TRI-BRANCH VEIN PATTERN CLASSIFICATION FOR SECURITY

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INTRODUCTION

Finger vein recognition employs vein patterns on the finger palmar side in identity authentication. The vein pattern is generally captured by the near-infrared light, as the light can be intensively absorbed by the hemoglobin in the vein but easily transmitted through other finger tissues. As an internal physiological characteristic, finger vein has higher security over other external biometric traits (e.g., face and fingerprint) owing to difficulty in copy or steal the trait.
In finger vein recognition, the existing feature extraction methods can be classified into two groups, i.e., non-vein pattern based methods and vein pattern based methods.

We will be using vein pattern methods. The following are the types:

1. *Gray Value Based Methods:*The vein pattern extraction methods were developed based on the imaging characteristic of finger vein that the gray value of vein point is lower than its neighbor non-vein points

2.*Curvature Value Based Methods:* There are four typical methods in this kind, i.e., maximum curvature point, adaptive curve transformation, anatomy structure analysis-based vein extraction (ASAVE) and mean curvature.

3.*Convolution Response Based Methods:* Gabor filters are used for vein pattern extraction, in which the Gabor templates were designed firstly, and then the convolution response values of the templates on finger vein image were employed to detect the vein pattern.

The vein structure near the bifurcation point of vein pattern, named the tri-branch vein structure, is explored and employed to improve the performance of template matching by the proposed user-specific threshold based filter framework.

LITERATURE SURVEY

Literature review of two papers was done:

1. *A Novel Finger Vein Recognition System Based on Enhanced Maximum Curvature Points*

   The *proposed system* consisted of four steps:

   1) Pre-processing of the infrared image
   2) Extraction of the vein pattern based on the EMC technique
   3) Binarization of the vein pattern
   4) Matching of the extracted vein pattern with the vein patterns in the database

   The *algorithm* consisted of three parts:

   1) Extraction of the vein centre positions
   2) Hessian enhancement
   3) Connection of the centre points

2. *Finger Vein Recognition based on Deep Learning*
   It was a 5 step process involving:
   a. Sensor module
   b. Image processing
   c. Feature extraction
   d. Matching module
   e. Decision making

PROPOSED METHODOLGY

The bifurcation point and its three local vein branches are powerful in the assistance to the template matching. We name one bifurcation point and its three local vein branches as the tri-branch vein structure. The structure will be extracted from the vein pattern and used to assist the template matching.

In addition, to deeply explore the discrimination of the structure, the structure should be used independent of other vein points.
1)The tri-branch vein structure is used in the first level of the framework to filter the imposters and give the candidates for the probe.
2)The user-specific thresholds, not one common threshold, are used in filtering.
3)The reasons for using the tri-branch vein structure, instead of the whole vein pattern, in the first level of the framework are twofold.

Obviously, the tri-branch vein structure spends less time cost and space cost than the whole vein pattern in matching. More importantly, the orientation of branches and the angles between two branches in one structure, and the distribution of multiple structures in vein patterns vary largely in impostor vein patterns.

WORKING PRINCIPLE

Two key points involved in execution:

1. How to define and extract the tri branch vein structure
2. How to define user specific threshold

Tri branch vein structure extraction:

1. Thinning and denoising:
    - The single pixel wide vein network is extracted front the vein network by the morphological vein thinning operation.
    - In the vein network, the intersection of the burr and vein branch can be mistakenly seen as the bifurcation point.
    - We detect and remove the burr based on its length, as the burr is much shorter than the real vein branch.
2. Bifurcation detection:
    - The switching number between 0 and 1 in the eight neighbor points of the bifurcation is six. Based on this, the bifurcation detection method is designed.
    - Assuming the current point and its eight neighbor points are denoted by p(x, y) and P = {p1, p2, . . . , p8}respectively. The point p(x, y) is seen as a bifurcation, if Ns is equal to 6, which is defined as follows:

$$N_s = \sum_{i=1}^{8} |p_{i+1} - p_i|, \quad where\ p_9 = p_1$$

3. Branch Tracking:
    - Three nonzero neighbor points can be detected for one bifurcation point, and these neighbors are the initial points of three vein branches.
    - Once the initial point is found, each local branch of the bifurcation can be tracked point by point until its length is equal to 15 points.
    - Based on the first three steps, the single-pixel wide tribranch vein structure (i.e., the bifurcation and its local branches) is detected.
    - The more robust multiple-pixel wide structure will be achieved by the following one step.
4. Morphological dilation and dot product

- The morphological dilation operation is performed on the single-pixel wide tri-branch vein structure
- The structuring element is a 8×8 matrix with element value 1.
- The dot product between the dilated structure and the whole vein pattern is conducted to obtain the map of tri-branch vein structures.

