

工學碩士 學位論文

A Study on the Core Detection of Fingerprint  
Based on the Ridge Direction

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2001年 2月

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制御計測工學科

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A Study on the Core Detection of Fingerprint  
Based on the Ridge Direction

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**Abstract**

The core of fingerprint is a basis for fingerprint identification. widespread algorithms for core detection use the template matching technique. But these methods occasionally extract wrong cores which are not related with the real core of fingerprint.

This paper proposes a core detection method using normal direction information of the ridge. The proposed method extracts a core by calculating deviations of normal directions on the basis that the ridge radiates from its core in every direction. According to the experiment results, it is certain that the proposed method can extract a core more efficiently than the template matching method.

# 1

가  
가  
가  
가  
[1-3]  
가  
(minutiae) 가  
(matching)  
(ending point),  
(bifurcation) (core)  
(gray level) [4-6],  
(wavelet) [7-8] (Fourier) [9]  
(subregion)  
(template)<sup>[4]</sup>

(ridge)

가

<sup>[11]</sup>

가

## 2

가

### 2.1

(valley)

(delta)

가

가

[4]

2.1

(arch),  
(whorl)

(right delta),

(left delta)

가

가 1

가 1

가 1 2 가

[12]

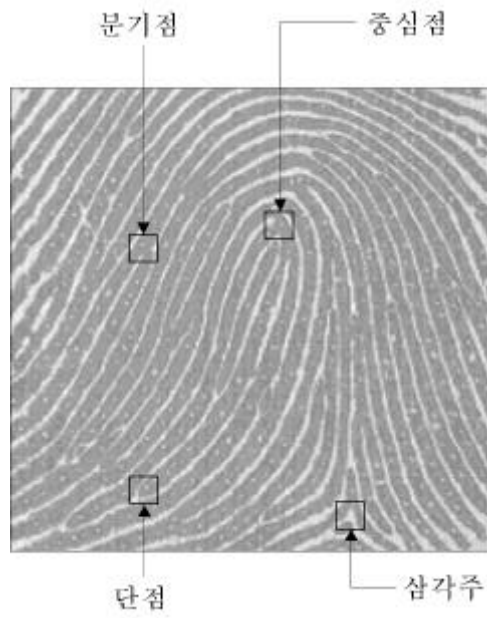
가

가

가

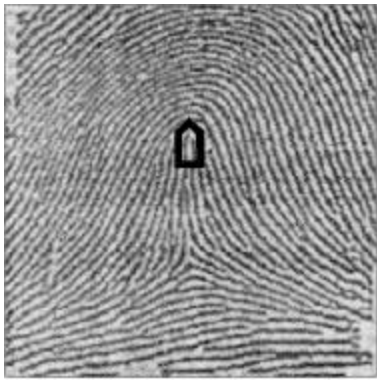
가

2.2



2.1

Fig. 2.1 Structural features of Fingerprint



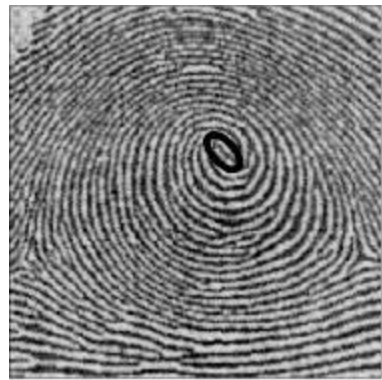
(a)



(b)



(c)



(d)

## 2.2

Fig. 2.2 Type classification of fingerprints



2.2

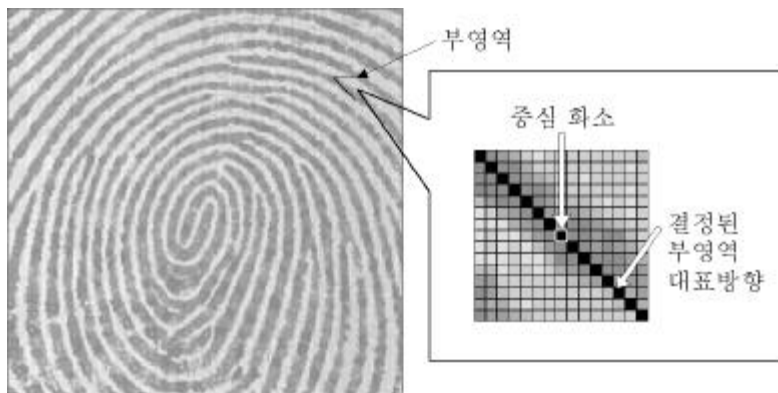
가

[4-6]

가

가 가

2.3



2.3

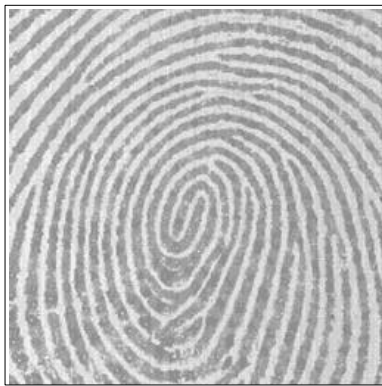
Fig. 2.3 Example of direction determination of sub region

