RECOGNITION OF FACE PATTERNS USING SINGULAR VALUE DECOMPOSITION TO IDENTIFY FRIENDSHIP RELATIONSHIP

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Abstract

A system to recognize the faces of family members is the next generation of the system based on biometrics that we commonly encounter using facial patterns and characteristics as identification objects. This family member recognition system uses existing facial patterns in the database system as storage, then does a comparison with the tested image. The facial pattern recognition system has some problems, for example, difficulty in recognizing objects with different lighting levels in the process of taking the picture. To overcome the obstacles that occur due to variations in light levels was developed software by applying the singular value decomposition (SDV) method. The result of In this study, the application of facial pattern recognition is thought to have a relationship kinship that is useful for identifying someone who is in the test image as well as displays a person's identity if a match is found with the sample on the application. In this study, the samples used were 100 facial images and 50 facial images of random humans, the resulting level of accuracy of this software is 92.8769*% in recognizing patterns of kinship face,* 60.1775*% in matching the test image with the existing sample on the basis application data and 90.9567% when determining the identity of someone who is the same as databases.*

Keywords: *Family, Faces, Pictures, SDV.*

INTRODUCTION

Identification of a person in a particular incident that resulted from someone difficult to recognize must be done using technology and applications certain (Qing, 2014), the identification or disclosure of a person's data is very interesting carried out, previously carried out using biometric technology (Wu, 2008), A biometric system is a method that can identify a person's identity by using physical characteristics or a person's limbs (Xia, 2014), such as fingerprints fingers, eye retinas, palms, facial patterns and so on (Akter, 2016)."The biometric system application has several advantages, such as not being easily lost/forgotten, not easily counterfeited (Muslim, 2018), and having characteristics or uniqueness between one person and another (Bobadilla, 2013). Multiple biometric systems applied to various types (fields) of work, even today almost implemented in every company (Baker, 2013)".

Various problems that must be solved is the difficulty of recognizing certain objects at a very low level of lighting (even dark) (Mulyanto, 2017), such things, if analyzed, will reduce the level of accuracy of system performance at the time perform matching (testing) of the observed images (Rafael, et al. 2022). Besides this due to variations in poor lighting levels, the poor image quality also greatly affects the level of accuracy of system performance in the testing image (identification) of a particular object (Zeng, 2006).

Based on the explanation of the background of the problems above, in application development research using Singular value decomposition (SVD), the problem is formulated as follows: (1) How to make a pattern recognition application face for

identification of kinship? (2) How to measure the level of application accuracy which was built using SVD can recognize a person's facial pattern with a certain level of lighting? The benefits of this research produce software that can be applied to certain systems, such as attendance data processing employees, means of logging in to an application (user authentication), means of identifying criminals, and so on.

LITERATURE REVIEW

Making a person's facial pattern recognition application is a sub-class computer software, which uses the capabilities of the computer directly to perform certain tasks or functions desired by application users (James, et al. 2021). A particular application is sometimes compared to other system software integrating all kinds of machine (computer) capabilities (Kumar, 2021), but does not directly apply this ability to perform a task specific to users.

The face or face pattern is the most important part as an identifier a person is at the very front of the head, the face in humans covers the entire area from the forehead to the chin, including the hair, eyebrows, eyes, nose, cheeks, mouth, lips, teeth and skin (Kuhn, 2018). The facial function is normally used to see one's expression, appearance, emotion, identity, and even character It is estimated that it is enough to look at the face, wrinkles on a person's face (Qing, 2014), from various literature information, that there is no one similar facial pattern, even in humans who are identical twins there are still things that differentiate between the two (Wang, 2018).

Image or image is mathematically a continuous function (continue) of the reflected light intensity in a two-dimensional plane (Mulyanto, 2017). An image or image on a computer can be colored, the modeling commonly used is the RGB model, this RGB model consists of three separate image fields, where each field has a gray interval [0-255], with a grayscale spectrum, is the formed color from the combination of the three main colors in the same amount and are in the same line connecting black and white dots (Rafael, 2002).

