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Efficient Descriptor of Histogram of Ridges Orientation Delineate for Fingernail

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Abstract: Fingernails structure are rich in orientation, ridges and edge features. Inspired by Edge Histogram Descriptor (EHD), this paper presents an efficient orientation-based local descriptor, named histogram of ridges orientation delineate (HROD). HROD is based on the fact that human vision is sensitive to edge features for image perception. For a given image, HROD algorithm first execute and perform a pre-process i.e., re-sizing, filtering, enhancement, segmentation, edge detection and feature extraction. Then, finds oriented edge maps according to predefined orientations using a well-known edge operator mask (2×2 sub block) and obtains a ridges orientation delineate map by choosing an orientation with the maximum edge magnitude for each pixel. In the experiment on this research, five oriented edge maps were used to generate and detect the maximum edge orientation construction of each block, namely vertical, horizontal, diagonal 45°, diagonal 135° and isotropic (non-orientation specific) orientation. Experimental results on fingernail images show that the performance of HROD comparable with the state-of-the-art orientation-based methods (e.g., Gabor filter, histogram of oriented gradients, and local directional code). Furthermore, the proposed HROD algorithm has advantages of low feature dimensionality and fast implementation for a real-time fingernails orientation recognition system.

Keywords: Edge Histogram Descriptor (EHD), Histogram of Ridges Orientation Delineate (HROD), edge orientation; Bit-Point (BP); vertical edge orientation; horizontal edge orientation; diagonal edge; non-edge orientation (isotropic).

I. INTRODUCTİON

The nails tissues are a complex structure that located on the surface and edges of the hand (fingertips) and foot (toes). The main functions of these nails are protection and sensation. A fundamental understanding of the anatomy of the nail structure is necessary to understand the origin of nail diseases and underlying pathologic conditions [1]. Generally, the nail comprises of the nail matrix, the lunula (half-moon-shaped area), the nail fold, the nail plate, and the nail bed [2]. Figure 1 shows the overall anatomy of nail.

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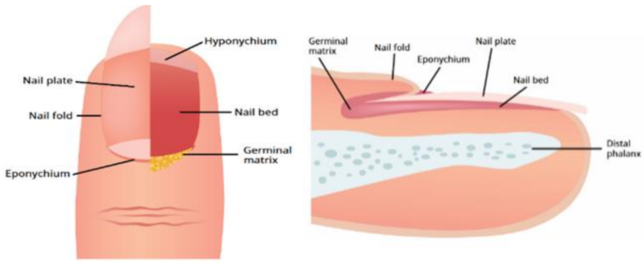

Fig. 1. Illustrated diagram of nail anatomy [3]

The nails reflect the overall health and conditions and could be an obvious sign of serious case. Thus, an understanding of basic nail anatomy and familiarity with several basic types of nail colors, lines and structure enable the general practical (GP), clinician and hospital to diagnose and treat the nail disorders and to recognize possible underlying systemic diseases [1]. Nail condition is so important, in fact, that the authors of a 2015 study [4] noted that because even subtle nail abnormalities can indicate systemic diseases, dermatologists should examine the nails during every routine visit.

As nail tech, it is likely seen nails that are break easily or weak, dotted with white spots, lines or wavy with ridges. The white horizontal lines across the nails could be Beau's lines, which appear as transverse depressions in the nail plates [5]. These lines are usually the sign of other issues in the body such as chronic illness, injury or a reaction to medication and may suggest the effect of toxins [6]. Variations in the nails color are common in patients (44% of patients) receiving chemotherapy [6,7,8]. However, in a people with no history of significant drug-related insult, such lesions may be important clues in the diagnosis of systemic illness [9]. Some patterns and nails lines are obvious and clear as shown in Figure 2, (A), (B) and others are less apparent as seen in figure 2 (C).

Fig. 2. (A) Mees Lines (Arrows) in the Fingernails of a 27-Year-Old Woman. (B) Beau Lines (Arrowheads) in the Fingernails of a 41-Year-Old Woman. (C) Beau Lines in the Fingernails of a Male. [5]

Beau lines and onychomadesis may occur due to trauma, surgery, infection, Raynaud disease, pemphigus or chemotherapy (i.e., toxoids) [6-8]. On the other hand, in Mees lines (i.e., true leukonychia) a change occurs in the cooler of the nail with no parallel lines to the lunula across the entire nail bed and with no palpable ridges [6].

Mees lines are associated with arsenic poisoning, Hodgkin lymphoma, carcinoid tumors and chemotherapy (i.e., cyclophosphamide, vincristine and doxorubicin).
Muehrcke lines are easily distinguished from Mees lines because Muehrcke lines fade with digital compression and do not migrate with the growth of the nail. 1–3 Mees lines are associated with arsenic poisoning, Hodgkin lymphoma, carcinoid tumors and chemotherapy (i.e., cyclophosphamide, vincristine and doxorubicin). Muehrcke lines result from liver disease, nephrotic syndrome, malnutrition and severe hypoalbuminemia [6-8]. However, for the true leukonychia, the white discoloration is unaffected by pressure, and the opacity moves distally as the nail grows out, which can be recorded by serial photography on subsequent visits [10]. Mees lines are also associated with acute systemic stresses, such as acute renal failure, heart failure, ulcerative colitis, breast cancer, infections such as measles and tuberculosis, and systemic lupus erythematosus, and with exposure to toxic metals such as thallium [11]

Other type of white longitudinal bands (Onychomycosis) may also appear as fungal infection of the nail accounting for up to 50% of all cases of nail disease. This infection may present as longitudinal white or yellowish bands or "spikes" on the nail plate with associated hyperkeratosis, known as a dermatophytoma, Figure 3 shows white-yellow longitudinal band [1].