[13-14]

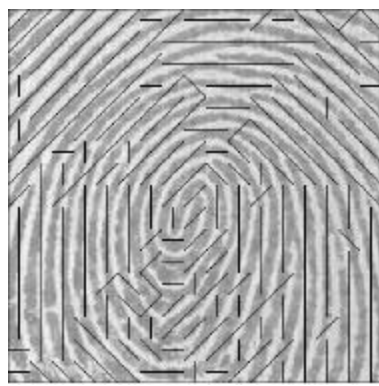
가

2.5

[4]



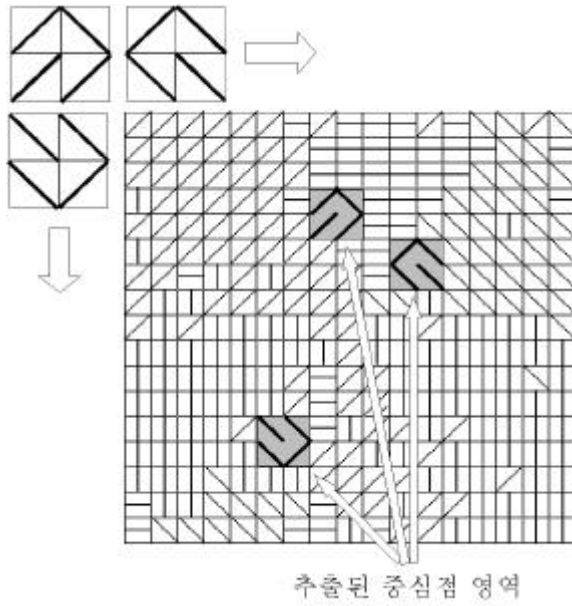
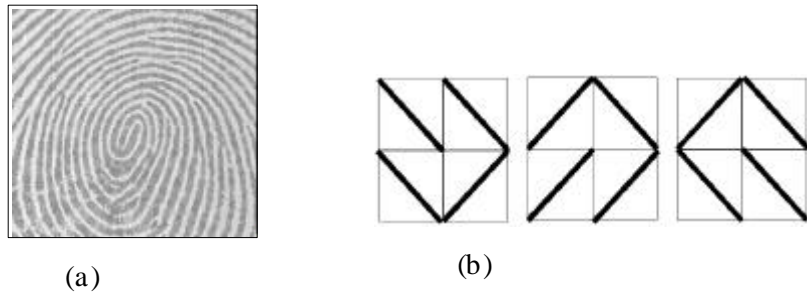
(a)



(b)

2.4

Fig. 2.4 An original image and its subregion direction



(c)