User specific threshold based filter:

- The tri-branch vein structure is employed to filter the imposters for the probe image in the first level of the proposed framework, but the false rejection of genuine image should be avoided as much as possible.
- Therefore, the minimum genuine similarity score of training images may be a reasonable filter threshold.
- If the probe user has a lower similarity score with one enrolled user than the minimum genuine score of the enrolled user, the probe is seen as imposter to the enrolled user.
- If the similarity score is larger than the minimum genuine score, the probe may be genuine to the enrolled user and will be further matched in the second level.
- Generally, a common threshold (i.e., the minimum genuine score of all users) is used for all enrolled users to filter the imposters.
- However, in a tri-branch vein structure based filter, it may be not a good choice.
- The main reason is that the genuine score of the structure varies largely from one enrolled user to another.
- In detail, this kind of local structure is sensitive to the image quality and finger displacement, which may cause very low genuine score.
- Considering that the importance of matching score output by each biometric trait varies with the user, the user-specific weights are used to fuse multi-traits for different users in a multibiometric system.
- Inspired by the user-specific weight, the user-specific threshold is learned and used to filter the imposters in our framework.
- The minimum genuine score among multiple images of one enrolled user is used as the threshold only for this user.
- The user-specific thresholds are learned from the training images.

- Assuming there are N enrolled users in the database, and each enrolled user has m training images.
- In the training step, the similarities of any two images among m training images are measured for each user, and the minimum value of C2m similarity scores will be used as the threshold for each user.
- Therefore, there are totally N thresholds for N enrolled users.

