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Article Title: Revolutionizing Palm Print Recognition with Advanced Sift-Based Feature Analysis Techniques

Revolutionizing Palm Print Recognition with Advanced Sift-Based Feature Analysis Techniques

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ABSTRACT

Palm print recognition has emerged as a robust biometric authentication method due to its distinctiveness and reliability. This paper explores the revolution in palm print recognition driven by advanced feature analysis techniques, focusing on the integration of sophisticated preprocessing and feature extraction and classification methods. Effective palm print recognition relies heavily on preprocessing technique such as noise reduction, contrast enhancement, and image filtering. Thus, this study emphasize the role of Gabor filter excel in image processing by effectively capturing spatial frequency and orientation information. The paper highlights the use of Local Ternary Patterns (LTrP) and Local Modified Ternary Patterns (LMTrP) to enhance the accuracy and robustness of feature extraction in palm print matching and identification. Additionally, the Scale-Invariant Feature Transform (SIFT) used to further strengthens the system by providing further enhancing the reliability and rotation. Moreover, this paper implemented by using python programming language. Overall, this work provides insights into their combined impact on the accuracy and reliability of palm print recognition systems, marking a significant advancement in biometric authentication technology.

Keywords: Palm print, Scale-Invariant Feature Transform, Gabor filter, Local Ternary Patterns, Local Modified Ternary Patterns.

1 Introduction

Biometric identification technology employs human physical traits or behavioural features for verifying identity. Biometric features such as, fingerprints, palm prints, and palm vein patterns offer unique benefits in terms of distinctiveness, ease of collection, and stability. Recently, palm print recognition as a biometric method has become more popular compared to other biometric traits; the palm print approach is regarded as one of the most efficient means for enhancing an individual's authentication security [1-2]. Palm print recognition has attracted growing attention and has become a major area of research as a reliable means of personal recognition. The efficacy of any palm print recognition system primarily relies on the efficiency of the employed feature extraction technique. Biometric identification using palm prints is considered one of the most effective and dependable authentication methods relative to other physical attributes. It offers numerous benefits: low expense, convenience of use, public acceptance, and greater uniqueness. [3-4]

To optimize these systems, preprocessing techniques are fundamental in enhancing image quality and preparing data for analysis. Preprocessing techniques including noise reduction, contrast enhancement, image filtering, are crucial for developing any biometric system as they are require to eliminate noise and enhance the clarity of the palm image [5]. Pre-processing in a palm print system involves isolating the most significant area on the palm surface, which contains the most relevant information. In preprocessing image filtering technique used for modifying an image's appearance by changing the colors of its pixels. Image filtering such as, mean filtering, Gaussian filtering median filtering etc. [6-7]. While median filtering is notable for its effectiveness in maintaining sharp boundaries and managing outliers successfully reducing noise. Nevertheless, this technique cause a potential loss of details. Mean filtering provides straightforwardness and effectiveness in reducing noise, making it ideal for real-time applications and rapid processing. However, it affect a potential for blurring or losing fine details. Gaussian filters smooth images effectively while preserving edges, but they also blur fine details and reduce sharpness. [8-9].

To address these challenges, preprocessing image filtering explore the Gabor filter in palm print recognition because they capture detailed texture information at multiple scales and orientations. Gabor filters are robust to changes in lighting and scale, enhancing their performance in varying imaging conditions. Their robustness to noise and variations in illumination further enhances the accuracy of recognition systems.

By utilizing Gabor filters in the frequency domain and combining them with feature extraction methods. Some feature methods such as Local Binary Patterns (LBP), Local Difference Patterns (LDP), etc. While LBP method captures local texture information by comparing pixel values to their neighbors and encoding comparisons as binary patterns. It is highly effective in distinguishing fine texture variations and is robust to minor changes in illumination. However, LBP struggle with rotational variations and produce large feature vectors that are computationally expensive to handle [10-11]. LDP enhance the texture representation by capturing directional information from local regions, making it particularly adept at handling rotational and scale variations. But it is more complex and computationally intensive, requiring careful parameter tuning and potentially leading to longer processing times.[12-13] Consequently propose both LTrP and LMTrP methods that used to enhance palm print recognition systems by providing richer and more detailed representations of palm print patterns, which lead to improved accuracy and robustness in palm print matching and identification. LTrP technique better to noise and variations in illumination, providing a more robust representation of the palm print texture. LMTrP provide a richer and more

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comprehensive feature representation, leading to higher recognition performance, especially in applications involving palm print of varying scales and conditions.