2.5

Fig. 2.5 Core templates and cores extracted by core templates

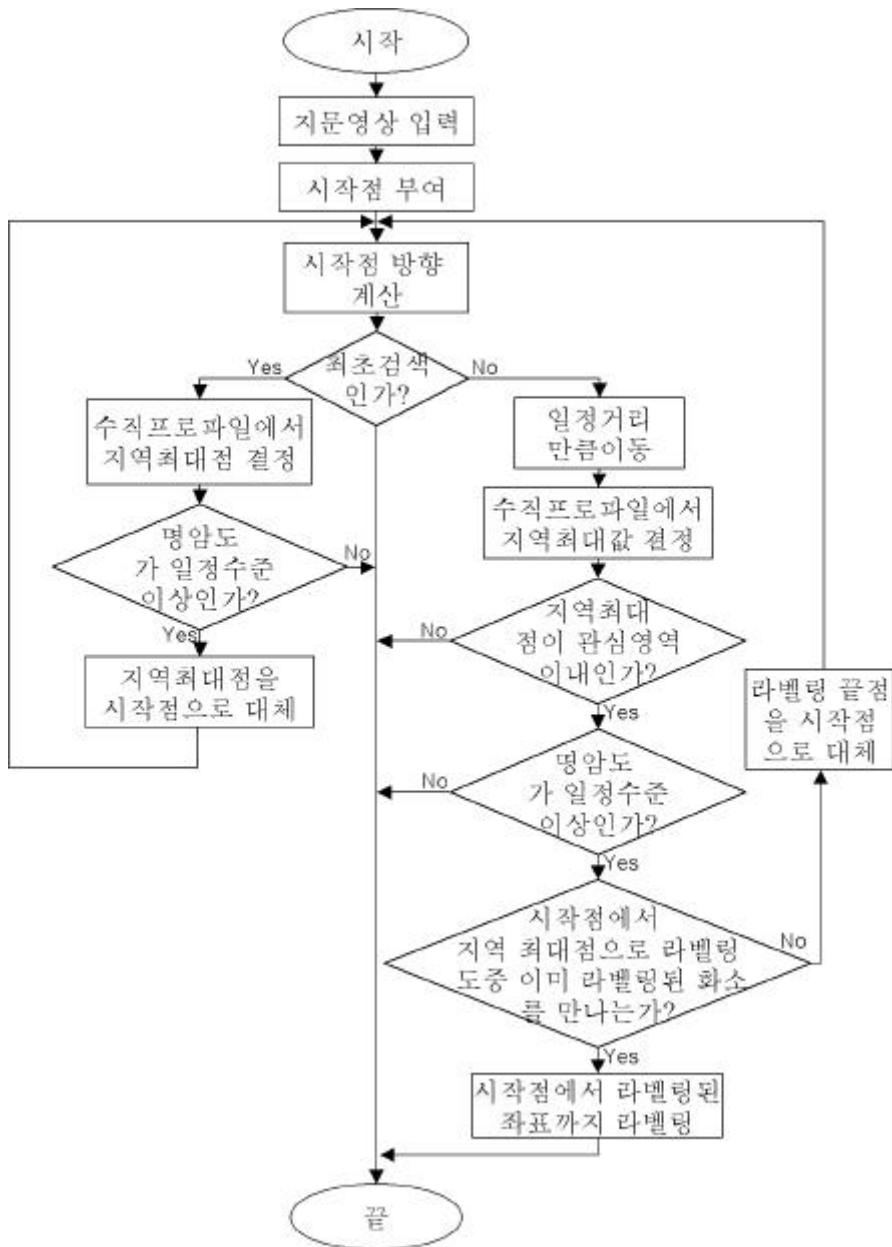
3

3.1

(local maximum)

3.1

3.2



3.1

Fig. 3.1 Flow chart of a ridge tracking

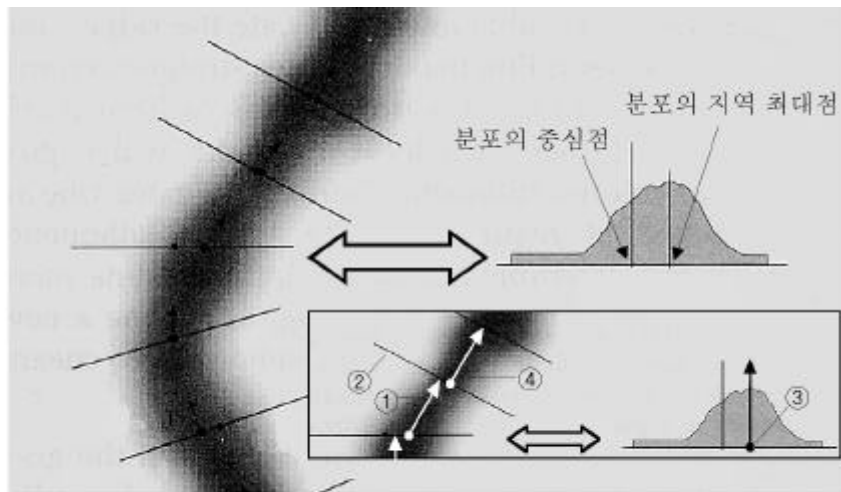
(labeling)

3.1

3.3 (a)

가

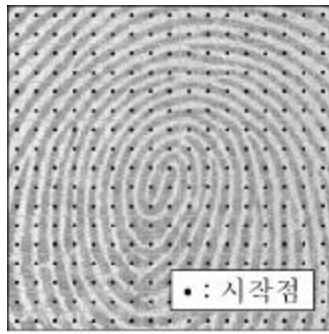
가



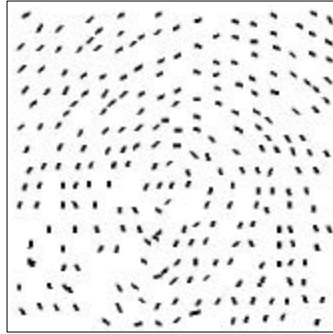
추적 단계: ① 이동 ② 수직 프로파일 생성 ③ 지역 최대점선택 ④ 방향결정

3.2

Fig. 3.2 Steps of the ridge tracking



(a)



(b)

1



(c)

2



(d)

3



(e)

4



(f)

5

3.3

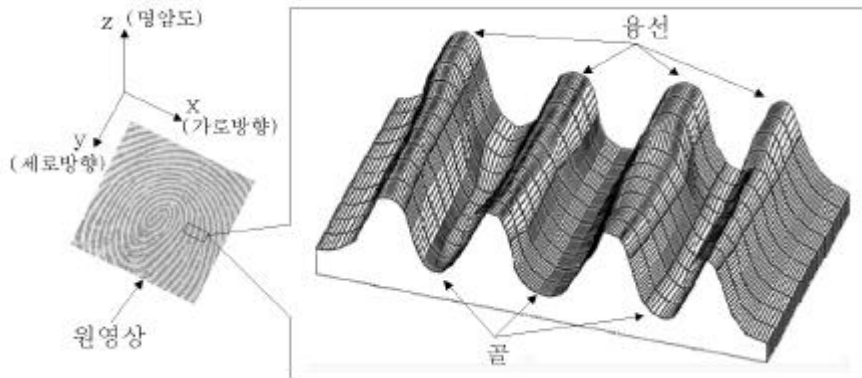
( )

Fig. 3.3 An original image and process of the ridge tracking

3.1.1

가

3.4 x y z 가



3.4

Fig. 3.4 Surface of a fingerprint

Rokhlin<sup>[16]</sup>

Donaghue

4



(normal vector) 가 .

