A minutia matching algorithm in fingerprint verification

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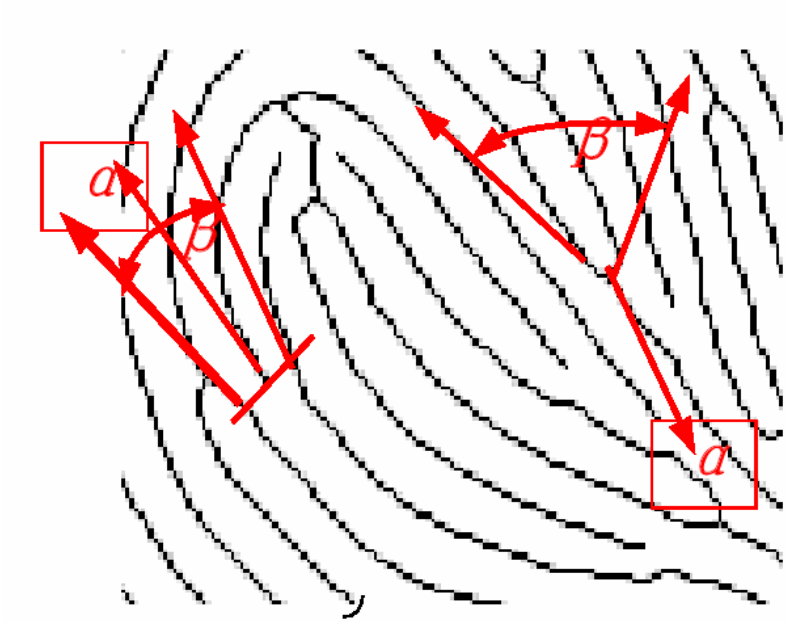
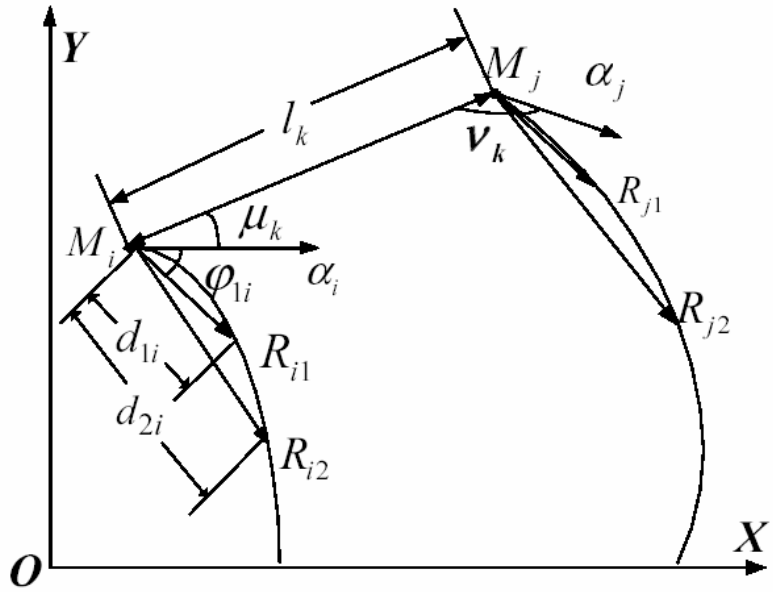
Outline