Additionally, combine the feature extraction techniques in revolution of palm print recognition systems to achieve more precise and reliable identification. Oriented FAST and Rotated BRIEF (ORB) is enhance speed and computational efficiency, making it ideal for applications requiring rapid processing. However, ORB not perform to handling significant scale changes and sometimes produce less distinct feature points. Speeded-Up Robust Features (SURF) is another technique to faster and more efficient, using a simpler and faster approximation for feature detection and description. But it not achieve the same level of precision in detecting intricate details.[14-15] To tackle this issues initiate a SIFT feature extraction method helps in identifying key points and descriptors that remain consistent despite changes in scale or rotation, further enhancing the reliability of the recognition system. Its ability to maintain performance across different scales and orientations ensures that SIFT handle a wide range of palm print variations, making it a reliable choice for robust and precise identification in practical applications.

This study advances palm print recognition by integrating several key innovations. First, it applies Gabor filters for detailed texture analysis, improving robustness to lighting and scale variations. By combining these filters with advanced texture methods LTrP and LMTrP further enhances texture representation, making the system more resilient to noise and varying conditions. Additionally, the study SIFT to ensure accurate and efficient recognition across different scales and orientations. These contributions collectively improve the accuracy, robustness, and speed of palm print recognition systems.

2 Proposed System Description and Modelling

Block Diagram

Palm print recognition provides a secure and user-friendly method for biometric authentication, utilizing the unique patterns in each person's palm. It offers a high level of accuracy and is difficult to forge, enhancing security. The process is quick and non-invasive, making it suitable for various applications. Overall, palm print technology enhances security and personal identification in various applications, from access control to forensic investigations. Figure 1 illustrates the sequential process of the palm print recognition system, highlighting each key step involved in achieving accurate and reliable biometric authentication.

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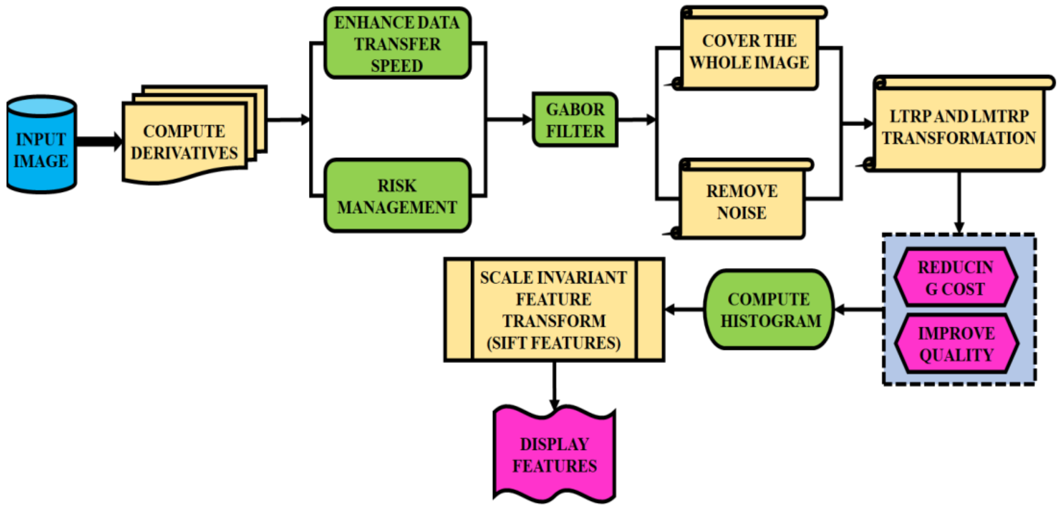

Figure 1: *Block Diagram of Proposed System*

The palm print recognition process involves several sequential steps. It begins with image acquisition, capturing high-resolution palm images. Preprocessing includes reducing noise and improving contrast to ensure image sharpness. Next, derivatives of the image are calculated to speed up data processing and manage risk. A Gabor filter is then applied to eliminate noise throughout the image. For feature extraction, LTrP and LMTrP are used, balancing cost and quality. A histogram of the images is computed to give a comprehensive view of the palm texture. SIFT is utilized to identify and describe robust features that are resistant to scale and rotation changes. Finally, the system visualizes these features for precise matching and verification. This approach is designed to improve both the efficiency and accuracy of palm print recognition, providing a dependable solution for biometric applications.

The following discussion covers preprocessing with Gabor filters, feature extraction with LTrP and LMTrP, and classification using SIFT.

2.1 Preprocessing Based Gabor Filter

Gabor filters are particularly effective in capturing texture and edge information by analyzing variations in spatial frequency and orientation. In palm print recognition, preprocessing using Gabor filters is a powerful technique for enhancing image quality and extracting crucial features. It is not only a common technique for enhancing palm print images but also for extracting texture features from the images. Addressing the challenge of configuring the Gabor filter's parameters improve the efficiency of the Gabor filter bank for palm recognition. Gabor functions create filters with various scales and orientations based on different parameters, optimizing the filtering process. Moreover, the larger kernel size of the Gabor filter is advantageous for examining the structure of palm print primary vein information from palm

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print images. As a result, palm print recognition systems benefit from improved accuracy and reliability, especially in scenarios where image quality compromised by variations in lighting or resolution. This approach provides greater resilience to rotational variations in palm print images compared to using a single value. These techniques enhance image quality and improve recognition performance. The Gabor filter formula expressed as:

$$G = exp\left(-\frac{x\prime^2+\gamma^2 y\prime^2}{2\sigma^2}\right) sin\left(2\pi\frac{x\prime}{\lambda}+\psi\right) \quad (1)$$

This technique is advantageous because it improves robustness to noise and variations in illumination, leading to more accurate and reliable feature extraction for biometric applications.