가

(average tangent vector) .

.

3.5

$(i_0, j_0)$

$(i_0, j_0)$  가 , 9

(tangent window) .

$(i_x, j_y)$  ( $x = 1, \dots, 9, y = 1, \dots, 9$ ) ,  $(i_x, j_y)$  4

(3-1)

$n_{xy}$  <sup>[11]</sup> .

$$n_{xy} = [ a_{xy} , b_{xy} , 1 ] \quad (3-1)$$

,

$$a_{xy} = \frac{ - a_1 + a_2 + a_3 - a_4 }{ 4 }$$

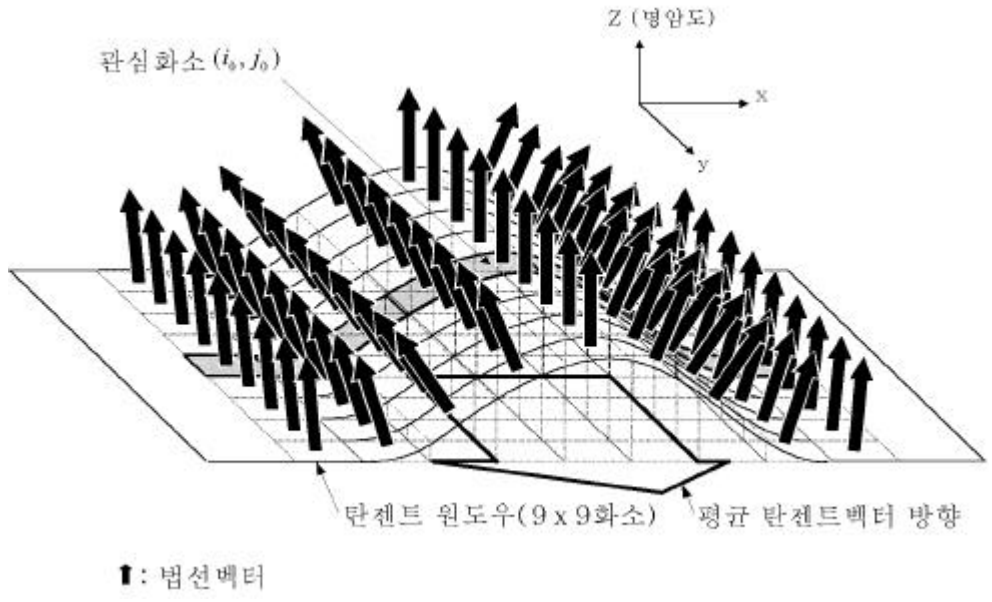
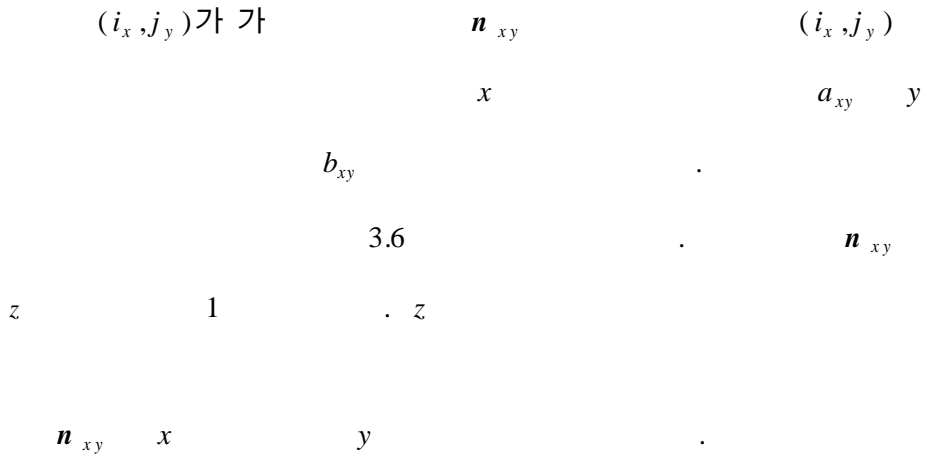
$$b_{xy} = \frac{ - a_1 - a_2 + a_3 + a_4 }{ 4 }$$

$$a_1 = gray(i_{x+1}, j_{y+1}) \quad a_2 = gray(i_{x-1}, j_{y+1})$$

$$a_3 = gray(i_{x-1}, j_{y-1}) \quad a_4 = gray(i_{x+1}, j_{y-1})$$

$a_1, \dots, a_4$  :