- Introduction of minutiae
- Aligned minutia matching
- Conclusion

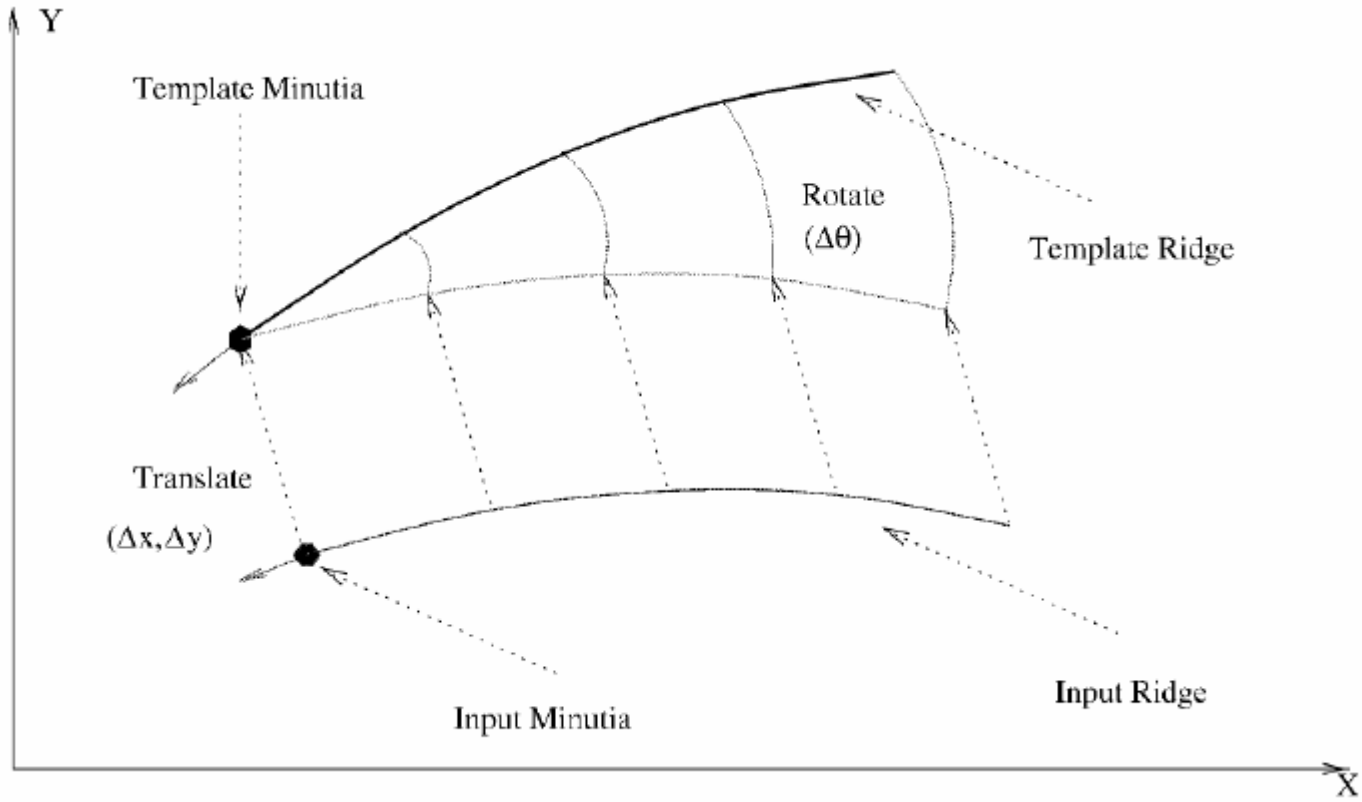
Introduction of minutiae





$$M_k = (x_k, y_k, \alpha_k, \beta_k, \varphi_{1k}, \varphi_{2k}, d_{1k}, d_{2k})^T$$

