Palmprint Classification

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Abstract— **In today's world, biometrics system is used almost everywhere for the security and personal recognition. The palmprint is one of the most reliable physiological characteristics that can be used to distinguish between individuals. Palmprint classification provides an important indexing mechanism in a palmprint database. An accurate and consistent classification can greatly reduce palmprint matching time for a large database. We propose a palmprint classification algorithm which is able to classify palmprints into ten evenly-distributed categories (1, 2, 3, 4, 6, A, B, C, D, and E). The algorithm uses a novel representation and is based on a two-stage classifier to make a classification.**

I. Introduction

Today, in our daily life, we are often being asked for verification of our identity. Normally, this is done through the use of passwords when pursuing activities like domain accesses, single sign-on, application logon etc. In the process, the role of personal identification and verification becomes increasingly important in our society. With the onslaught of improved forgery and identity impersonation methods, previous ways of correct authentication are not sufficient. Therefore, new ways of efficiently proving the authenticity of an identity at a low cost are greatly needed.

Various avenues have been explored to provide a solution and biometric-based identification is proved to be an accurate and efficient answer to the problem. Biometrics has been an emerging field of research in the recent years and is devoted to identification of individuals using physical traits, such as those based on iris or retinal scanning, face recognition, fingerprints, or voices[1]-[4]. As unauthorized users are not able to display the same unique physical properties to have a positive authentication, reliability will be ensured. This is much better than the current methods of using passwords, tokens or personal identification number (PINs) at the same time provides a cost effective convenience way of having nothing to carry or remember.

Although there are numerous distinguishing traits used for personal identification, this research will focus on using palmprints to more correctly and efficiently identify different personnel through classification at a low cost.

Palmprint is preferred compared to other methods such as fingerprint or iris because it is distinctive, easily captured by low resolution devices as well as contains additional features such as principal lines. With the help of palm geometry, a highly accurate biometric system can be designed. Iris input devices are expensive and the method is intrusive as people might fear of adverse effects on their eyes. Fingerprint identification requires high resolution capturing devices and may not be suitable for all as some may be finger deficient [5]-[8]. Palmprint is therefore suitable for everyone and it is also non-intrusive as it does not require any personal information of the user [9]-[12]. Palmprint images are captured by acquisition module and are fed into recognition module for authentication [12]-[17]. As shown in Fig.1, recognition module has many numbers of stages which are preprocessing, feature extraction, template extraction as well as matching with the database [18]-[21]. This requires a large amount of time. This makes it important to divide this major category into evenly-distributed subcategories so that the classification process becomes more efficient.

In the current systems [12]-[17], firstly, the user's palmprint is captured by the system. Then, it is compared to every single image in the database, and a result is produced. On the next page, current process will be shown using a flow chart. This process posed some limitations. The captured image had to be compared with every single image in the database. This method takes up excessive amount of resources. Furthermore, it is time-consuming. Even if every comparison of image just takes up a few milliseconds, in this context we are referring to thousands of images. As such, the computational complexity is too high to be practical.