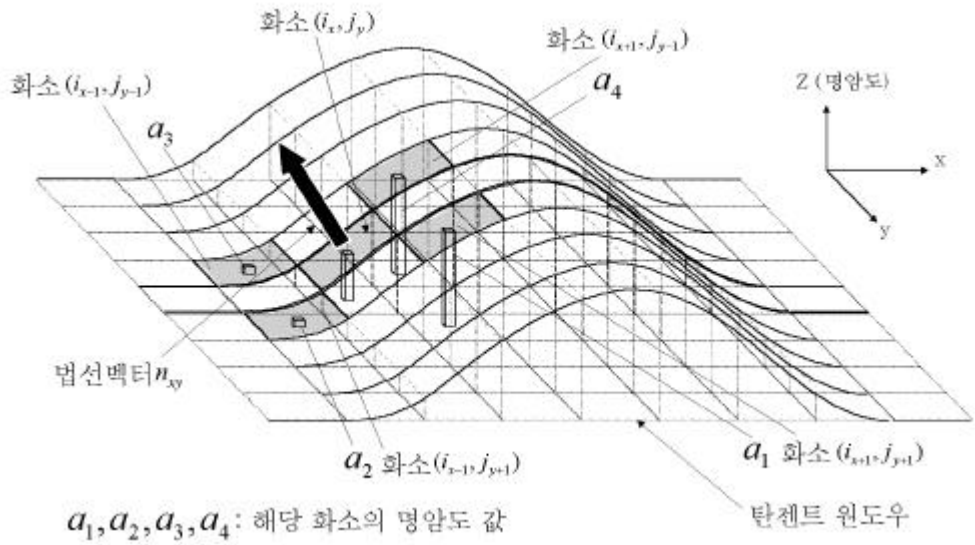
.



3.5

Fig. 3.5 Normal vectors within the tangent window

$n_{xy}$  ( $x = 1, \dots, 9, y = 1, \dots, 9$ ) 가



### 3.6

Fig. 3.6 Determination of normal vector

3.7                      3.6                       $n_{xy}$                        $z$   
 ,                      ,                       $v_{xy} = (a_{xy}, b_{xy})$  ( $x = 1, \dots, 9$   
 ,  $y = 1, \dots, 9$ )                      ,                       $t = (t_1, t_2)$   
 (3-2)                       $t$ 가                      .

$$\text{Min} \sum_{x=1}^9 \sum_{y=1}^9 | [ \mathbf{v}_{xy} \bullet \mathbf{t} ] |^2 \quad (3-2)$$

$$(3-3) \quad .$$

$$\mathbf{t} = \begin{cases} \left[ 1, \frac{B-A}{2C} - \text{sgn}(C) \sqrt{\left(\frac{B-A}{2C}\right)^2 + 1} \right] & \text{if } C \neq 0 \\ [1, 0], & \text{if } C = 0 \text{ and } A \leq B \\ [0, 1], & \text{if } C = 0 \text{ and } A > B \end{cases} \quad (3-3)$$

$$A = \sum_{x=1}^9 \sum_{y=1}^9 (a_{xy})^2$$

$$B = \sum_{x=1}^9 \sum_{y=1}^9 (b_{xy})^2$$

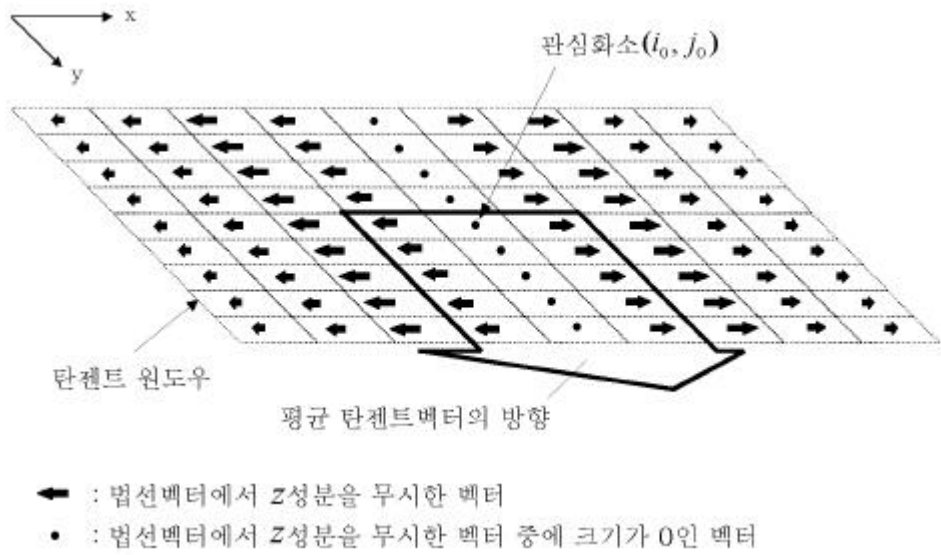
$$C = \sum_{x=1}^9 \sum_{y=1}^9 a_{xy} b_{xy}$$

$$\Phi \quad (3-3)$$

$\mathbf{t}$

$$(3-4)$$

$$\Phi = \begin{cases} \tan^{-1} \left( \frac{t_2}{t_1} \right) & \text{if } t_1 \neq 0 \\ 90, & \text{if } t_1 = 0 \end{cases} \quad (3-4)$$



3.7 z

Fig. 3.7 Vectors ignored z component from normal vectors and average tangent vector

### 3.1.2

(3-4)