Fig. 3. Onychomycosis of the Great Toenail Resulting in a Dermatophytoma, Visible as a White-Yellow Longitudinal Band [1].

A method of potassium hydroxide stain can be performed on the subungual debris, which is then examined with direct microscopy to determine any possibility of fungal infection [12]. Alternatively, a piece of nail plate clipping can be sent in a 10% buffered formalin container with a request for a fungal stain such as periodic acid-Schiff [12]. Microscopic examination of a dermatophytoma shows a dense mass of dermatophyte hyphae, otherwise known as a fungal abscess [13]. The inspector can play an important role in diagnosis because clinical findings suggestive of a dermatophytoma are associated with a poor response to antifungal therapy [14]. However, these techniques and observations are required a highly skills stuffs and professional clinical practice as well as an expensive tool and equipment i.e Microscope.

Many different health conditions can cause changes in the nails and nail bed, including shaping ridges in the nails. Vertical ridges in the fingernails are most common and are usually harmless. This kind of fingernail ridge is normally caused by aging. More specifically, by an aging nail matrix. As the cells in the matrix age, they make a less regular nail - a fingernail with vertical ridges. However, horizontal ridges and lines are often a sign of an underlying condition that requires diagnosis and treatment.
Thus, inspection of the fingernails and toenails and structure should be part of a complete physical and routine examination. Therefore, this study provides a simple technique of monitoring and observing fingernail's structure that can improve and faster the overall inspection. In addition, the micro-lens on the mobile phone can detect fine lines and small structure that cannot be seen by a naked eye, thus, acquiring accurate data and provides conventional results.

II. METHOD

A. Experimental Setup

The experimental setup was constructed as hardware setup and image processing technique (IPT). The IPT, computer vision and artificial intelligence AI have enabled manufacturers and researchers to automate a wide range of tasks. This study has developed a special effort that required to make such complex technology robust and mature, to meet the high demands required by modern general clinical practice. The method is easier to apply in our system, it is simply used a cheap consumer micro-lens that attached to the phone to get high-resolution images of nails and to quantify symptoms that may attacks the nails itself and to develop an automated nails monitoring system of possible illness finding. Figure 4 shows experimental setup. The system includes micro-lens, phone, adjustable phone handle, USB cable, piece of clothing or paper (for background enhancement) and MATLAB algorithm script.

Fig. 4. The Overall System Design and Experimental Setup

B. Examining Algorithm

Image pre-processing techniques are basically used to bring out details that are obscured or simply to highlight certain features of interest in an image. These are mainly a process and are designed to employ query of an image to take advantage of the visual aspects of the human visual system. The Content Base Image Retrieval (CBIR) and Histogram of Ridges Orientation Delineate (HROD) equalization techniques were used with proposed method algorithm to enhance the detection.

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The CBIR is also known as query by image content, which refer to a process of retrieving expected image from image database according to the content of the query image. The content of image is mainly referring to its color, texture and shape features of the query image which can be automatically extracted from the images using various feature extraction technique. The CBIR is different than the traditional technique that only based on metadata such as keywords, tags, or description associate with the image. The keyword in the traditional technique is also limit the scope of queries because of the set of predetermine criteria. While the CBIR technique provides the flexibility to search and focusing on the content of the image with no predefine criteria. Figure 5 shows the CBIR technique that implemented on this study.

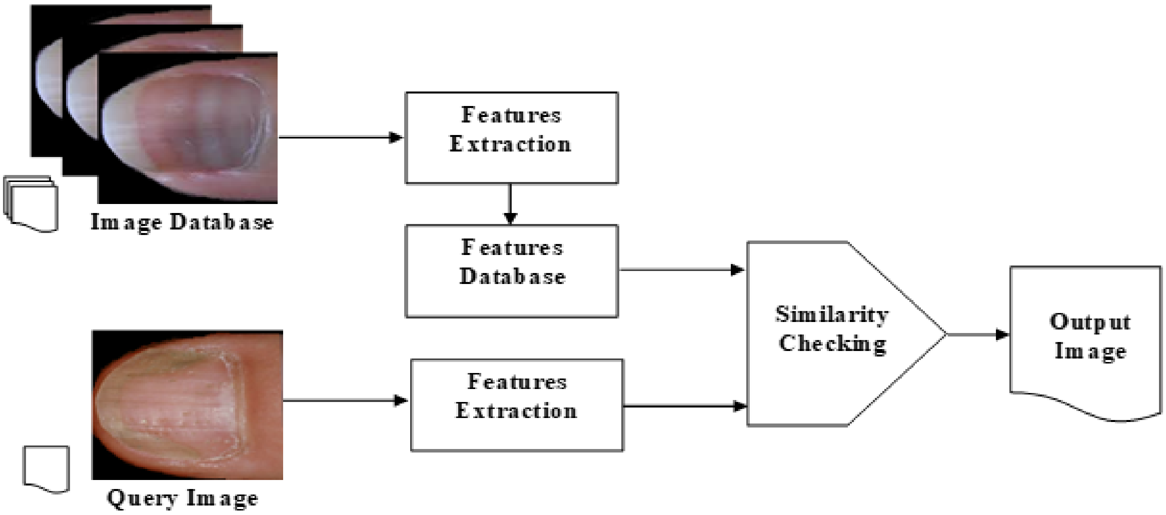


Fig. 5. The CBIR Technique Algorithm

Figure 5 shows the overall extraction processing of similarity between the query image and the database images by using the smallest distance features between these images. On the base of the minimum and smallest distance, the features can be extracted easily, thus, the output can be obtained with most similarity features. More details will be explained in the following section.