2.2 Feature Based LTRP and LMTRP

LTrP is enhanced by a modification that increases its resistance to noise and lighting changes, further refining texture representation. The LTrP approach generally involves calculating a texture pattern for each pixel by examining its surrounding area, enabling the system to capture local variations and distinctive features of the palm print. Histograms from local regions of LMTrP are collected and merged into a unified feature vector to characterize the image. Subsequently, kernel linear discriminant analysis is applied to the feature vector for dimensionality reduction. LMTrP-based palm print recognition is highly distinctive and less affected by minor misalignments. For palm print feature representation, line-shaped filters are used, and local region histograms of LMTrP are compiled into one feature vector. To improve discriminative power and reduce storage requirements, dimensionality reduction techniques are applied to the feature vector.

LTP horizontal and vertical direction formulated as,

$$I_h^{n-1}(g_c) = I_h^{n-2}(g_h) - I_h^{n-2}(g_c) \quad (2)$$

$$I_v^{n-1}(g_c) = I_v^{n-2}(g_v) - I_v^{n-2}(g_c) \quad (3)$$

Where, g_h represent the horizontal direction of g_c, and g_v represent vertical direction of g_c.
LMTrP horizontal and vertical direction formulated as,

$$I_h^{n-1}(g_c) = \frac{\left(\sum_{R=1}^{m_1} I_h^{n-2}(g_{\beta,R}) + I_h^{n-2}(g_c)\right)}{N_1+1} - \frac{\sum_{R=1}^{m_2} I_h^{n-2}(g_{\theta,R})}{N_2} \quad (4)$$

$$I_v^{n-1}(g_c) = \frac{\left(\sum_{R=1}^{m_1} I_v^{n-2}(g_{\beta,R}) + I_v^{n-2}(g_c)\right)}{N_1+1} - \frac{\sum_{R=1}^{m_2} I_v^{n-2}(g_{\theta,R})}{N_2} \quad (5)$$

Where, m_1 denotes the thickness of adjacent pixel g_c along the β direction, and m_2 represent the thickness of adjacent pixel of g_c along the θ direction.

LTrP offers robustness to noise and illumination changes, while LMTrP provides a richer and more detailed feature representation, particularly useful for varying scales and conditions.

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2.3 Feature Extraction Based Sift

SIFT is an advanced algorithm used to detect and describe distinctive key points across varying scales and orientations. This method is particularly valuable in palm print analysis due to its ability to handle variations in scale, rotation, and image quality. SIFT provides a set of unique descriptors that are highly effective for matching and classifying palm print. In palm print recognition, SIFT's robustness is crucial for accurately detecting and describing key points, even under different conditions of finger pressure and noise. The SIFT detector is utilized on high-contrast fingerprints that have undergone preprocessing procedures such as noise reduction, thinning, expansion, and enhancement. The enhanced SIFT detector then identifies a refined set of reliable key points, providing detailed and accurate descriptions of palm print features. This approach ensures that the SIFT algorithm effectively utilized for diverse computer vision applications, including object detection, recognition, and image retrieval, by improving the robustness and precision. SIFT formula expressed as,

$$Sift = \frac{1}{k}\sum_{i=1}^{k} d(p'_i, q'_i) \quad (6)$$

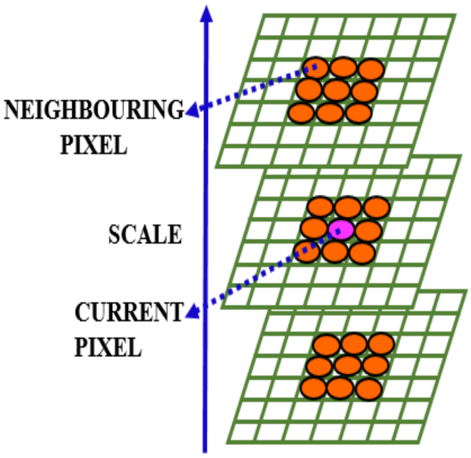

Figure 2: *SIFT diagram*

Overall, the above techniques contribute to a more accurate and robust palm print recognition system by addressing different aspects of preprocessing, feature extraction and pattern analysis.

3 Results And Discussions

The overall work focuses on improving palm print recognition systems through an approach that integrates advanced preprocessing, feature extraction techniques. Initially, high-resolution palm images are captured and preprocessed using Gabor filters to enhance image quality and

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reduce noise. Feature extraction is performed with LTrP and LMTrP to provide detailed and robust texture representations. SIFT is then used for accurate feature extraction and matching, ensuring reliable identification despite variations in scale and rotation. This integrated approach enhances the efficiency, accuracy, and robustness of palm print recognition, making it a dependable solution for biometric authentication in various applications.