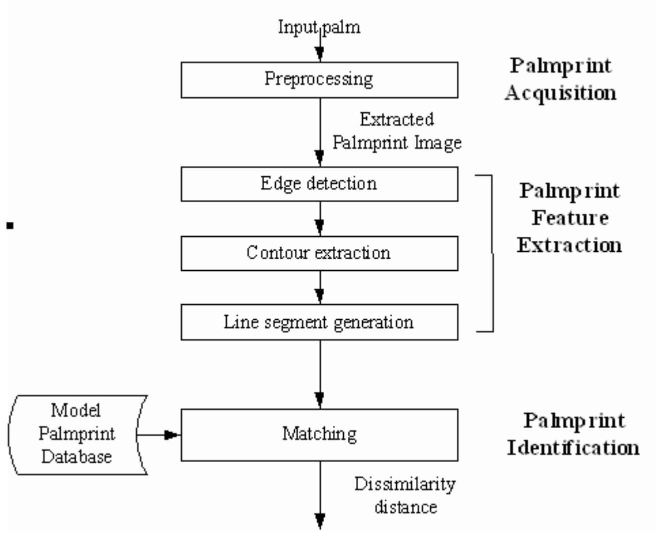

Fig.1. Flow of traditional palmprint matching

Wu *et al* [22] proposed the classification of palmprints using principle lines. The algorithm has the ability to classify low-resolution palmprints into six categories according to the number of principal lines and the number of their intersections. The samples of 6 categories of palmprints are shown in Fig.2. The proportions of these six categories (1–6) from a 13,800 samples database [23] are 0.36%, 1.23%, 2.83%, 11.81%, 78.12% and 5.65%, respectively. The proposed algorithm is shown to classify palmprints with an accuracy of 96.03%.

We did a survey on the people living in Singapore. This includes people from different gender, age groups and nationalities [24]. The survey results show that we could classify the resident's palmprint into 6 different categories. These are mainly palms with one principal line, two principal lines without intersection, two principal lines with intersection, three principal lines without intersection, three principal lines of which two intersects and three principal lines of which all lines intersects each other. They are same as the 6 categories described in [22]. Also, we found that 80% of the residents fall in the 5th category, which matches the distribution in [22].

As illustrated in the following pie chart, which is shown in Fig.3, the six categories of palmprint are not evenly distributed with the main bulk of the samples falling into Category 5. Assuming worst case situation, an input palmprint image falls into Category 5, the matching process may still have to search through 78.12% of the original database samples before finding a match. Therefore in this proposed algorithm, the resulting classification may not reduce search time significantly [25].

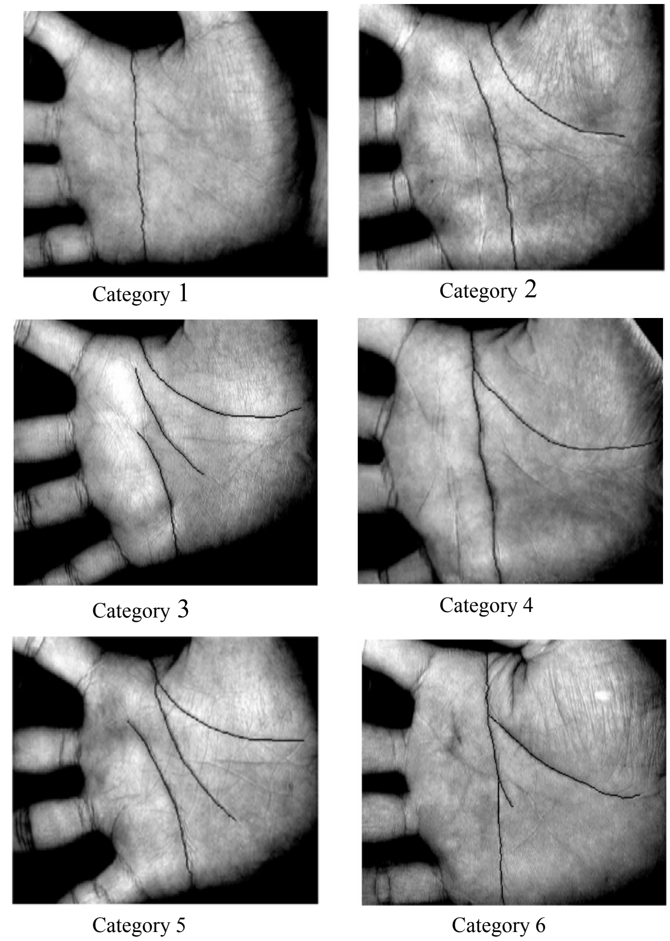

Fig.2. Samples of 6 categories

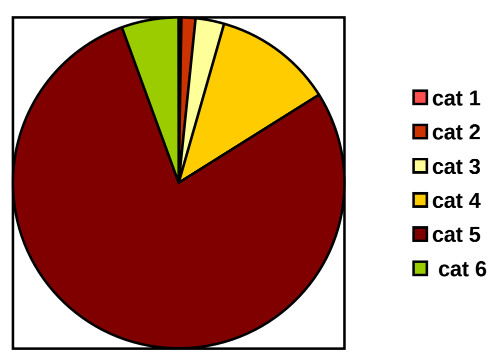

Fig .3. Pie chart of category distribution

As such, in this research we decide to further categorize the palmprints that fall into Category 5 into five sub-categories. The further classification method will be elaborated in section 3. The rest of this paper is organized as follows: Section 2 introduces the structure of the proposed palmprint classification system. The algorithm is discussed in detail in

Section 3. Section 4 presents the results for hierarchical classification. Finally, the conclusion and future work are highlighted in Section 5.