C. Algorithm Data Processing

There are many descriptors methods that can be used to extract the interest features, similarity, and differences of the images such as color, texture, shape, motion descriptor and localization. The edge histogram descriptor (EHD) is used in this study as one type of texture descriptor. The EDH is a powerful low-level descriptor for image search and retrieval. Thus, the distribution of edges is a good texture signature that is used for images matching. The EDH is useful when the underline region is not homogenous in texture properties. The EDH captures the spatial disruption of edges which are broadly group into five categories; vertical, horizontal, diagonal 45°, diagonal 135° and isotropic (non-orientation specific). The detailed block diagram of proposed methodology is shown in Figure 6.

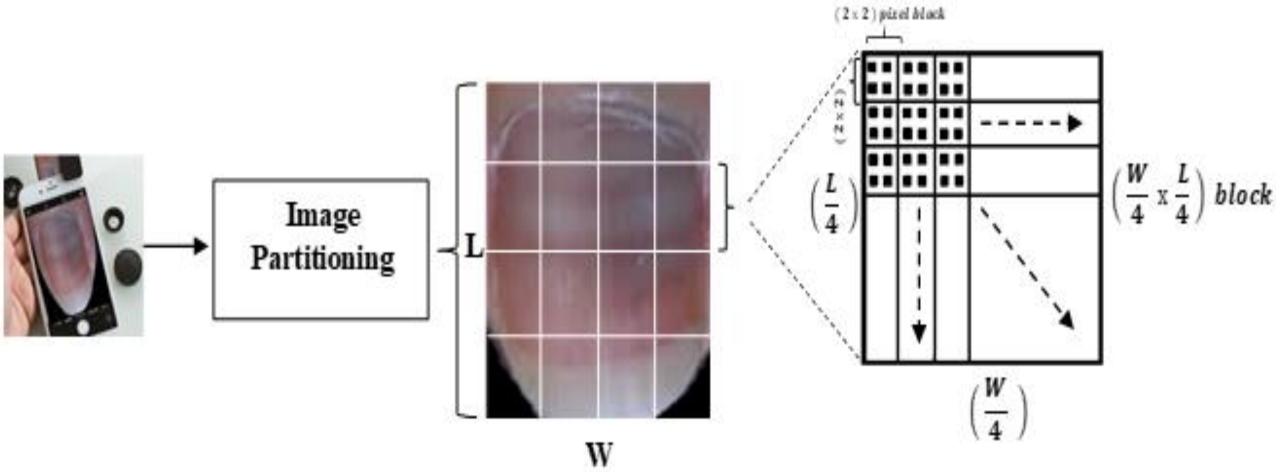


Fig. 6. Image partitioning implementation

Figure 6 shows the process of image partitioning which divided the raw image into the length *(L)* and width *(W)* of *4×4* (*16* sections) non-overlapping block. Each extracted block of *16* section is further divided into *2×2* small pixel block for capturing the local edge orientation. The capturing edge orientation for each extracted block $\left(\frac{W}{4} \text{ x } \frac{L}{4}\right)$ (1) is then initialized by *5* Bit-Point (*5BP*) as following; $BP = [V, H, D45, D135, NON] = [0, 0, 0, 0, 0]$ (2)

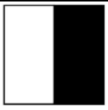
Where *BP* is Bit-Point, *V* represents Vertical edge orientation, *H* is Horizontal edge orientation, *D45* is Diagonal edge at *45°* orientation, *D135* is Diagonal edge at *135°* orientation and *NON* is non-edge orientation (isotropic).

Therefore, the partition image has *16-BP[N]* for all *16* blocks as overall and each of these blocks comprises of *5-BP*, thus if the *BPs* are kept side-by-side, it makes *EHD* vector of total length of *80-BP*.

$$EHD = \begin{bmatrix} BP[1] & BP[2] & BP[3] & BP[4] \\ BP[5] & BP[6] & BP[7] & BP[8] \\ BP[9] & BP[10] & BP[11] & BP[12] \\ BP[13] & BP[14] & BP[15] & BP[16] \end{bmatrix} \quad BP[8] \rightarrow [V, H, D45, D135, NON] \qquad (3)$$

Now for the capturing the local edge orientation from each *2×2*-pixel sub block, it will apply an operator of *2×2* as shown in the following Table 1.