Figure 3: *Input Image*

Figure 3 represent the input image of original visual data in palm print, which is employed to analysis, serving as the foundation for extracting unique features essential for accurate identification.

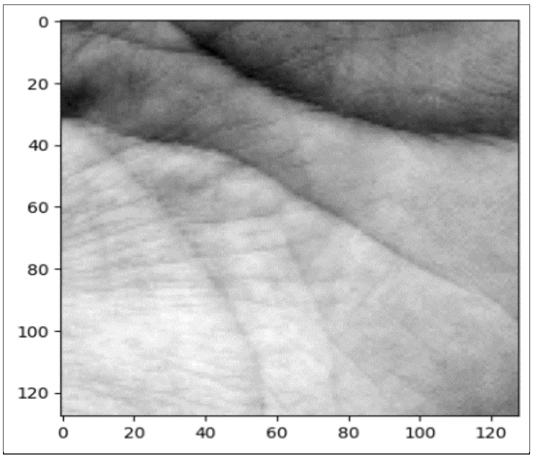

Figure 4: *Gray scale Image*

Figure 4 describe a grayscale image, it is a digital picture where each pixel represents different shades of gray, from black to white. In contrast to color images, which use several channels (such as red, green, and blue) to depict various hues, grayscale images consist of a single channel.

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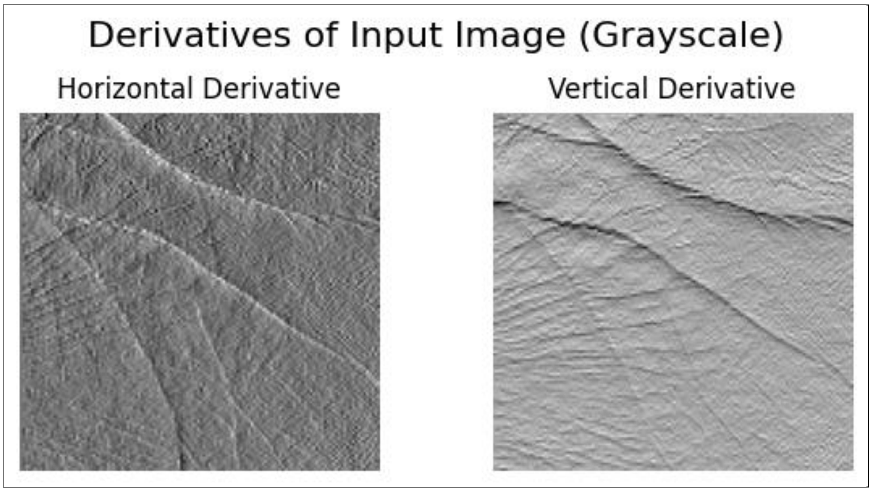

Figure 5: *Derivatives of input Image*

Figure 5 represent the derivatives of input image to detect changes in intensity and highlight features like edges. Horizontal derivatives identify vertical edges by measuring intensity changes across columns, while vertical derivatives reveal horizontal edges by measuring changes across rows. This way, horizontal derivatives detect vertical features, and vertical derivatives detect horizontal features.

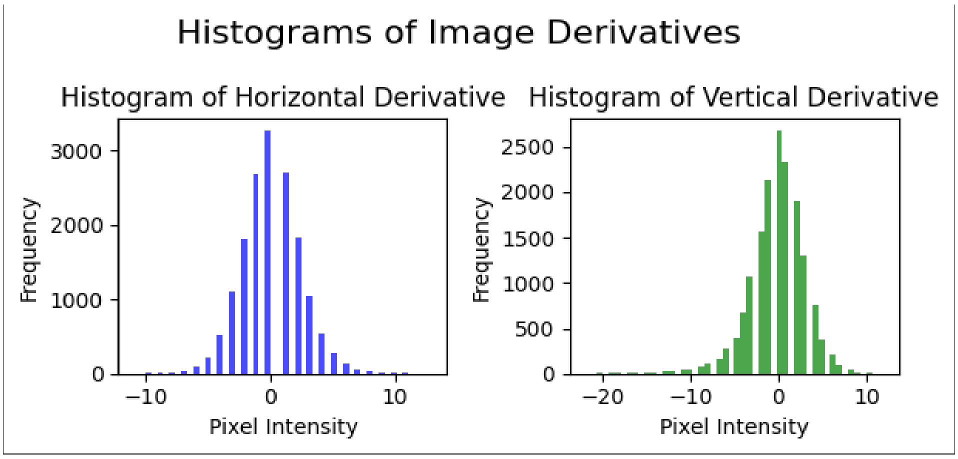

Figure 6: *Histograms of image derivatives*

Figure 6 analyze a histograms image derivatives visual charts that represent the spread of gradient values calculated from an image's horizontal or vertical derivatives. These charts reveal how often various gradient magnitudes occur, offering insights into the image's texture and edge properties.

