75%
10	73%	63%	86%	74%	73%	65%	82%	73%
11	76%	70%	83%	76%	76%	73%	80%	75%
12	74%	64%	86%	75%	74%	67%	83%	74%
13	77%	71%	85%	77%	77%	74%	81%	76%
14	74%	65%	86%	75%	75%	68%	84%	75%
15	77%	71%	84%	77%	78%	75%	81%	77%

Table 2 shows that the highest accuracy for Manhattan distance is K = 13 and K = 15, at 77%. As for Euclidean distance, the highest accuracy is with K = 15, amounting to 77%. With an accuracy value of 77%, both Manhattan distance and Euclidean distance have the same value, namely K = 15.

2. Support Vector Machine.

Support Vector Machine (SVM) is a powerful and versatile machine learning algorithm used to separate data into classes based on optimal separation among those classes.

This study continued by evaluating the SVM's performance in classifying gender based on eye images by utilizing relevant evaluation matrices.

Table 3. Displays the results evaluation performance SVM approach.

Algorithm	F1 Score	Recall	Precision	Accuracy
SVM	79%	81%	81%	78%

3. Decision Tree

Decision Tree is an intuitive and interpretive machine learning algorithm that enables a deep understanding of the decision-making process. This study evaluate the ability of the Decision Tree to classify gender based on eye images, as well as visualize the decision tree to describe the decision-making process executed by this algorithm.

Table 4. Displays the results evaluation performance Decision Tree approach.

Algorithm	F1 Score	Recall	Precision	Accuracy
Decision Tree	76%	74%	79%	72%

3.3 Evaluation

Based on the results from testing, the whole model is successful getting an accuracy worth 78%. See results accuracy from precision and recall there are minimal errors in the implementation. These results are a good look at the high F1 score signifying that results balanced classification. It shows that the SVM Algorithm is capable of knowing objects well.

Table 5. Evaluation of gender classification based on KNN, SVM, and Decision Tree.

Algorithm	F1 Score	Recall	Precision	Accuracy
KNN	78%	75%	81%	77%
SVM	79%	81%	81%	78%
Decision Tree	76%	74%	79%	72%

Discussion

Based on the results obtained from the study that implemented the SVM algorithm for classification, several important conclusions can be drawn:

1. Superior Accuracy: The study successfully demonstrated the effectiveness of the Support Vector Machine (SVM) algorithm in calculating and achieving the highest accuracy results. This highlights that SVM outperforms other algorithms such as K-Nearest Neighbors (K-NN) and Decision Tree when it comes to accuracy in the context of gender classification based on eye images.

2. Dataset and Preprocessing: It's worth noting that the study utilized a substantial dataset comprising 11,525 images for the purpose of gender classification. Additionally, preprocessing techniques, including image resizing and Histogram of Oriented Gradients (HOG), were employed. These preprocessing steps likely contributed to the achievement of a remarkable 78% accuracy threshold.

3. Potential for Improvement: One key takeaway from this research is the potential for further enhancement. The SVM algorithm has demonstrated its capabilities, but there is room for improvement. Future research can focus on expanding the dataset, which could lead to even better accuracy rates. Moreover, conducting comparative studies with K-NN and Decision Tree algorithms on larger datasets could provide valuable insights into the algorithmic performance.

This study underscores the effectiveness of the SVM algorithm for gender classification based on eye images, particularly in terms of accuracy. The findings suggest that with more extensive datasets and continued research, SVM has the potential to further improve its performance in this domain when compared to other classification algorithms.

Conclusion

Based on the results of training using the K-NN, SVM, and Decision Tree algorithms, a gender classification model was successfully created by identifying eye images. After each model is evaluated at the testing stage, the most accurate results are obtained using the SVM algorithm, achieving an accuracy of 77%. However, it should be noted that this accuracy is not too much different from the K-NN algorithm or Decision Tree.

While this research has provided valuable insights into gender classification based on eye image, there are several upcoming areas of work that could be explored further:

1. Additional Data Use: One important step is to consider the use of larger and more diverse datasets. With richer datasets, better accuracy results are likely to be achieved. Additional data may include variations in ethnicity, age, and other eye characteristics.

2. Algorithm Optimization: There is potential to further optimize SVM, K-NN, and Decision Tree algorithm parameters. Further research on how to optimally set these parameters can help improve model accuracy.

3. Exploring the use of neural networks, such as Convolutional Neural Networks (CNNs), for eye image classification tasks may also be an exciting upcoming job. CNNs have proven successful in many computer vision problems and can provide better results in some cases.

By exploring these aspects, future research may continue to improve and expand understanding of sex classification based on eye imagery and possibly lead to wider applications in a variety of industries.

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