Table 1. Five Types of Edges in *EHD*

Edge Type	Visual Representation	Operator Mask
Vertical edge (*V*)		$\begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix}$
Horizontal edge (*H*)		$\begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$
Diagonal edge (*45°*)		$\begin{bmatrix} \sqrt{2} & 0 \\ 0 & -\sqrt{2} \end{bmatrix}$
Diagonal edge (*135°*)		$\begin{bmatrix} 0 & \sqrt{2} \\ -\sqrt{2} & 0 \end{bmatrix}$
Non-edge orientation		$\begin{bmatrix} 2 & -2 \\ -2 & 2 \end{bmatrix}$

Each operator mask is applied on *2×2* sub block by the following formula;

$$ET = \left| \sum_{i=0}^{3} p_i \cdot m_i \right| \quad (4)$$

Where *ET* represents the Edge Type;

$p_i = \begin{bmatrix} p_0 & p_1 \\ p_2 & p_3 \end{bmatrix}$ represents *2×2*-pixel sub block;

$m_i = \begin{bmatrix} m_0 & m_1 \\ m_2 & m_3 \end{bmatrix}$ represents *2×2* operator mask.

After applying all operators mask on a single *2x2* image sub block, the five corresponding of edge types (*ET*) will be obtained such as ET_v, ET_h, ET_{45}, ET_{135} and ET_{non}. The maximum of these values is compared with a threshold value (*T*) to fin the dominant edge type as following;

$$ET_{dominant} = max(ET_v, ET_h, ET_{45}, ET_{135}, ET_{non}) > T \quad (5)$$

after finding the maximum value among these values, the dominant edge type ($ET_{dominant}$) will be equal to that maximum number. Then count of corresponding Bit-Point (*BP*) is increased by one and it is repeated for all 2x2 sub blocks in one $\left(\frac{W}{4} \text{ x } \frac{L}{4}\right)$ image block.

Thus, for one $\left(\frac{W}{4} \text{ x } \frac{L}{4}\right)$ image block, we obtained the complete Bit-Point *BP* and can be expressed as following;

$$BP[1] = [b_0, b_1, b_2, b_3, b_4] \quad (6)$$

The operations are repeated for all sixteen- $\left(\frac{W}{4} \text{ x } \frac{L}{4}\right)$ image block to acquire all *16 BP*. After getting *BP* for all sixteen- $\left(\frac{W}{4} \text{ x } \frac{L}{4}\right)$ image block, these *16 BP* can be re-arranging as following;

$$All_{BP} = \begin{bmatrix} b_0 & b_1 & b_2 & b_3 & b_4 \\ b_5 & b_6 & b_7 & b_8 & b_9 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ b_{75} & b_{76} & b_{77} & b_{78} & b_{79} \end{bmatrix} \begin{matrix} \rightarrow BP[1] \\ \rightarrow BP[2] \\ \vdots \\ \rightarrow BP[16] \end{matrix} \qquad (7)$$

For accurate result, the global BP_g can be calculated by taking the mean of each column and then combined all extracted *BP* with global BP_g to make the *EHD* vector of *85 PB* in total.

$$EHD = [\underbrace{BP[1], BP[2], BP[3], \ldots\ldots BP[16]}_{80\text{-}BP}, \underbrace{BP_g}_{5\text{-}BP}] \qquad (8)$$

D. Nail Examination Essentials (Protocol)

A complete examination includes all 10 nails (individually or unit) of the hand. Subjects should be instructed to remove all nail polish or any barrier on their nails prior to carry the examination. Photo shoots and careful measurement help document the status of the nails as well as the overall of a health condition that might detected. A set of images in database are stored for further processing, comparison and similarity detection. This examination and processing are executed by using MATLAB image processing toolbox such as image acquisition, background subtraction, segmentation, edge detection, filtering, enhancement, feature extraction, normalization and classification. In addition, the main CBIR and EHD proposed method were implemented for accurate extraction result.

In this examination, a twenty (20) participances in the experimental protocol with approval of the Taif University Ethics Committee (No. 44-283). The committee for Bioethic with No. (HAO-02-T-105) and the committee considered that the proposal fulfils the requirements of Taif University and accordingly ethical approval was granted (from March 23rd). The participants ask to place their hand and/or fingertip on the defined position as showing in Figure 7, however, take a photo of the whole unit (hand) require more time and processing such as resizing, disregarding the palm and fingers and detect area of interest (nails).

Thus, this study only considers taking individual finger at a time.

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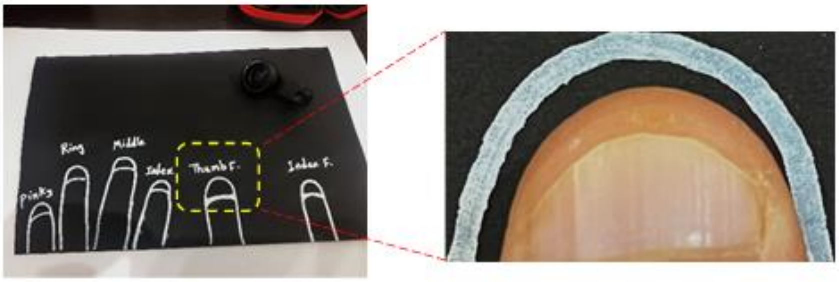

Fig. 7. (a). The Area of Interest (Nails), (b). the Nail on Place

In addition, two photos are taken in a row for the same finger where the user asks to place his/her finger with no pushing down toward the table as a first shoot (normal placing), and the second photo is taken with a little pressure applied toward the table as shown in Figure 8. The idea is to keep tracking all possibilities of fine lines that could appear. However, on occasion we cannot tell the difference with naked eyes, but by pre-processing and algorithm implementation.