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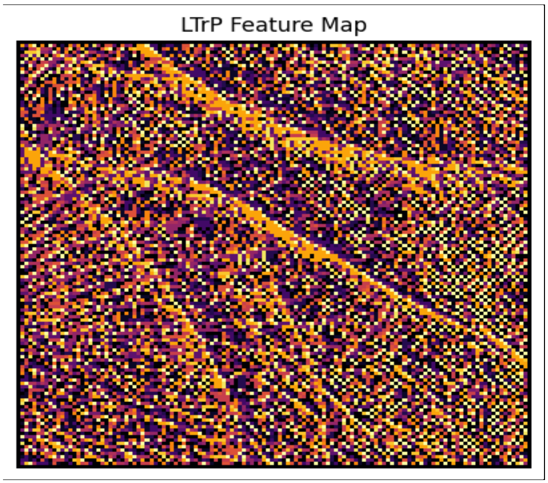

Figure 7: *LTrP Feature Map*

Figure 7 illustrate the LTrP feature map in image processing designed to capture local texture details by examining variations in pixel intensity. It enhances the Local Binary Pattern (LBP) method by using a ternary (three-valued) encoding system.

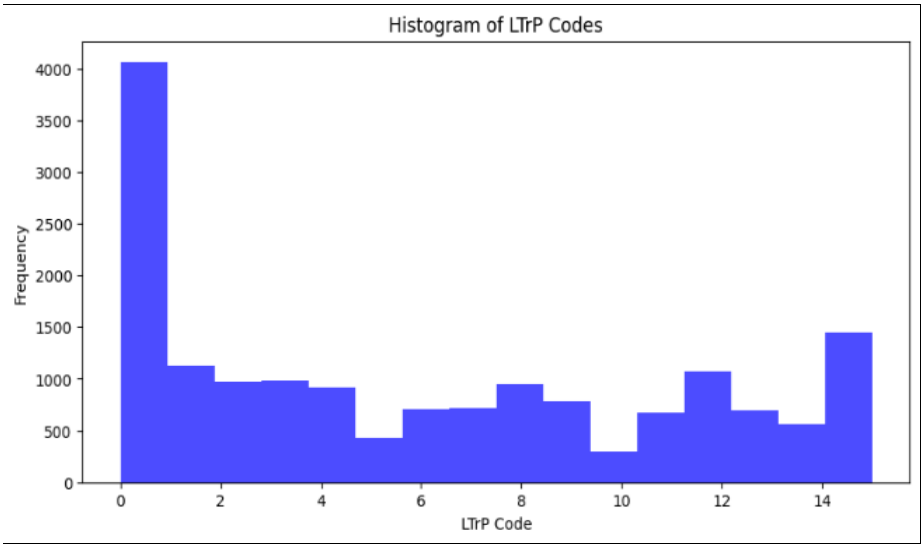

Figure 8: *Histogram of LTrP Codes*

Figure 8 represent histogram of LTrP codes visualization that outlines the spread of local ternary pattern codes throughout an image. It consolidates the count of each ternary code, reflecting texture details and local differences.

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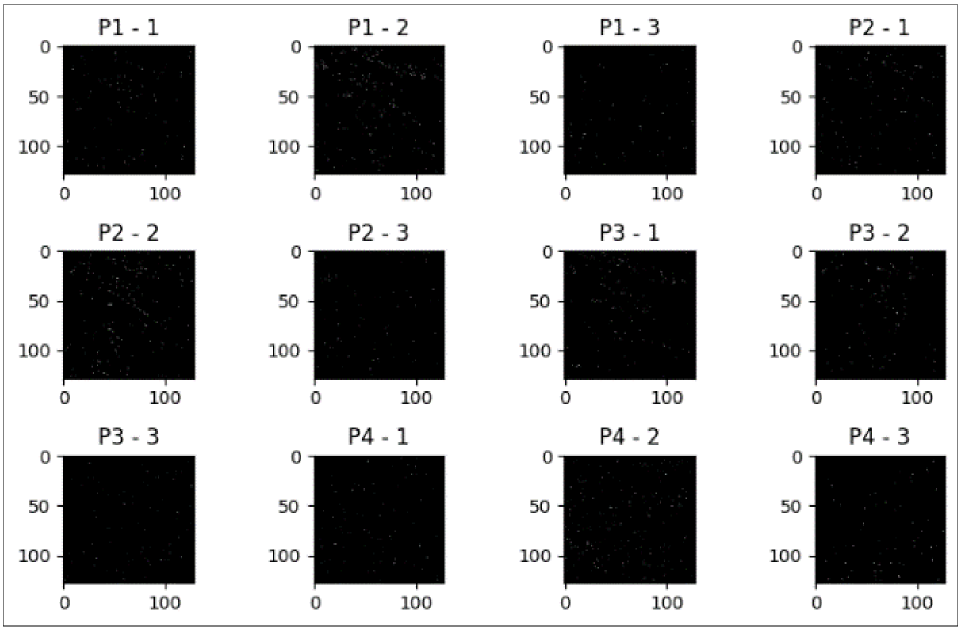