가 가

가 3.8 (a)

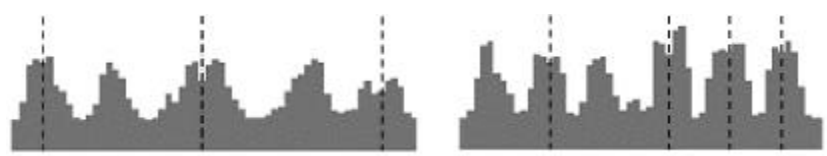
(local minimum)

(volcano silhouette)

3.9

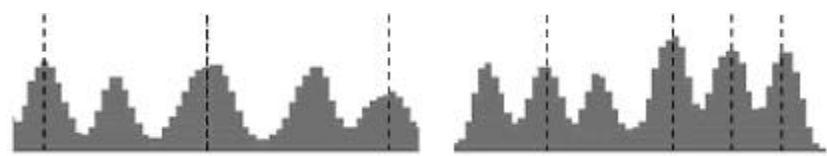
3.10 가 (Gaussian) 가

3.8 (b) 3.8 (a)



(a)

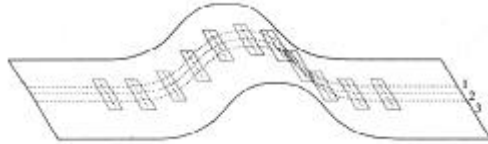
( )



(b)

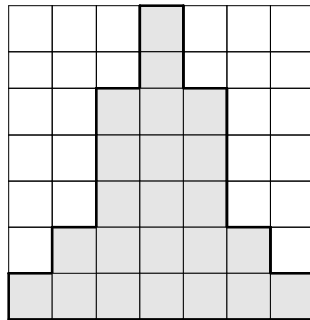
3.8

Fig. 3.8 A silhouette and an adjusted distribution of gray level



3.9

Fig. 3.9 Three parallel planes



3.10 가 가

Fig. 3.10 The weighting mask with a symmetric Gaussian silhouette

가

가

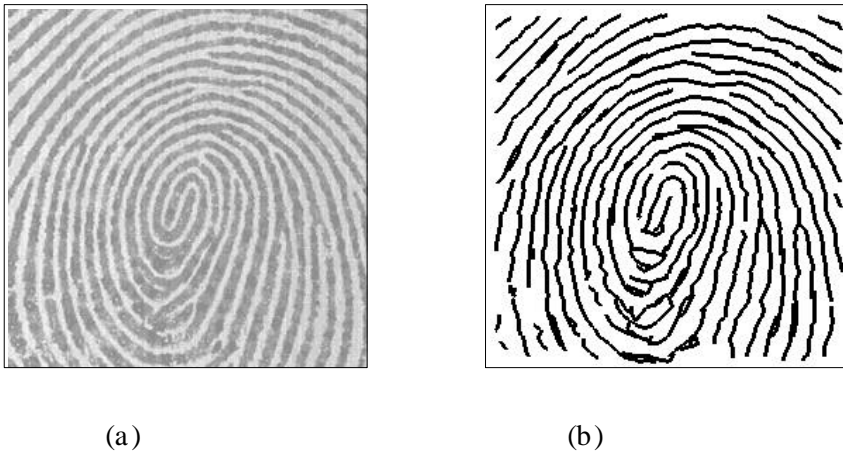
3.2

가



3.2.1

3.11



3.11

Fig. 3.11 Input and output image

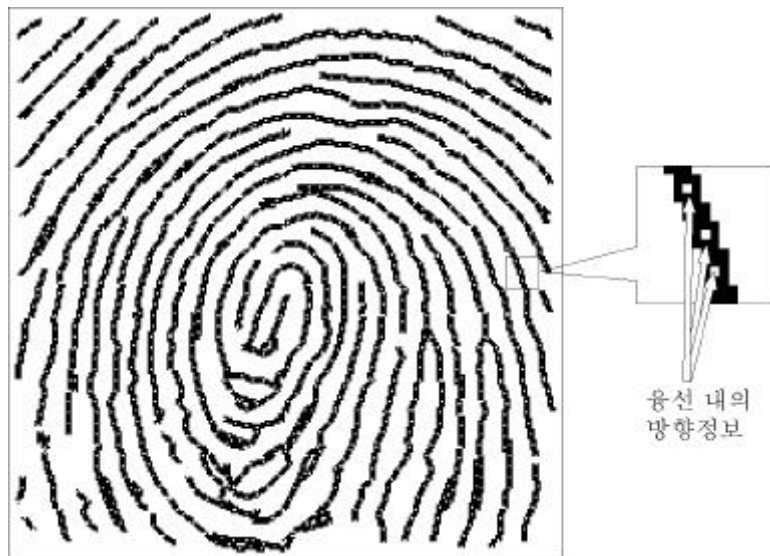
3.12

가  
가

가

가

가



3.12

( 가 )

