Palmprint recognition using the cosine method

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Abstract. Palmprint Recognition Technology now requires breakthrough identification of diverse people. Palmprint recognition is the right choice of the system, namely the acceptance of biometrics that can be done quickly and cheaply because it has a significant enough media dimension that is difficult to manipulate. The four classifications of the biometric algorithm, the use of matching methods is still less attractive to researchers. In general, the part of the research concern is in the preprocessing and dimension reduction sections. Although researchers more widely use the Euclidean matching method, the selection of cosine methods is worth considering. The cosine method for the palmprint recognition matching process will have a significant effect on increasing the verification value when inserting the use of the contra-variance formulae in the equation. The selected amount of contra-variance is the data of the training. From the results of research that have been carried out, the rate of EER and verification are quite promising. The value of research results can compensate for other researchers in the same field.

1. Introduction
The palmprint recognition is part of the biometrics discipline used to get to know someone through the palm. As with the use of fingerprints, the palmprint recognition is increasingly in demand by researchers when in real life it can be used as a means of identifying evidence of a crime. In America, more than 30% of recent crime can be traced from the mark of the palm and not from fingerprints. Advantages use the palmprint recognition, the process of recognizing someone can run faster by merely waving. Besides that, the identification of palms can be made using low image resolution. As a recognition medium, the palms of the palms are used as feature matching obtained from three specifications: main lines, principal ridge, and bifurcation. Knowing the feature of hands can be done because no one has the same line pattern, even for twins. The different imprint of the hand pattern begin to form when the baby is still in the embryo for the 13th week, and it is correctly printed by the 18th week [1]. For the medical field, the recognition of the palms can be used to diagnose several inherited diseases such as down syndrome, aarskog syndrome, cohen syndrome and fetal alcohol syndrome [2].

There have been several researchers who have contributed to the palmprint biometrics field. Kang stated that the use of image filters was able to improve the performance of retinal biometric systems [3]. Shanmugapriya concluded that the use of the image filter was able to increase the local and global detail value of the palmprint [4]. Sharma proposed using the image filter method to reduce and even eliminate noise in nonlinear mapping [5]. After image normalization, it is necessary to homogenize the position of all images. Sung stated that the right method for normalizing the location of various images is to use Gabor [6]. Along with Sung's opinion, Wang noted that Gabor's use helped strengthen the information feature [7]. The adverse effect of using the Gabor method is the increasing number of images that must be processed. To overcome the Gabor method problem then the dimension reduction process is used. Badrinath prefers the use of the PCA method to dimensions reduction in his research; meanwhile, Aykut suggests using KPCA dimension reduction techniques [8]. After the remaining data is only valuable data, the analysis continues with the matching process. According to Ong, the matching method that
many researchers use in biometrics is the Euclidean technique [9]. The advantage of using the Euclidean technique is the simplicity of the function, the ability to find a different scope of resolution, and excel in completing different models [10]. Until now there are no researchers who claim to identify the object of research correctly without errors successfully. The best way to improve a biometric recognition system is to improve the performance of each stage of classification, starting from the data acquisition process, preprocessing, extracting information patterns, and last is using matching methods. According to Kong, to obtain a biometric system with high accuracy and fast processing, it is necessary to classify algorithmic methods in four stages, namely image acquisition, preprocessing, data extraction, and matching [2]. Zhang said that research that follows the four classifications could accommodate five primary objectives of a biometric system that are to resist changes in illumination, rotation, translation, increasing insignificant the amount of data, and accurate in the matching process [11]. Aykut and Ekinci used the original PolyU database then combined it with the Gabor method [8 x 5], the KPCA dimension reduction technique, and Euclidean matching succeeded to get a verification value of 97.12% [12]. Badrinath and Gupta used morphology method for image enhancement followed by Gabor technique [8 x 5], PCA method, and the Hamming method for matching was able to produce a verification value of 95.409% [13]. Li [14] in a study using binary form data input, then using the Gabor method [6 x 3], PCA applications for dimensional reduction, and the use of weight sum matching techniques managed to obtain research values for EER of 0.03. Finally, Xu [15] used the skeleton method for image enhancement processes, continued the use of Gabor [6 x 6], and the multiple matchers matching method succeeded to gain an error rate of 0.18.

Most researchers only offer algorithms in specific subsections of the overall biometric recognition classification. In this research, the author suggests using a 3W (wavelet, Wiener, weighting) method to improve the appearance of the image. The 3W technique is image filter algorithms that is a combined algorithm consisting of wavelet transforms, Wiener filters, and weighting methods. In general, researchers in the palmprint recognition divide the research subsection into four parts. The warkac method is a term for four algorithmic systems which includes the choice of 3W method, Gabor method, KPCA, and cosine matching. Expected research output is the capability of the system algorithm to obtain a low EER (equal error rate) rate and high verification value.