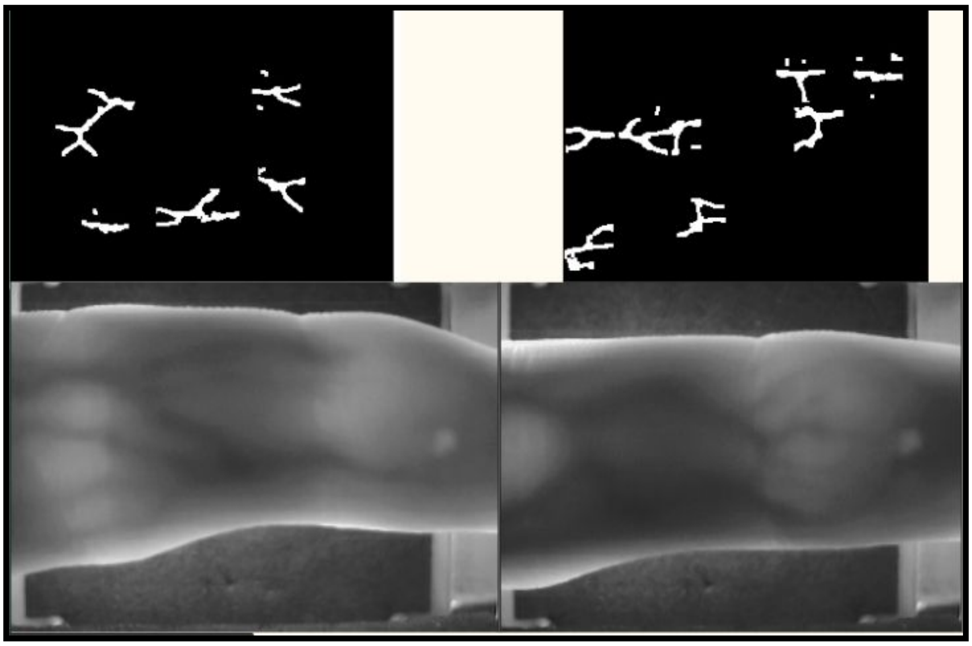
SNAPSHOTS OF THE CODE

```
% Extract veins using maximum curvature method
sigma = 3; % Parameter
v_max_curvature = miura_max_curvature(img,fvr,sigma);

% Binarise the vein image
md = median(v_max_curvature(v_max_curvature>0));
v_max_curvature_bin = v_max_curvature > md;
% End of Segmentation & Extraction

%wvp = imbinarize(rgb2gray(imread('Capture.png')));
wvp = wiener2(v_max_curvature_bin,[7 7]);
%h = fspecial('gaussian',11,4);
h = fspecial('gaussian');
wvp = imfilter(wvp,h);
```

```matlab
% Thinning of finger vein
thinnedImg = bwmorph(wvp,'thin',Inf);

% Denoising to remove burr from the image
E = bwmorph(thinnedImg, 'endpoints');
[y,x] = find(E);
mask1 = false(size(thinnedImg));
for k = 1:numel(x)
    D = bwdistgeodesic(thinnedImg,x(k),y(k));
    mask1(D < 20) =true;
    %mask1(D < 65) =true;
end
deburrImg = thinnedImg - mask1;
%End of Denoising process
```

```matlab
% Do the actual filtering
fx  = imfilter(img, hx,  'replicate', 'conv');
fxx = imfilter(img, hxx, 'replicate', 'conv');
fy  = imfilter(img, hy,  'replicate', 'conv');
fyy = imfilter(img, hyy, 'replicate', 'conv');
fxy = imfilter(img, hxy, 'replicate', 'conv');
f1  = 0.5*sqrt(2)*(fx + fy); % \
f2  = 0.5*sqrt(2)*(fx - fy); % /
f11 = 0.5*fxx + fxy + 0.5*fyy; % \\
f22 = 0.5*fxx - fxy + 0.5*fyy; % //

[img_h, img_w] = size(img); % Image height and width

%% Calculate curvatures
k = zeros(img_h, img_w, 4);
k(:,:,1) = (fxx./((1 + fx.^2).^(3/2))).*fvr; % hor
k(:,:,2) = (fyy./((1 + fy.^2).^(3/2))).*fvr; % ver
k(:,:,3) = (f11./((1 + f1.^2).^(3/2))).*fvr; % \
k(:,:,4) = (f22./((1 + f2.^2).^(3/2))).*fvr; % /
```

FINAL OUTPUT ON EXECUTING THE PROPOSED METHODOLOGY



COMPARISON

- *Comparison With Vein Feature Based Recognition*

The compared features are extracted from the vein patterns detected by different methods shows that the proposed framework achieves the best performance. The main reason for such good performance lies in the fusion of local tri-branch vein structure and global vein pattern.

- *Comparison With Typical Finger Vein Recognition Method*

Compared with the non-vein pattern based methods, the proposed framework only uses the vein pattern and its structure, without non-vein region, which can avoid the bad effect of the noises in non-vein region to the recognition performance.

- *Time Cost Measurement*

The time cost of the structure extraction is very small. The first step in structure extraction, i.e., thinning and denoising, costs a great part of time. The main reason is that the deburring in denoising is performed twice owing to there being lots of burrs in the vein network extracted from low quality images.

FUTURE SCOPE

Spatial Pyramid Pooling of Selective Convolutional Features for Vein Recognition:

- Unlike most of these studies which adopt activations of the fully connected layer of DNN as the image representation, convolutional activations is adopted as the region representation.
- A novel selective convolutional feature model based on spatial weighting is proposed to weigh the importance of local features at different regions for classification to acquire more robust and discriminative feature representation
- Also enhances the discriminability of feature representation

Medical Imaging

- It is a technique in which internal parts of the human body are clinically analyzed and create visual representation of body organs and tissue.
- This technology helps the doctor inject drip to the patient.

Biometric Recognition for Authentication

- This technology can be helpful in biometric recognition authentication purposes.
- One can unlock their personal information or access confidential data with the help of unique vein structure security system

REFERENCES

1. A Novel Finger Vein Recognition System Based on Enhanced Maximum Curvature Points
   Published in: *2018 IEEE 13th Image, Video, and Multidimensional Signal Processing Workshop (IVMSP)*

2. A Palm Vein Recognition System
   Published in: *2010 International Conference on Intelligent Computation Technology and Automation*