Figure 9: *Features of LTrP*

Figure 9 characteristics of LTrP, its capability to capture intricate texture details by translating pixel intensity variations into a ternary format. LTrP builds upon the LBP approach by employing three intensity levels—lower, higher, and similar—offering resilience against noise and fluctuating lighting conditions.

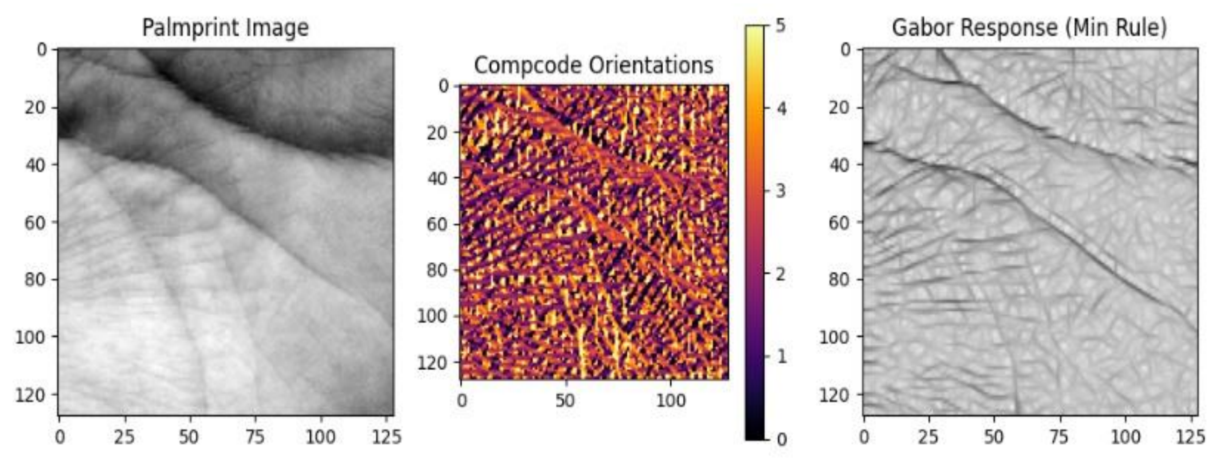

Figure 10: *Gabor Response*

Figure 10 display a Gabor response it's analyze to spatial frequency and orientation in image, effectively capturing texture and edge information by applying a sinusoidal wave modulated by a Gaussian envelope.

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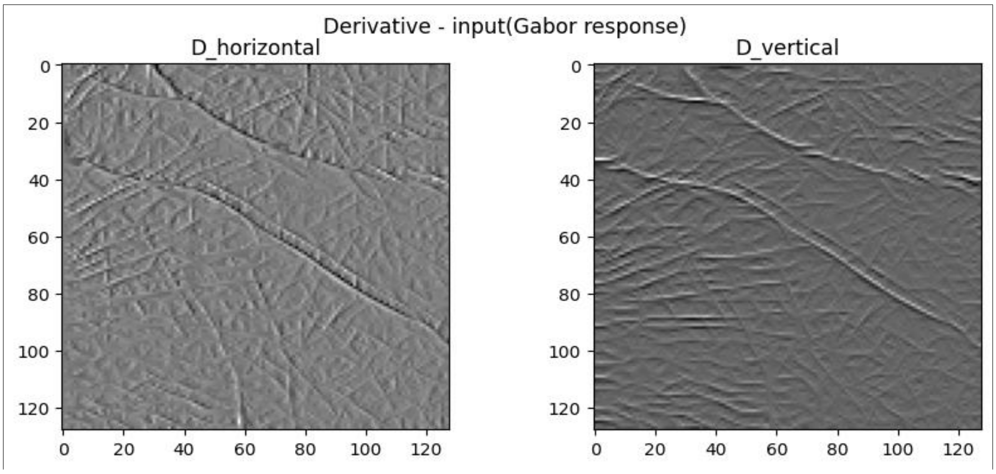

Figure 11: *Derivatives input (Gabor response)*

Figure 11 context of Gabor responses, derivatives of the input involve computing gradient data from the results of Gabor filters. When used on an image, Gabor filters generate outputs that emphasize particular frequencies and orientations.