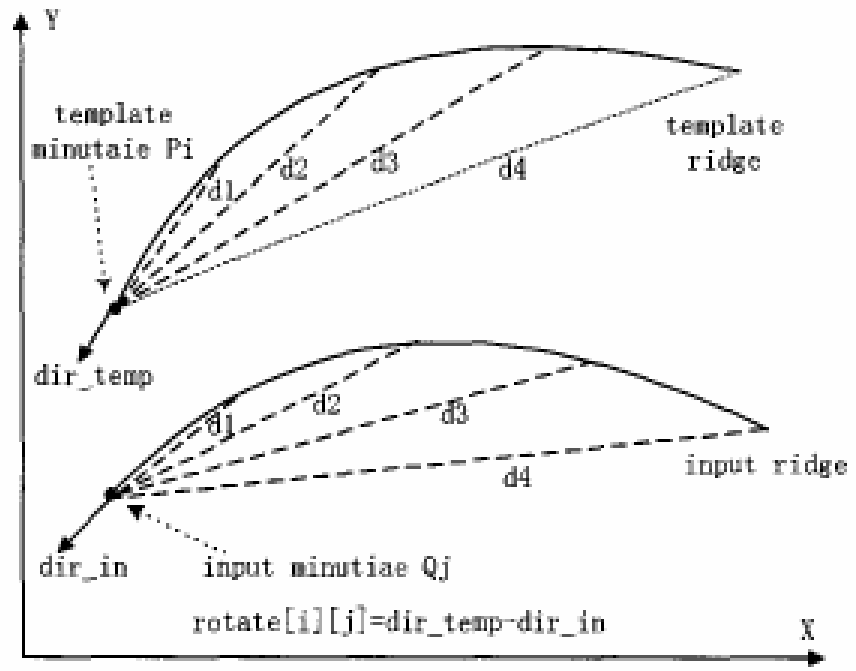
Alignment of minutiae set



$$P = \left((x_1^p, y_1^p, \theta_1^p)^T, \cdots, (x_M^p, y_M^p, \theta_M^p)^T\right) \quad Q = \left((x_1^Q, y_1^Q, \theta_1^Q)^T, \cdots, (x_N^Q, y_N^Q, \theta_N^Q)^T\right)$$

其中P代表註冊指紋的M個特徵點，Q代表輸入指紋的N個特徵點

Alignment of minutiae set cont.



IF type is not the same or Diff_ang > Td or Diff_dist > To rotate[i][j] = 400

ELSE rotate[i][j] =dir_temp - dir_in

$$Diff\_dist = \frac{1}{L}\sum_{i=0}^{L}\left|R(d_i) - r(d_i)\right| \qquad Diff\_ang = \frac{1}{L}\sum_{i=0}^{L}\left|R(a_i) - r(a_i)\right|$$

cont.

$$(x^r, y^r, \theta^r)^T$$

$$\begin{pmatrix} r_i \\ e_i \\ \theta_i \end{pmatrix} = \begin{pmatrix} \sqrt{(x_i - x^r)^2 + (y_i - y^r)^2} \\ \tan^{-1}\left(\frac{y_i - y^r}{x_i - x^r}\right) + rotate[i][j] \\ \theta_i - \theta^r \end{pmatrix}$$

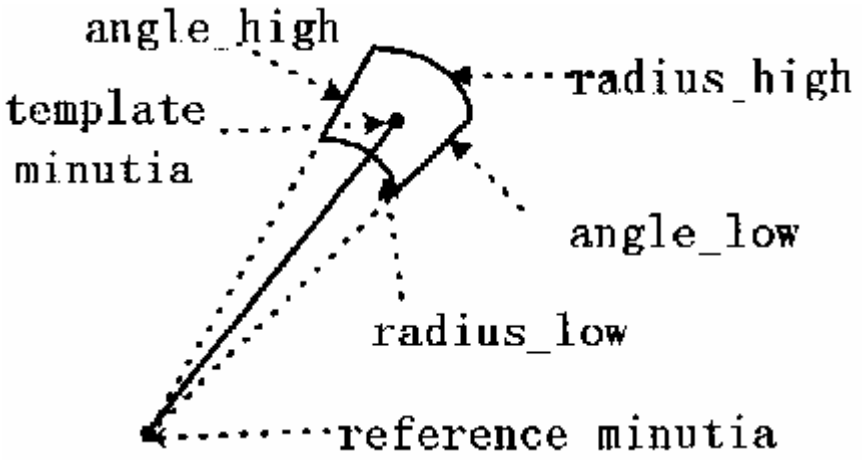
Aligned minutia matching

1) For i (1 ~ M) and j (1 ~ N),. If rotate[i][j]=400, then repeat this step and choose another Pi and Qj, else go to step 2). If all possible minutia pairs have been considered, go to step 4).
2) Take Pi and Qj as reference minutia. Convert each minutia point in the template minutia set and the input minutiae set to the polar coordinate system.

$$P_i^s = \left((r_1^p, e_1^p, \theta_1^p)^T, \cdots, (r_M^p, e_M^p, \theta_M^p)^T\right) \qquad Q_j^s = \left((r_1^Q, e_1^Q, \theta_1^Q)^T, \cdots, (r_M^Q, e_M^Q, \theta_M^Q)^T\right)$$