Fig. 3.12 Directional information of ridges

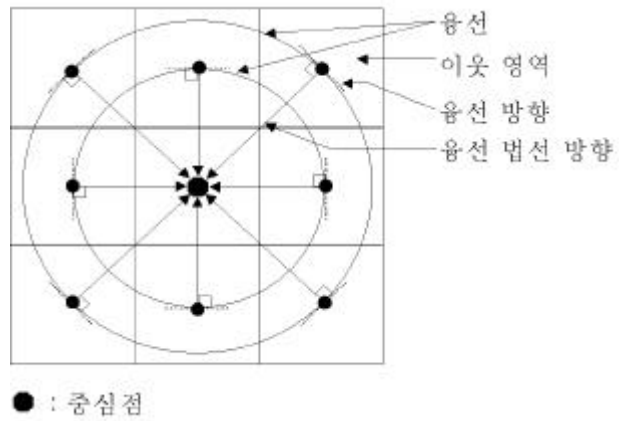
(The white dots within black ridges contain directional information)

3.2.2

3.13

가 가

가 . 3.14



3.13

Fig. 3.13 Normal directions of concentric circle ridge formation

가

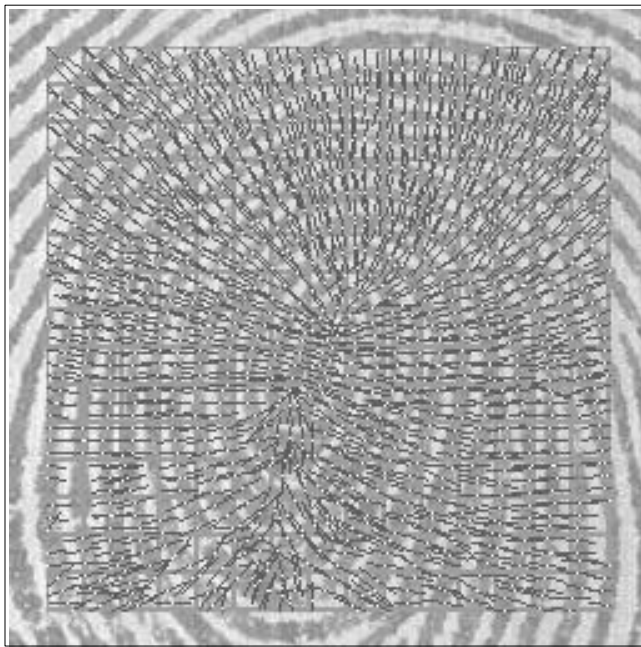
가 ,

가

가 .

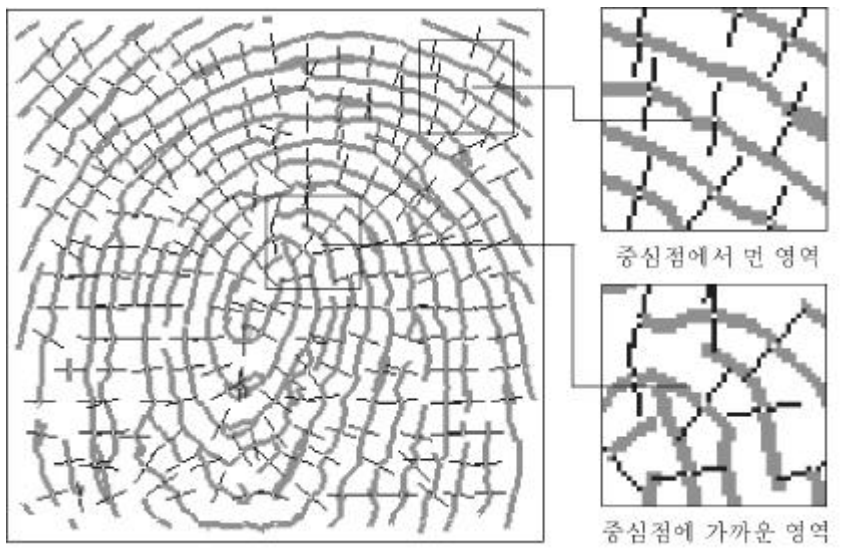
가

가 . 3.15



3.14

Fig. 3.14 Normal directions of the ridges



3.15

Fig. 3.15 Normal directions from the first local maximum points

(3-5) , 가 가

$$(i_c, j_c) = \left[ \frac{1}{N} \sum_{k=1}^N D_{m_k} \right] \quad (3-5)$$

,  
 $(i_c, j_c)$  :

$N$  :