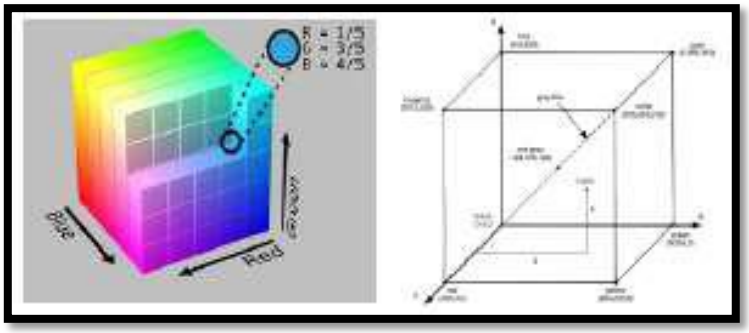

Figure 1. RGB Color Space & Explanation of RGB Space

Digital image processing can be defined as a function of two variables or f(x,y), where the x and y functions are the coordinates of the values and the spatial f(x,y) is the intensity at these coordinates (Waskom, 2021). Where an image is converted to digital form so that it can be stored on computer memory or other media, process image data conversion to digital form can be done using several devices, for example, scanners, digital cameras, camcorders, and so on. Activity Digital image processing is an activity to

improve the quality of digital images so that easily be interpreted by humans/machines (computers) (Zhau, 2020 and Rafael, 2002). Where the input is in the form of an image and the output is also in the form of an image but with quality better than the input image.

Figure 2. Image Processing Workflow

In this study pattern recognition is a grouping of numerical data and symbolic (including imagery) automatically carried out by machines (computers) (Zhau, 2020). Which is the purpose of this grouping is to recognize an object present in a particular image.

Figure 3. Pattern Recognition Workflow

2.1. Singular Value Decomposition (SVD)

Singular value decomposition (SVD) is a method of decomposing something matrix into three matrix components (Baker, 2013), in which one of the matrices the entry is the singular value of the matrix (Guan, 2017). SVD Enter category unsupervised learning (Akter, 2016). In the corresponding order of correspondence singular vector, where the singular value holds very important information about the data, namely the data that contributes the most to the variation of the data in general the whole which is stored in the first singular value (James, 2021). which models decompose a complex matrix data set into its fundamental parts (Kumar, 2021). Redundant data is removed in such a way that list N a unique vector of a matrix can be defined as a linear combination of the dimensions of the vectors less unique. In certain calculations a decomposition of the singular value of matrix $A \in R^{mxn}$ is a factorization $A=U\Sigma V^T$ where:

$$\Sigma=\begin{pmatrix} \sigma_1 & 0 & \dots & 0 \\ 0 & \sigma_1 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \sigma_p \end{pmatrix}$$ with value p= min (m, n) and $\sigma_1 \geq \sigma_2 \geq \dots \geq \sigma_p \geq 0$.

Where U is an orthogonal matrix of size mxm and V is a matrix orthogonal of size nxn. σi for i= 1,2, …, p is called the singular value of A.

2.2. Matrix Laboratory (MATLAB).

Matlab (Matrix Laboratory) is a high-level programming language devoted to the needs of technical computing, visualization, and programming such as mathematical computing, data analysis, algorithm development, simulation and modeling, and calculation charts (Waskom, 2021). Matlab comes with special features for math, physics, statistics, and visualization functions. MATLAB is developed by MathWorks, which was created to provide easy access to the data matrix on the LINPACK and EISPACK projects.

METHOD

SVD is a technique for decomposing matrices of any size (usually a very large size matrix is applied) to make it easier data processing. The SVD result is a singular value stored in a diagonal matrix D. SVD (Singular Value Decomposition) algorithm that can use for pattern recognition of a person's face, namely as follows (Zeng, 2006):