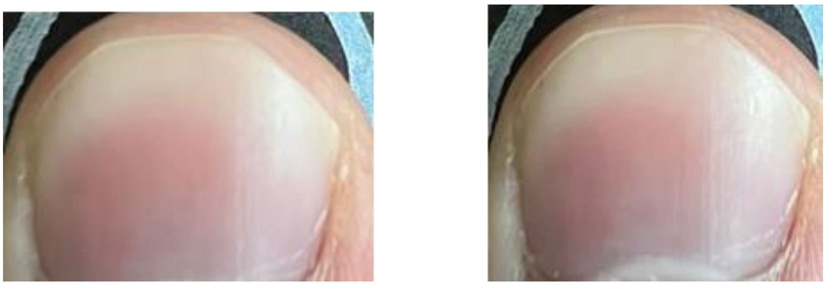

Fig. 8. Capture Two Photos, (a) with no Pressed, (b) with Little Push Toward the Table

III. RESULTS AND DİSCUSSİON

A. Data Analysis of Detection

Primary signal processing of the recorded datasets was executed using the MATLAB software (The MathWorks, Inc., Natick, MA, USA) to evaluate the performance of proposed algorithm with a physical inspection. Figure 9 shows nails of different participants that captured during the examinations.

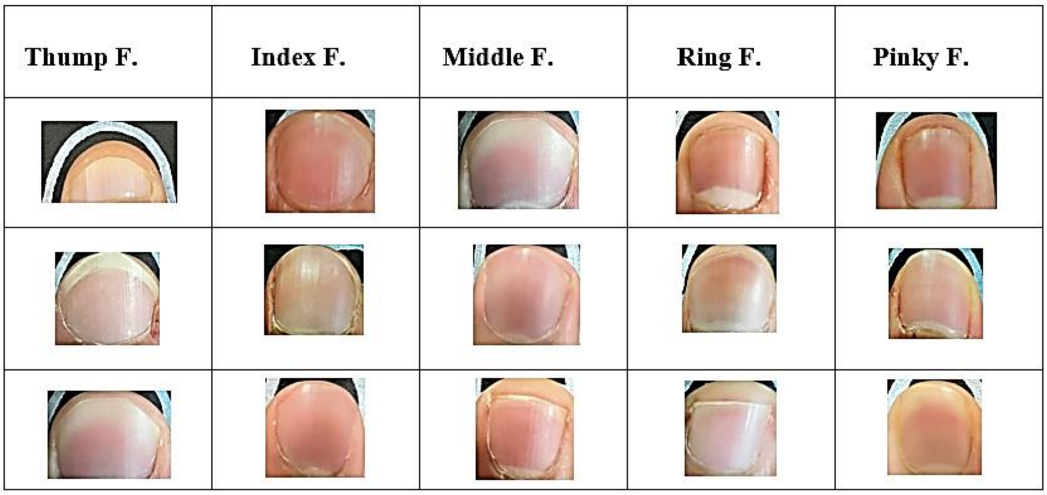

Fig. 9. Fingers (Nails) of Different Subjects

The edge histogram descriptor (EHD) can be extracted easily by implementing the algorithm and can be compared with database photos for further inspection. The algorithm runs to analyze each sample along with capturing the local edge orientation and to decide whether the samples are similar or close to database photos. The edge can be determined through the minimum point detected between 2×2-pixel sub block and 2×2 operator mask.

The running algorithm on the sample detects the maximum magnitude values in each sub block and scan through the entire target (nail photo) and comparing them. Figure 10 shows outcome of pre-processing and enhanced the data, the time of processing is small < 7s. The results obtained from the preliminary processing procedure of detection maximum orientation values are better than a physical inspection method and not comparable due to the present of fine lines that cannot be detected with naked eyes.

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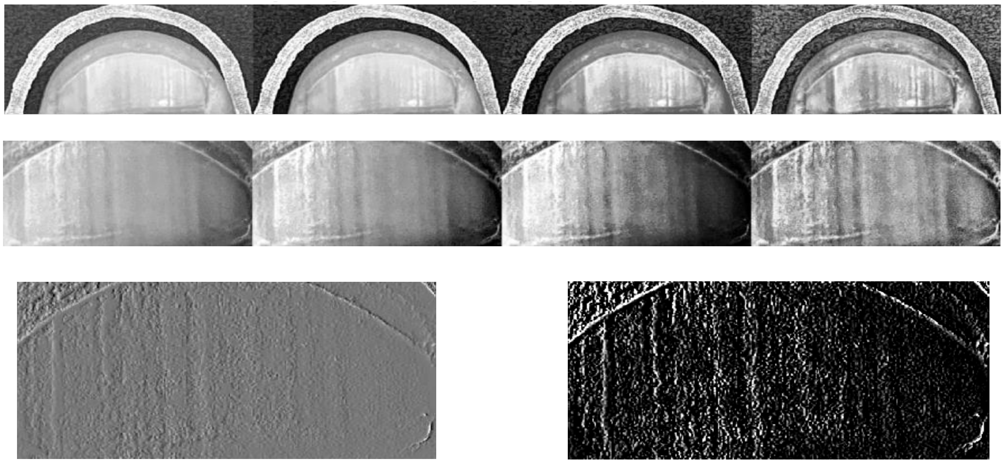

Fig. 10. Outcome Pre-Processing and Enhancement

Figure 11 shows the graph of EHD of both images and comparing the factors of how they are difference from each other.