II. SYSTEM OVERVIEW

Previously, Wu *et al*'s [22] proposed classification method divided palmprints into six palmprint categories. This section proposes a novel classification method to further categorize Category 5 of the previous classification into five sub-categories, which are shown in Fig. 4.

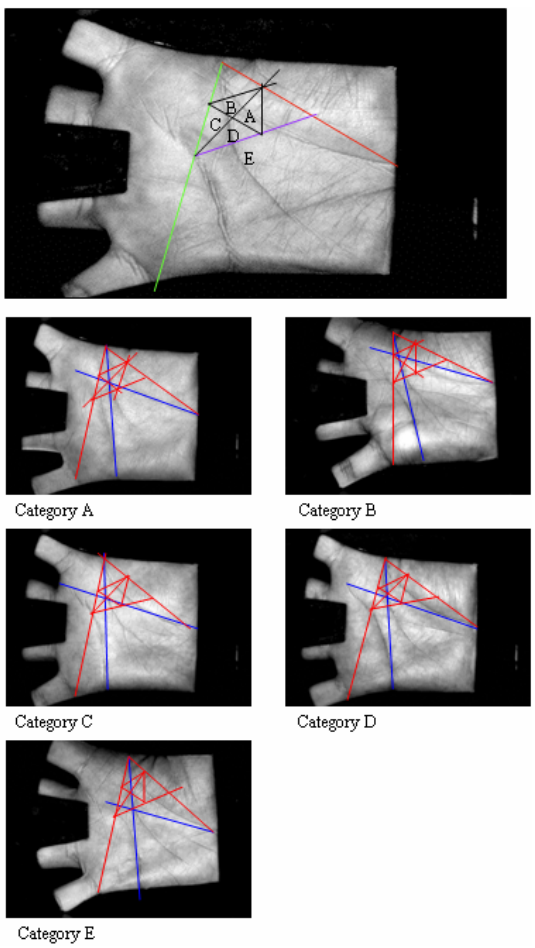

Fig.4. Proposed five categories

At the top of Fig 4, the various categories from A to E are shown there. It can be seen that the triangle at the top right hand corner is A, top left hand corner is B, bottom left hand corner is C, bottom right hand corner is D and finally anything outside these 4 triangle is considered E.

Flowchart in Fig. 5 shows the new process after importing the proposed hierarchical classification technique into the matching system. Firstly, the image is captured via a palmprint capturing device. After the palmprint is captured, it is matched with the algorithm described in [22]. It has been mentioned earlier that 78% lie in the category 5 while the rest lie in different categories. In the decision making process, the input palmprint image will be categorized with Wu's classification method and if it falls into Category 5, the image will be further sub-categorized into A, B, C, D or E. Fig.6 illustrates the relationship between the categories and sub-categories. Matching will be done with the same fining category in the database.