1. The image corresponds to a matrix of size mxn. For example M=mxn and $f_i \forall_i$ is a vector of size Mx1. For example, there are many pattern images faces used as databases. Form a training matrix S=[f_1,f_2,…, f_N].
2. Compute the average face image S, $\bar{f}=\frac{1}{N}\sum_{i=1}^{N} F_i$
3. Compute a difference vector $ai= fi- \bar{f}$; i= 1, 2,…, N
4. Form a matrix A=[a_1,a_2,…,a_N]
5. Calculate the SVD of, namely: $A=U\Sigma V^T$;
6. Compute the scalar projection (face basis difference vector), ie: xi=[u_1,u_2,…,u_r]$^T a_i$;
7. Set ε_{f0} as the maximum allowable face space tolerance and ε_0 as the maximum allowed face tolerance in the database.
8. Enter some images that you want to examine (for example p images), convert these images into the form of a matrix of size mxn, then change the form of this matrix into a matrix of size g (Mxp) as the first step above. Where $M=mxn$.
9. Calculate the scalar projection of the difference vector of the input image onto the face base y_i=[u_1,u_2,…,u_r]^T($g_i-\bar{f}$); for i=1, 2,..., p.
10. Compute the vector projection of the input image difference vector into the face space, ie: f_{pi}=[u_1,u_2,…,u_r]y_i; see explanation below $\forall\ y_i \in R^r$ dan i=1, 2, …, p.
11. The distance from g_i to the face space (the face space relative to the face database in the first step) is the distance between ($g_i-\bar{f}$) and the projection f_{pi}, i.e. $\varepsilon_{fi}=\|(g_i-\bar{f})-f_{pi}\|_2$ =[$((g_i-\bar{f})-f_{pi})^T(g_i-\bar{f})-f_{pi}$]$^{1/2}$ for i=1,2,…,p.
12. If $\varepsilon_{fi}>\varepsilon_{f0}$ (ε_{f0} as specified in step 7 above), then gi is not a face. Stop program. But If $\varepsilon fi \leq \varepsilon f0$ then f is a face, go to step 13.
13. Calculate $\varepsilon_{ij}=\|y_j-x_i\|_2$=[$(y_j-x_i)^T(y_j-x_i)$]$^{1/2}$ for i=1,2,…,N; j=1,2,..,p.
14. Find the minimum εij ($mi(\varepsilon ij)$) for i=1,2,…N

If ($mi(\varepsilon_{ij})$)>ε_0 (ε_0 as specified in step 7 above) for i=1,2,…,N then gj is an unknown face (a face that is not in the database). But if ($mi(\varepsilon_{ij})$)≤ε_0 then g_j is a face that is in the database, as well as f, is the same face as the i^{th} database.

RESULTS AND DISCUSSION

The application to be designed is a facial pattern recognition application for users and then will do a comparison (matching) with sample data contained in the application database to find out the identity that exists in a picture. This human face recognition application requires several parameters such as input data, which consists of sample data i.e. human faces used to form a base on SVD (Singular Value Decomposition) and test image data viz any image that is used to carry out the process of testing the image samples that have been stored in the database. In addition, there are several outputs will be generated.

The process carried out by this application is (1) Initializing image samples contained in the system database; (2) Performing calculations and pattern checks of face

contained in the test image; (3) Making comparisons to the test images and sample images; (4) If there is a match the application will inform the identity someone in the picture. The following is the interface display which is implemented in the Human Face Recognition Application Using the Method Singular Value Decomposition (SVD) in MATLAB.