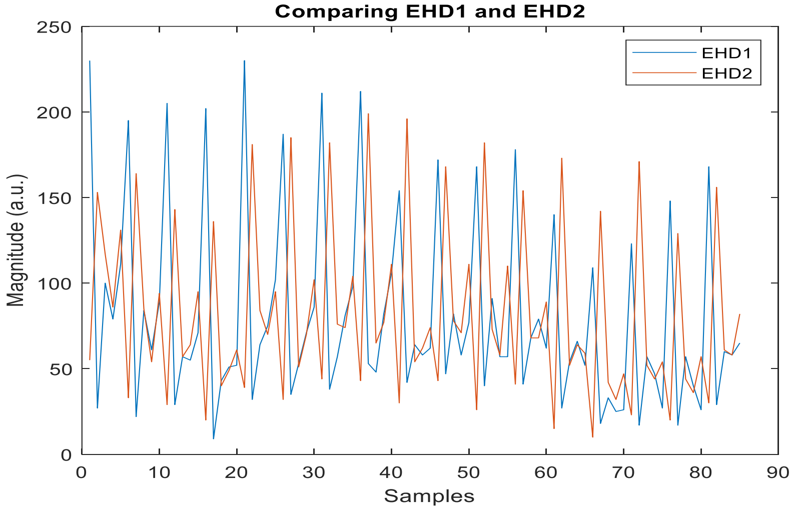

Fig. 11. Comparing of EHD1 and EHD2

Figure 12 show that the global bin of both images. Each bar represents edge orientation, the first bar from the left is a vertical, then horizontal, diagonal 45°, diagonal 135° and isotropic (non-orientation specific) at bar number 5.