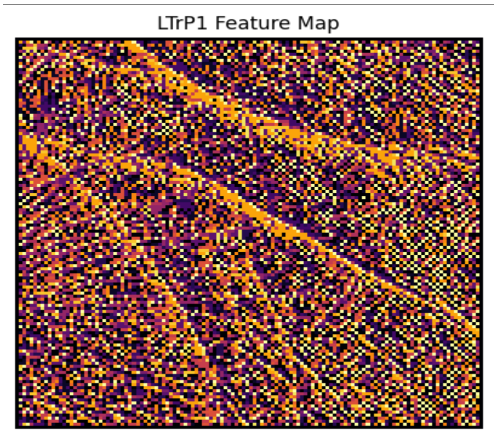

Figure 12: *LTrP1 Feature Map*

Figure 12 shows LTrP1 feature map version of the LTrP technique that emphasizes capturing local texture details in an image. This detailed texture representation is crucial for improving the accuracy and robustness of palm print recognition.

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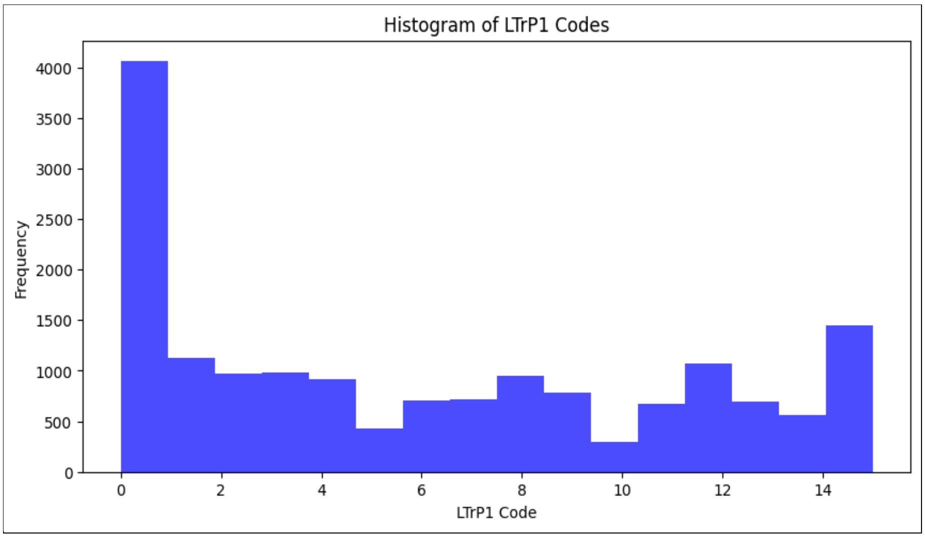

Figure 13: *Histogram of LTrP1 Codes*

Figure 13 represents distribution of local ternary pattern codes from the LTrP1 feature map, that illustrated by data visualization, known as the histogram of LTrP1 codes. It provides a summary of local texture variations and patterns by measuring the frequency of each ternary code across the image.

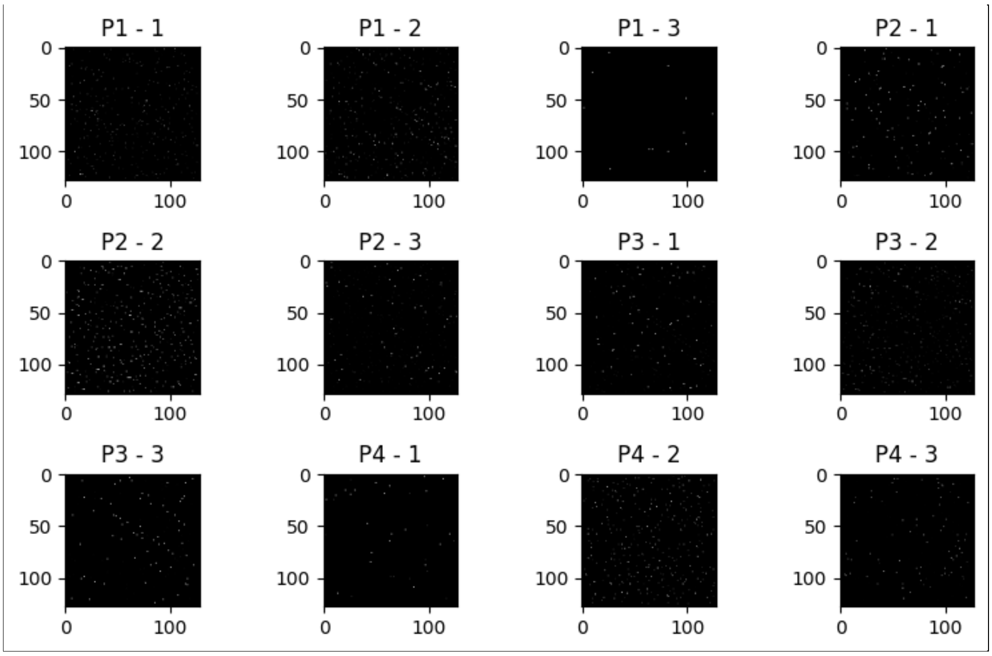

Figure 14: *Features of LTrP1*

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Figure 14 denotes LTrP1 texture analysis method that captures detailed local texture information by encoding pixel intensity variations into a ternary format.