2. Method
In research, input data using images from PolyU as many as 600 images. Each image has a variation of 9 pieces with a division of 3 for training, three testing, and 3 for evaluating. The simulation process uses Matlab software. The output of the research is the value shown in the table and four biometric curves, namely CMC, ROC, DET, and EPC. As a comparison, at the end of the paper also included a comparison of test scores with other researchers. The sequence of the research was carried out in series as shown in Figure 1.
After the image filter process using the 3W algorithm, the research process is continued using the Gabor method. The orientation parameter and the Gabor scale function to set the reference point for all images. The reference point is needed because of the thousands of images used in the study have different angles and scales so that a method is required to normalize the position of all images. Using the orientation and scale Gabor of [8 x 7] proved to have verification outputs that are suitable for the palmprint recognition [16]. The Gabor process has a negative impact, namely increasing the number of dimensions. The processed image increases by the multiplication between orientation and scale. The increase in the amount of data is identical to the increase in the computational process. A dimension reduction method is used to overcome the problem of large amounts of data which also means to reduce computational processing time. The dimensional reduction is used to eliminate as much unnecessary data as possible while maintaining only essential data. The presence of crucial data in the dimensional reduction process must be able to represent all existing data even though it has been deducted from unnecessary data. By Nibouche, the PCA method is often used by researchers in the palmprint recognition process [17]. In the study, the dimension reduction method used was the KPCA method according to the results of the study [1]. After the data that is left behind is only essential data, the research continues with the matching process. The Euclidean method is a commonly used matching method while in this study, the technique used is the Cosine method from the results of the study [1]. The distance method or matching technique in biometrics is a statistical technique used to evaluate the similarity of training information in impostor and genuine data. If no match is found, then the system is considered superior and vice versa if there is a lot of data compatibility between impostor and genuine then the system is deemed to be weak. According to Kang, in the introduction of the palms, the matching method that is widely used by researchers is the Euclidean method [9]. The advantage of using the Euclidean method is the simplicity of the function, the ability to search for a unique, and robust resolution scope in completing far different models [10]. Although it has advantages, Velasquez stated that the use of the Euclidean method has the disadvantage of not including the scope of correlation attributes which result in no consistency when adding attributes [18]. To overcome the weaknesses of Euclidean, some researchers used other matching algorithms such as the cosine method [19]. Qian [20] stated that there is a similar function between the use of the Euclidean method and cosine. The Euclidean method with cosine angle distance or known as cosine has a comparable measurement value when used in data input less than 128 samples [21]. The cosine matching is used to measure the similarity of two non-zero vectors. This measurement principle of cosine is when measures 0° or does not have an angle then it will have the highest value of 1, whereas if it has an angle it is said to have a value below 1. Two vectors have similarities when the two values are parallel or have an angle difference of 0°, and are supposed to have no similarity when perpendicular. The cosine distance formula can be written in the following equation.

\[ \cos \theta = \frac{A \cdot B}{|A||B|} = \frac{\sum_{i=1}^{n} A_i B_i}{\sqrt{\sum_{i=1}^{n} A_i^2} \sqrt{\sum_{i=1}^{n} B_i^2}} \]  \hspace{1cm} (1)

With \( A_i \) and \( B_i \) are components of vector \( A \) and \( B \) respectively. In research, the cosine method is used to compare data impostor with genuine generated from testing data or evaluating data. The effect of using a covar (contra-variance) values impacts towards better cosine system output. The covar value in research uses training data (\( \xi \)). If the covar value is inserted in Equation (1), the cosine equation becomes the following form.

\[ \cos \theta = \frac{A \cdot \text{covar}(\xi) \cdot B}{|A||B|} \]  \hspace{1cm} (2)

The covar calculations are not given to data testing or evaluating data. The output of the research will be worse when the covar value is allocated to both data.

3. Results and Discussion
The research that discusses matching methods using data from PolyU as many as 600 samples. Compared algorithms include the use of Euclidean techniques, City Block, cosine, Mahalanobis Cosine, Euclidean Modulation, Hausdorff, and Ndistance. The research results are shown in Table 1, and the biometric curves are shown in Figure 2.
Table 1. The research results that involved various distance methods for the palmprint recognition

| Method   | Time (s) | FRR   | FAR   | EER   | Ver. (%) |
|----------|----------|-------|-------|-------|----------|
| Euclidean| 0.73178  | 0.00364 | 0.00407 | 0.00385 | 99.63636 |
| CTB      | 0.71109  | 0.01182 | 0.01190 | 0.01186 | 98.81818 |
| Cosine   | 0.73379  | 0.00273 | 0.00272 | 0.00272 | 99.72727 |
| MahCos   | 0.74022  | 0.00364 | 0.00364 | 0.00364 | 99.63636 |
| ModEuc   | 0.72987  | 0.00364 | 0.00407 | 0.00385 | 99.63636 |
| Hausdorff| 0.71819  | 0.50364 | 0.50385 | 0.50375 | 49.63636 |
| Ndistance| 0.73510  | 0.49727 | 0.49641 | 0.49684 | 50.27273 |

Figure 2. Comparison value of the cosine method with other methods in the form of four biometric curves: (a) CMC (b) DET (c) EPC (d) ROC

Of all the distance methods used, the cosine method has the most prominent research value with an EER rate of 0.00272 and a verification value of 99.72727%. Some other techniques that have verification values above 99% are the use of the Euclidean, MahCos, ModEuc methods. To find out the comparative value of the distance method, the four biometric curves were used to strengthen the research result shown in the Table 1. The curves will reinforce the advantages of the cosine compared other methods. The cosine method with the representation of the green line in Figure 2 shows the superiority method in the four curves. Figure 2 (c), the green line is in the lowest position which means having the smallest error value. This fact is strengthened by the ROC curve in Figure 2 (d) that the green line has the most dominant range of the false accept rate which is close to 1 for all research values. To strengthen the results research, Table 2 shows the results of a study for the use of different distance methods.
4. Conclusions
The choice of 3W, Gabor \([8 \times 7]\), KPCA, and cosine methods can be used as an alternative algorithm in palmprint recognition. The four algorithms used will provide promising research results with an EER value of 0.00272 and verification of 99.72727\%. Especially the use of cosine methods, system performance, will have a significant impact when inserting covar over training data.

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| Research               | Distance | EER     | Verification (%) |
|------------------------|----------|---------|------------------|
| Aykut [8]              | Original | 0.00637 | 99.36364         |
| Badrinath [13]         | Hamming  | 0.02905 | 97.09091         |
| Kushan proposed method | Cosine   | 0.00272 | 99.72727         |

Table 2. Comparative value of matching methods between researchers in palmprint recognition.
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