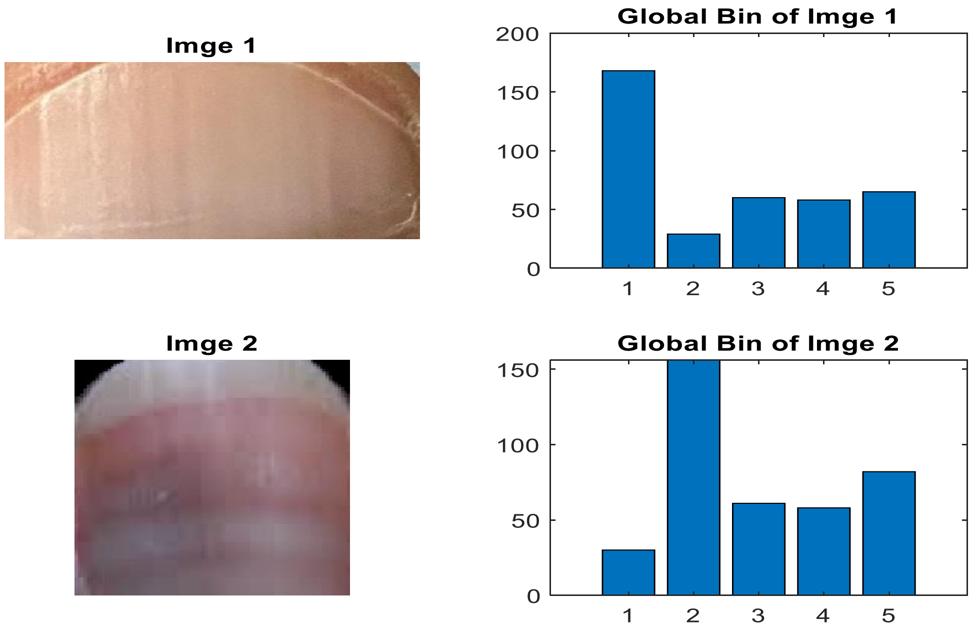

Fig. 12. Edge Orientation Detection of Different Images

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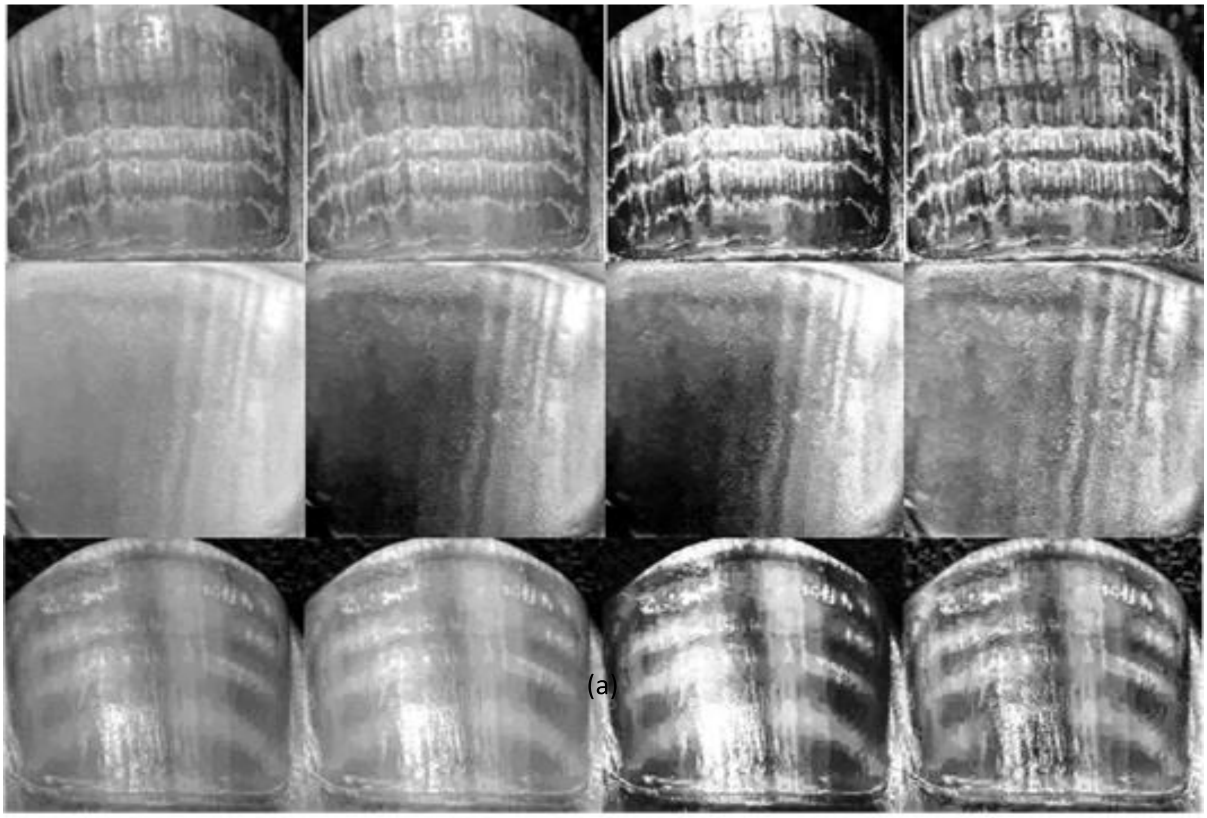
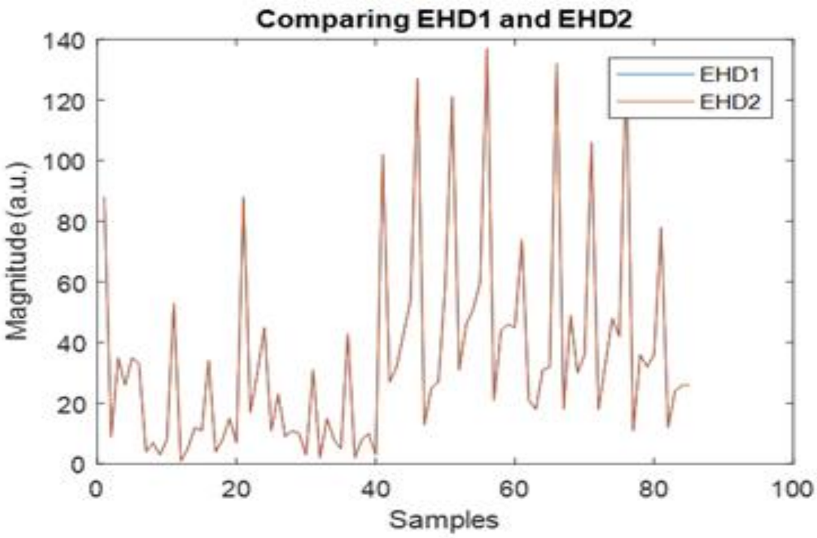
It can be seen from figure 12 that the dominant edge value of the first image is the vertical orientation, which represent the maximum vertical edges. Similarly, the highest value orientation is a horizontal bin on the second image. It can also be seen that both graphs have smaller values on other orientations. Occasionally, it is difficult to tell from the image itself by naked eyes, but by implementing the Edge Histogram Descriptor (EHD) algorithm, the outcome is obvious and clear on the graph. Figure 13 show the comparison that have been taken between the same image. It can be clearly seen that the graphs of figure 13 (b) are identical, there is no difference as it used the same image of comparison. Both EHD1 and EHD2 are matching thus the blue line legend (EH1) is not appear in the graph since it is located exactly underneath the red line (EH2).



(a)



(b)

Fig.13. (a) Enhancement Images, (b) Comparison of Edge Histogram Descriptor

Figure 14 shows the dominant edge orientation of each image. It is clear that figure 14 (a) and (b) has the highest horizontal values bin orientation, while the dominant values on figure 14 (c) are vertical bins. The idea of comparison two identical image is to prove the concept of algorithm and its implementation.