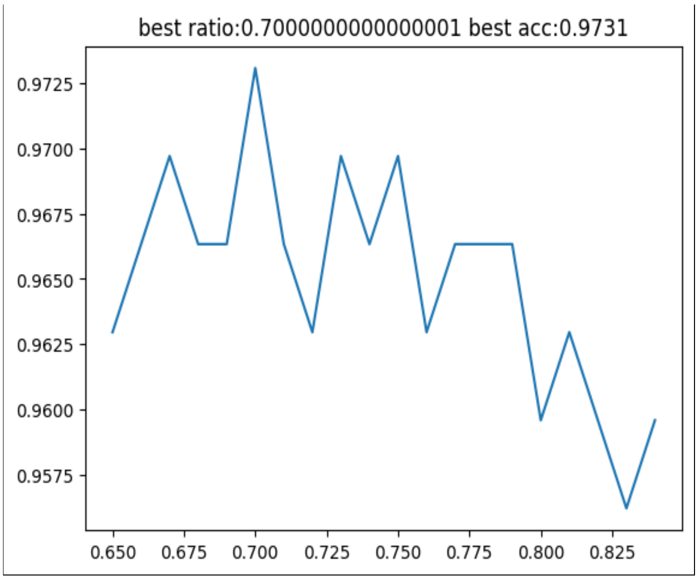

Figure 15: *Output*

Figure 15 represent the graph of the accuracy achieved in 97%, reflecting a high degree of effectiveness in the assessed metric. This high accuracy indicates that the palm print recognition system performs exceptionally well in correctly identifying and verifying palm prints, underscoring the effectiveness of the employed methods and techniques.

Table 1: *Comparison analysis of accuracy in palm print recognition*

Method	Accuracy
ORB [14]	87.51%
DenseNet201 [14]	92%
SIFT	97%

Table 1 represent an accuracy contrast of palm print recognition. From the table that the, SIFT model exceeds ORB [14] model and DenseNet201 [14] model in relation to accuracy with a rate of 97%.

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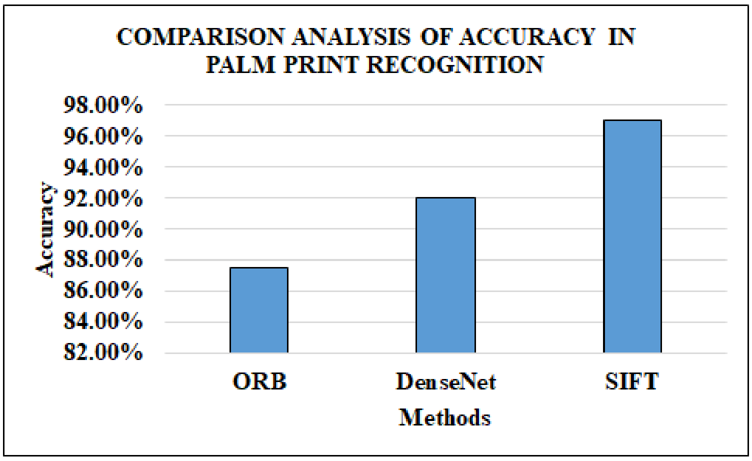

Figure 16: *Accuracy graph of palm print recognition***.**

Figure 16 denotes the analysis of accuracy in palm print recognition by presenting a detailed comparison of recognition performance across different preprocessing, feature extraction techniques.

Table 2: *Comparison analysis of recognition rate in palm print recognition*

Method	Average Recognition rate
AlexNet [2]	94.91%
VGG-16 [2]	94.1%
SIFT	95%

Table 2 represent an accuracy contrast of palm print recognition. From the table that the, SIFT model exceeds VGG-16 [2] model and AlexNet [2] model in relation to recognition with a rate of 95%.

4 Conclusion

This study presents a palm print recognition system developed effective integration of advanced preprocessing and feature extraction techniques. The integration of advanced feature analysis techniques, including SIFT, Gabor filters, LTrP and LMTrP, has significantly in palm print recognition systems. This model demonstrated substantial improvements in the accuracy and recognition rate of palm print recognition. The proposed system SIFT achieves a higher accuracy and recognition rate of other models. This high level of accuracy underscores the effectiveness of combining SIFT with Gabor filtering and advanced LTrP and LMTrP techniques in enhancing biometric authentication. The quantitative results show that the palm print recognition system achieved an accuracy rate of 97%, demonstrating exceptional performance in accurately identifying and verifying palm prints. Overall, this research highlights the potential of integrating these advanced methods to revolutionize palm print recognition technology. The improvements in accuracy and demonstrate that these techniques significantly contribute to the development of more secure and efficient biometric systems, paving the way for future advancements in biometric authentication technology.

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