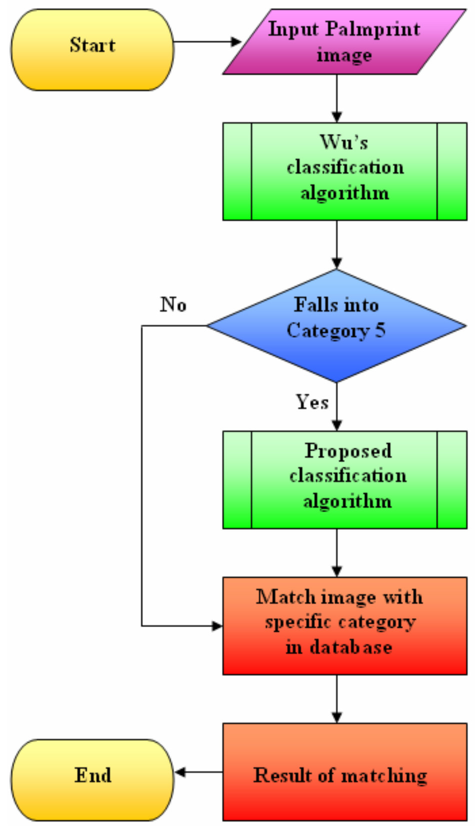

Fig.5. Block diagram of proposed palmprint matching system

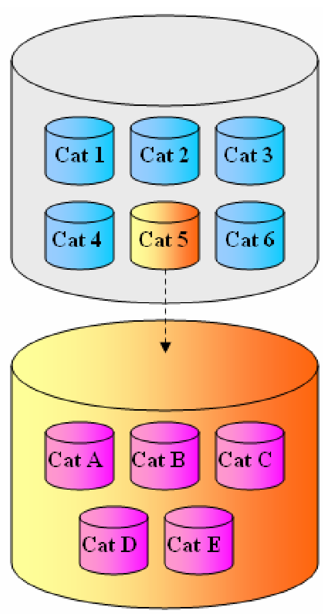

Fig.6. Categories and sub-categories

III. PROPOSED SECOND-STAGE CLASSIFICATION ALGORITHM

A. *Definition and notations of key lines and key points*

In this report we are concerning with three main lines on the palm namely life line, heart line and head line [26]. For clarity purposes, the convention for the rest of this paper will follow the diagrams below and the notations are defined on each line and each point.

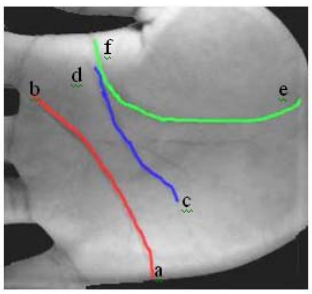

Fig.7 Principle lines

In Fig. 7,

- Line *ab* represents the heart line
    - a is start of heart line
    - b is end of heart line
- Line *cd* represents the head line
    - c is start of head line
    - d is end of head line
- Line *ef* represents the life line
    - e is end of life line
    - f is start of life line

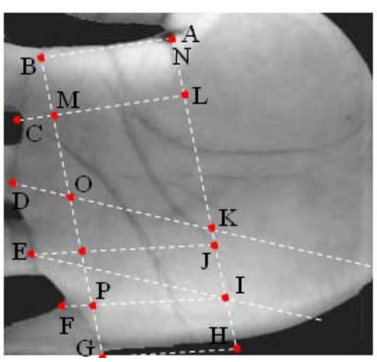

Fig.8. Key points notation

In Fig.8,

- AB is parallel to CL
- DK is parallel to EI
- FI is parallel to GH and EJ
- AH is parallel to BG

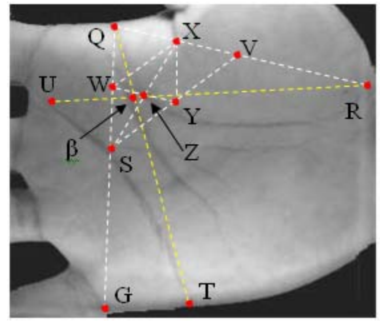

Fig.9. The points needed to do the sub-categorizing

B. *Construction of boundaries*

As mentioned earlier, Category 5 is subdivided into 5 categories A, B, C, D and E, depending on where the intersection point β falls in. The definition of the location of β is demonstrated in Fig.9. The sub-categories A, B, C, D and E, are defined in Table 1 and shown in Fig. 10.

TABLE 1
DEFINITIONS OF BOUNDARY OF EACH SUB-CATEGORY

Category	Falls in
A	XYZ
B	WXZ
C	SWZ
D	SYZ
E	Not in A, B, C or D

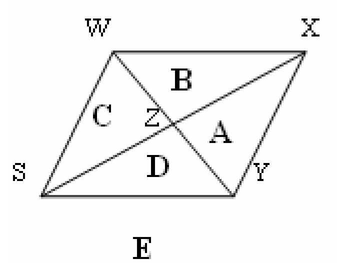

Fig.10. Boundaries

Based on the proposed algorithm, the task of locating the boundaries can be divided into four steps:

Step 1: Locate points G, Q, R, T and U.
(G is the point on the last finger)
(Q is the intersection of heart line and head line)
(R is the end of the life line)
Plot out the lines GQ and QR
Locate point S
(S is the intersection of GQ with heart line as shown in Fig.11 (a))

Step 2: Calculate, midpoint V of QR, midpoint X of QV, midpoint W of QS, midpoint Y of SV, intersection point Z of SX with WY as shown in Fig. 9(b).