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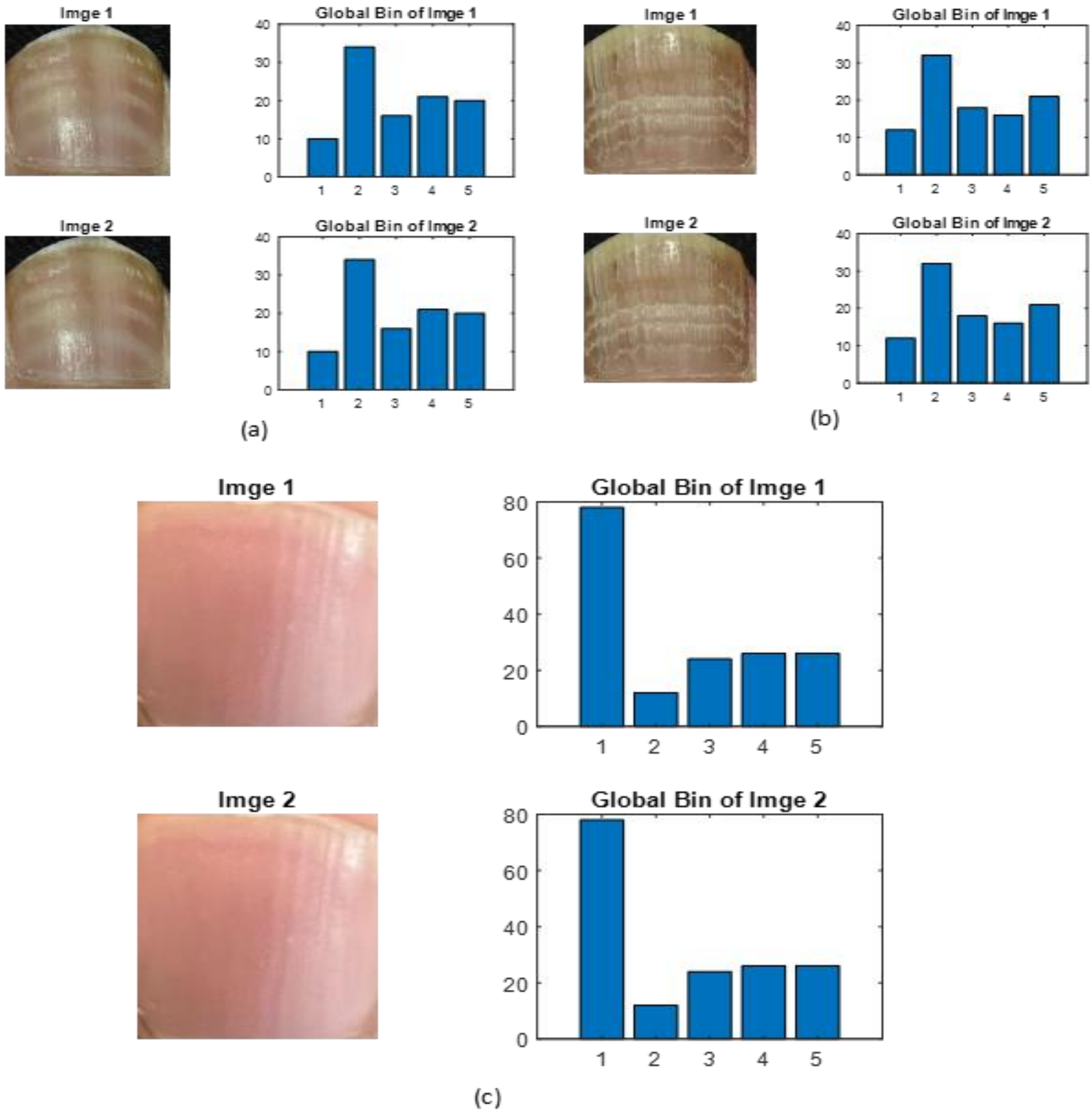

Fig.14. Edge orientation Detection of Similar Images

IV. CONCLUSIONS

This work introduced descriptors method together with help of phone for capturing the data. The edge histogram descriptor (EHD) is used in this study as one type of texture descriptor of the target (nail). A micro-lens is also used to enhance the quality of photo and make texture even more visible. The proposed algorithm is a low-level descriptor for image search and retrieval which then provides a good agreement and comparability with database photos. Thus, the distribution of edges is used to investigate the texture signature that is used for images matching. The EDH is useful when the underline region is not homogenous in texture properties. The captures of spatial disruption of edges which are grouped to different categories (vertical, horizontal...) to determine the orientation on a small region which then result into accurate result as overall.

However, due to the limitation of some invalid data error that appears due to misalignment of the finger and that can be overcome by the means of a proper finger position, adjust the holder height and changing the zoom-in and zoom-out on the phone while capturing the data. In addition, the limited source of database photos may result on less agreement during comparing phase. Furthermore, the camera quality is substantial. The outcome from the proposed work indicates that a new paradigm of nail monitoring could be used instead of using physical and naked eyes inspection to detect and compare ridges and lines in fingernails thus, this method can be incorporated into clinical for further assessment and does not require for highly staff training to operate.

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LIST OF ABBREVIATIONS

- EHD: Edge Histogram Descriptor,
- HROD: Histogram of Ridges Orientation Delineate,
- BP: Bit-Point,
- IPT: image processing technique,
- CBIR: Content Base Image Retrieval and
- HROD: Histogram of Ridges Orientation Delineate.

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DECLARATION

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Conflicts of Interest/ Competing Interests	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	Yes, The experimental protocol with approval of the Taif University Ethics Committee (No. 44-283). The committee for Bioethic with No. (HAO-02-T-105) and the committee considered that the proposal fulfils the requirements of Taif University and accordingly ethical approval was granted (from March 23rd).
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	As the only author, I have approved the final version of the manuscript and agree to be accountable for all aspects of this work.

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