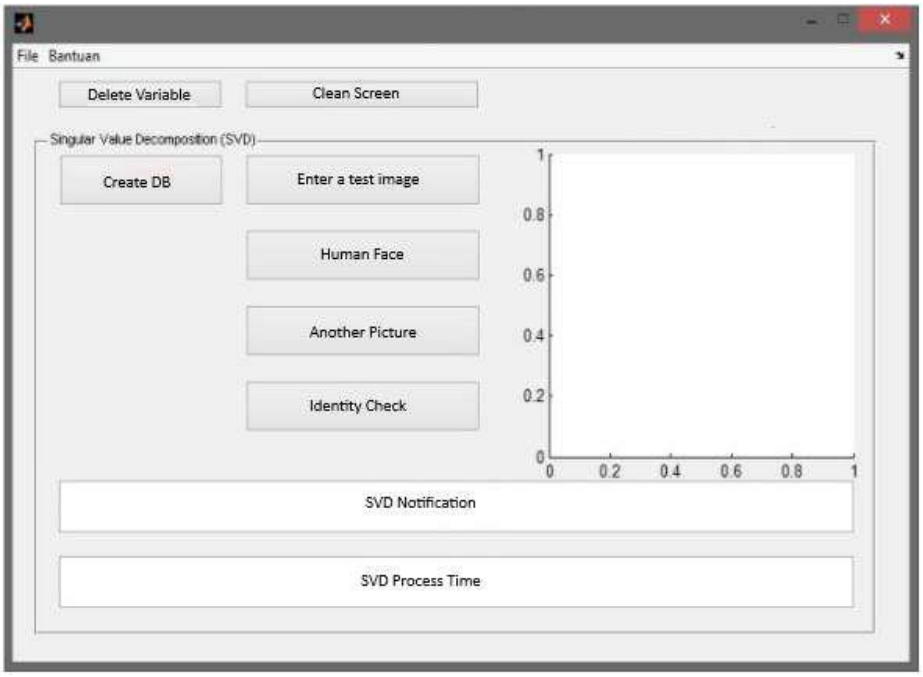

Figure 4. Human Face Recognition Application Interface

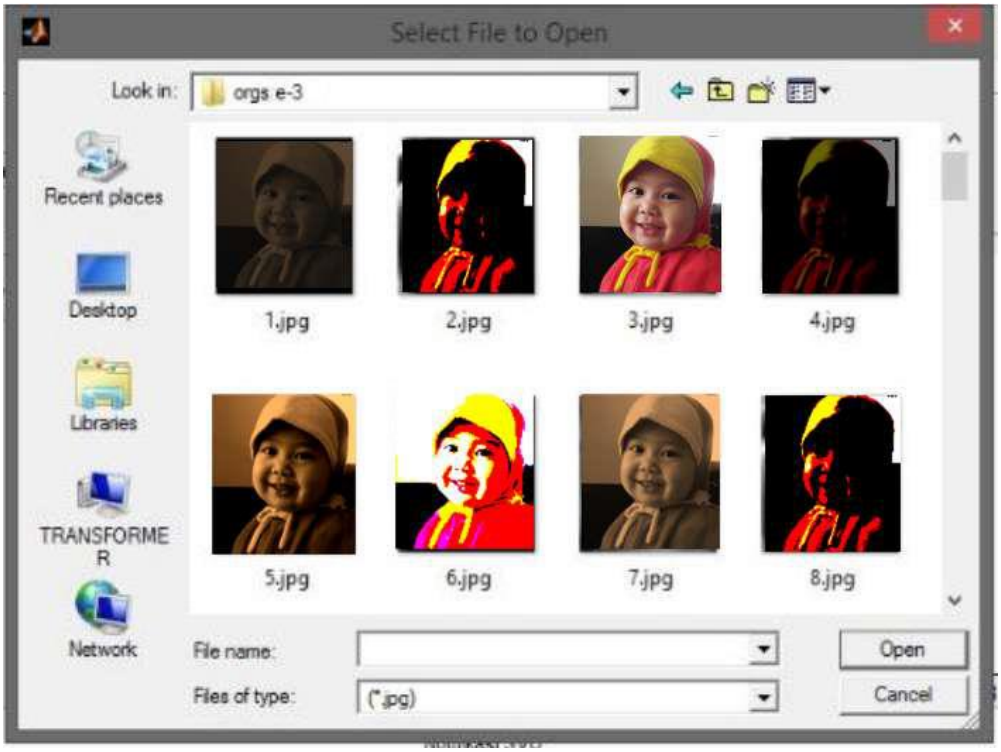

Figure 5. Adding Test Images to the Human Face Recognition Application

The following are some of the tests implemented in the Recognition Application Human Face:

1. Functional Testing on the Application Interface.

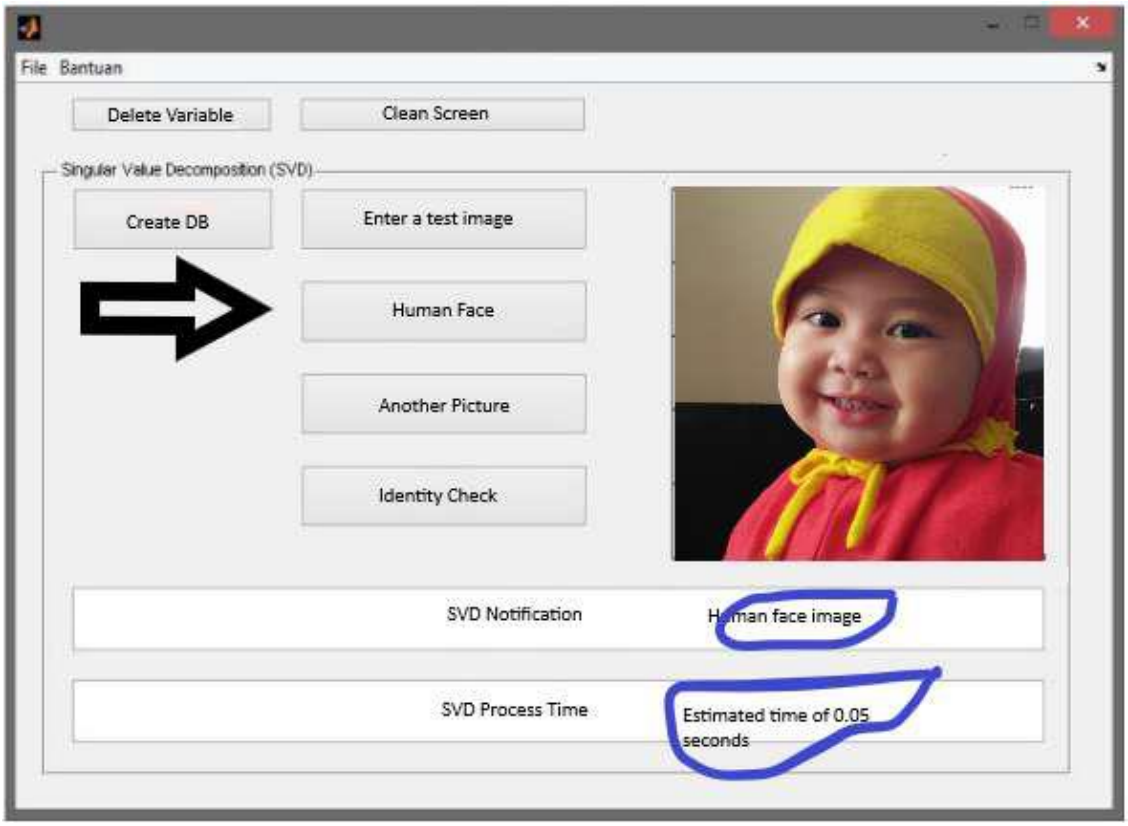

Figure 6. Testing Human Face Images

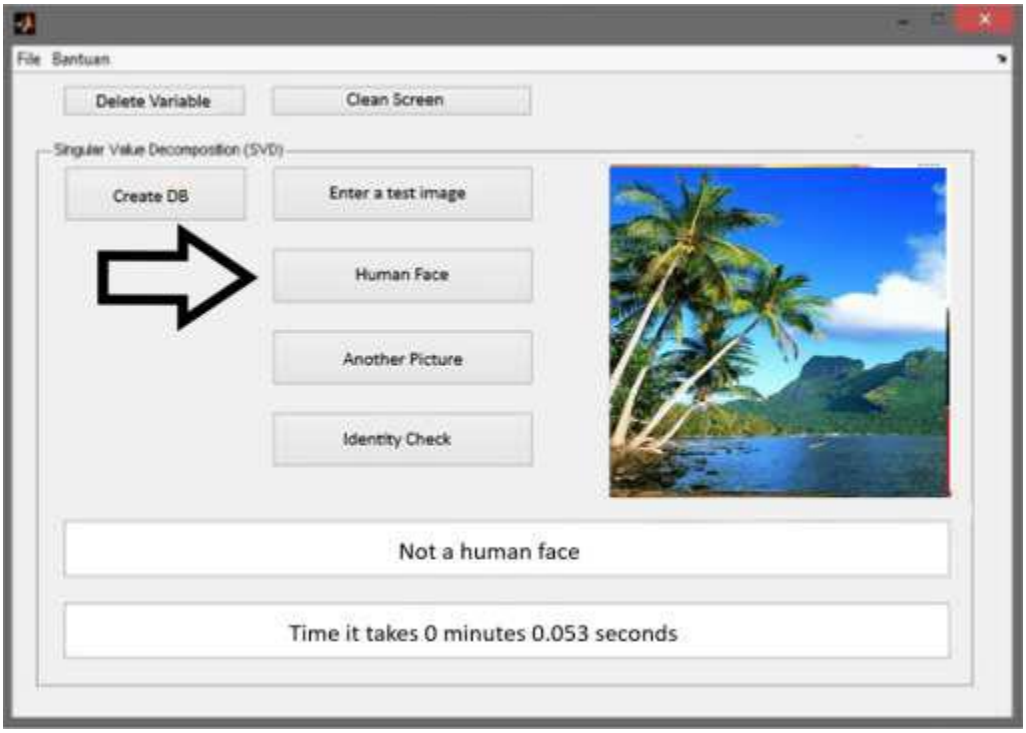

Figure 7. Testing is not an image of a human face

Figure 8. Image Matching with Database

Figure 9. Identification of Human Face Images

2. Testing the Success and Accuracy Levels of Human Face Recognition Applications. The time it takes the system to generate a human face base by calling the function [f, fbar, u, time] = db_form(5, 12, 40, 20) is 5.758 seconds. With the condition that 5 is the amount people contained in the database, 12 is the number of sample images used as a range of facial patterns of each person, and 40 and 20 are the dimensions of each image sample and test images. The percentage of success and processing time required

to recognize human facial patterns to determine the identity of the owner of the current image examined, by calling the following function:
[result, time] = check_face_space(f, fbar, u, xyz, 1800)

Table 1. Percentage of Success Image Recognition As Human Face (%)

*		Error				
		1464	1640	1800	1908	2022
Database to – (amount)	1-10 (100)	70.0768	84.7654	94.3077	96.0001	98.8753
	11-15 (50)	3.0987	5.0000	10.000	12.7890	20.0789
Average facial presentation		63.1755	89.7654	92.8769	89.9780	86.0983

Table 2. Processing Time Image Recognition as a Human Face (seconds)

*		Error				
		1464	1640	1800	1908	2022
Database to – (amount)	1-10 (100)	5.0788	5.0202	5.3077	5.0001	5.8053
	11-15 (50)	1.0987	1.0080	1.0000	1.7890	1.0701
Amount of processing time		6.1775	6.0282	6.3077	6.7891	6.8754

Percentage of success and processing time required in recognizing images face included in the database by function call:
[result, time] = check_db(f, fbar, u, xyz, 1550)

Table 3. Percentage of Success Face Image Recognition in Database (%)

*		Error				
		1550	1650	1800	1908	2022
Database to – (amount)	1-5 (50)	45.0788	47.0202	49.3077	53.0001	59.8053
	6-10 (50)	21.0987	24.0080	26.0300	28.7890	29.0701
Average facial presentation		60.1775	59.0282	54.3077	50.7891	46.8754

Table 4. Processing Time Face Image Recognition in Database (seconds)

*		Error				
		1550	1650	1800	1908	2022
Database to – (amount)	1-5 (50)	0.0788	0.0202	0.3077	0.0001	0.8053
	6-10 (50)	0.0987	0.0080	0.0300	0.7890	0.0701
Amount of processing time		0.1775	0.0282	0.3377	0.7891	0.8754

To be able to recognize the identity of the person contained in the picture as well processing time required by the system, can call the function:

[z, result, time] = check_identity(f, fbar, u, xyz)

and the result (level) of accuracy obtained in recognizing the identity of the person contained in the picture is *90.9567*% with a long processing time of 0.2460 seconds.

CLOSING

After doing several times of testing, this application can run well and can recognize images of human faces. The level of accuracy of this Application after Several trials were carried out as follows:

a. Whether an image is a face or not, up to 92.8769% of the time for 6.3077 seconds with the number of images: 700.
b. A face image is included in the database or not only by 60.1775% in 0.1775 seconds, with the number of faces: 100.
c. A face image that is in the database is the number of people to 90.9567%, in 0.2460 seconds, and the number of faces inside databases of 50.

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