Step 3: Calculate, intersection point β of TQ with RU as shown in Fig.10(c).

Step 4: Calculate the gradients and constant C for lines of equation for WY, SX, WX, XY, SY and SW. Using substitution method, find out which region point β lies in.

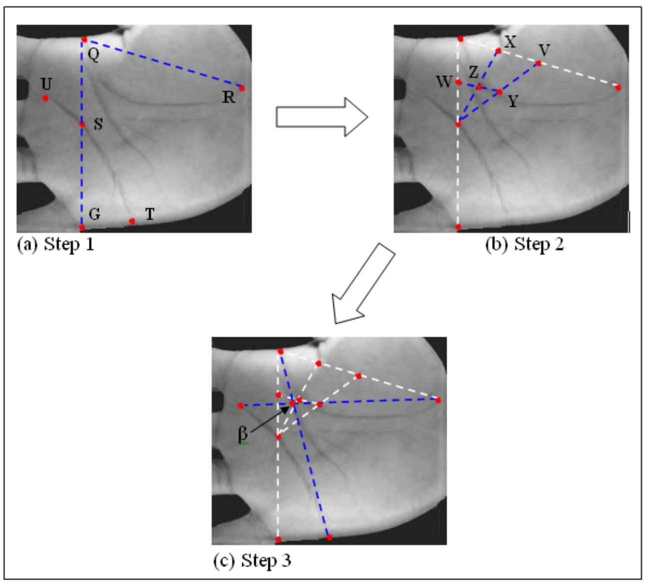

Fig.11 Steps of sub-classification

IV. Results

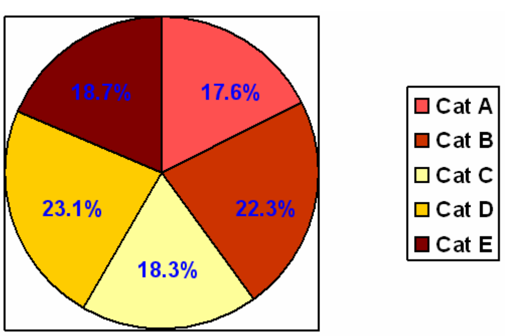

Fig. 12 Results of distribution of sub-categories

We report the results of our classification algorithm on the 500 palmprint database for the second stage palmprint classification. The pie chart shows the percentage of palms lies in which category. As you can see, the result is well-distributed. Among all the samples belong to category 5, 17.6% of them belong to category A, 22.3% of them to category B, 18.3% of them to category C, 23.1% of them to category D, and 18.7% of them to category E. This affirms the effectiveness of the algorithm. It can be concluded that the algorithm is successful and can be implemented into current palmprint matching systems.

V. Conclusion

Palmprint classification provides an important indexing mechanism in a palmprint database. An accurate and consistent classification can greatly reduce palmprint matching time for a large database. Automatic classification of palmprints is a difficult problem because of the selection of even-distribution signatures. The proposed two-stage classification algorithm gives even-distributed categories than the work reported in the literature. The novel representation scheme is directly derived from principal line structures. The representation does not use wrinkles, and singular points. It is capable of tolerating poor image quality. We have tested our algorithm and a very good performance has been achieved (0.36% for 1st category, 1.23% for 2nd category, 2.83% for 3rd category, 11.81% for 4th category, 5.65% for 6th category, 13.75% for category A, 17.42% for category B, 14.30% for category C, 18.05% for category D, and 14.61% for category E). These results are encouraging to reduce the computational complexity of the current palmprint matching program by 80% and the scheme will be tested in palmprint matching system.

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