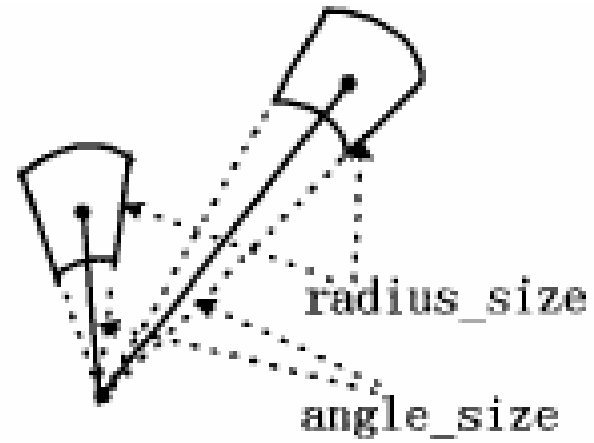
3) Match the resulting strings Pi'' and Qj'' with the process which will be introduced below to find the matching score of Pi'' and Qj''. Record it as m-score[i][j]. Then go to step 1).
4) Find the maximum value of m-score[i][j] and use it as the matching score of the input and template minutiae set. If the matching score is higher than a threshold value, then the input image is considered to come from the same finger as the template image, else we would consider these two images as coming from different fingers.

Bounding box

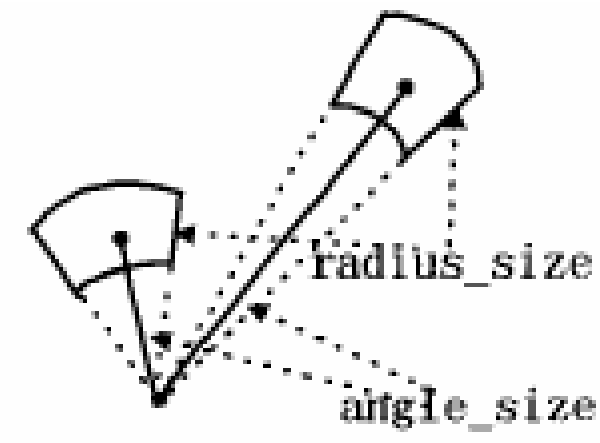


angle_size = angle_high – angle_low、radius_size = radius_high – radius_low

Changeable sized bounding box



Fixed sized bounding box



Changeable sized bounding box

Changeable sized bounding box cont.

$$radius\_size = \begin{cases} r\_small & \text{if } r\_size < r\_small \\ r\_size & \text{if } r\_small < r\_size < r\_large \\ r\_large & \text{if } r\_size > r\_large \end{cases}$$

$$r\_size = \frac{r}{\alpha}$$

$$angle\_size = \begin{cases} a\_small & \text{if } a\_size < a\_small \\ a\_size & \text{if } a\_small < a\_size < a\_large \\ a\_large & \text{if } a\_size > a\_large \end{cases}$$

$$a\_size = \frac{\beta}{r^2}$$

Process matching

1) Decide the size of the bounding box for each minutia in the template minutia set and set m-score[i] [j] = 0.
2) While 1 <= k <= M do

    While 1 <= L <= k and e_L^p <= angle_high[k] do

        If template_point[k] and input_point[L] satisfy conditional then

            m_score[i][j] = m_score[i][j] + 1;

            Adjust bounding box;

        End if;

        Increase L;

    End while;

    Increase k;

End while;

Process matching cont.

$$condition1 = \begin{cases} true & \text{if} \begin{cases} radius\_low[k] \\ < (\, r_l^P - r_k^Q \,) \\ < radius\_high[k] \\ \\ angle\_low[k] \\ < \Delta e \\ < angle\_high[k] \\ \\ \Delta\theta < \varepsilon \\ \\ rotate[k][l] < 400 \end{cases} \\ false & \text{otherwise} \end{cases}$$

$$\Delta e = \begin{cases} a & \text{if } (a = (e_L^P - e_k^Q + 360) \bmod 360) < 180 \\ a - 180 & \text{otherwise} \end{cases}$$

$$\Delta\theta = \begin{cases} a & \text{if } (a = (\theta_L^P - \theta_k^Q + 360) \bmod 360) < 180 \\ a - 180 & \text{otherwise} \end{cases}$$

Conclusion

Reference

- Luo Xiping, Tian jie, “A Minutia Matching algorithm in Fingerprint Verification, Proceeding of the 15th International Conference on Pattern Recognition, Vol.4, pp.833-836, 2000
- Anil Jain, Lin Hong and Ruud Bolle, On-Line Fingerprint Verification, IEEE Trans on Pattern Analysis and Machine Intelligence, vol.19, No.4. pp302-313, 1997
- http://www.fingerpass.net/

The End