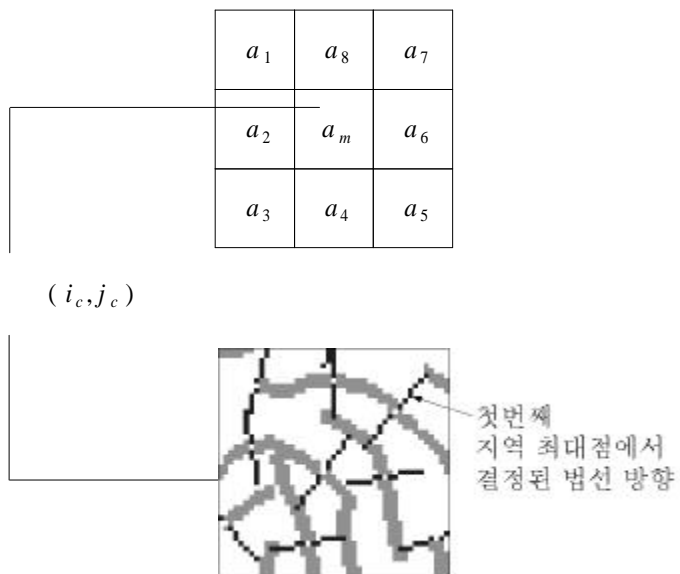
$$D_{m_k} = \begin{cases} |a_m - a_k| & , \text{ if } |a_m - a_k| \leq 90 \\ 180 - |a_m - a_k| & , \text{ if } |a_m - a_k| > 90 \end{cases}$$

$a_m$  :

$a_k$  :  $k$

3.16

가 90 (supplementary angle)



3.16

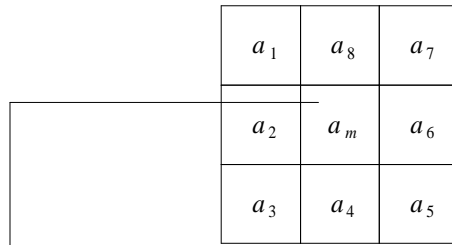
Fig. 3.16 Normal directions of ridges for a candidate core

3.17

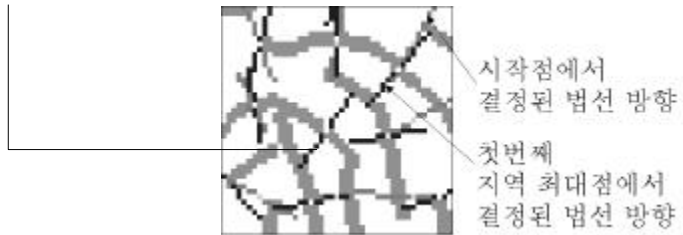
$$(3-5) \quad N = 8$$

$$(i_c, j_c)$$

3.18



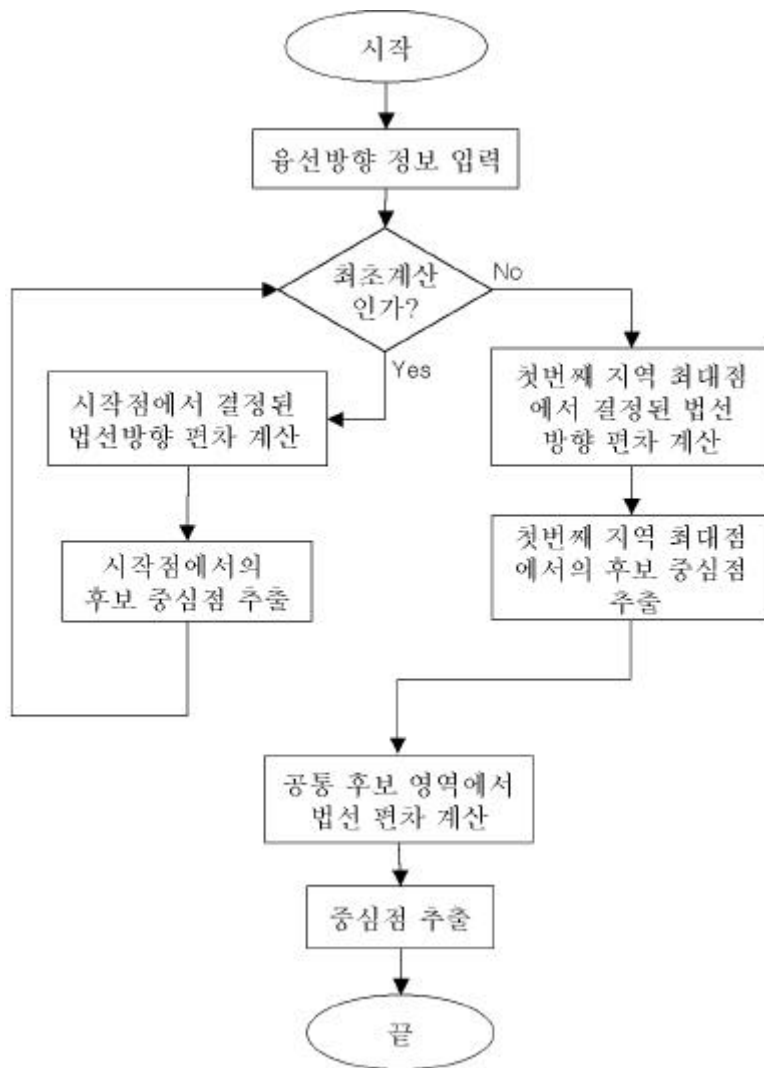
$(i_c, j_c)$



3.17

Fig. 3.17 Normal directions of ridges for a core





3.18

Fig. 3.18 Flow chart of a core detection

# 4

255 × 255

45

,

.

[4]

.

가

.

4.1

.

,

.

가

4

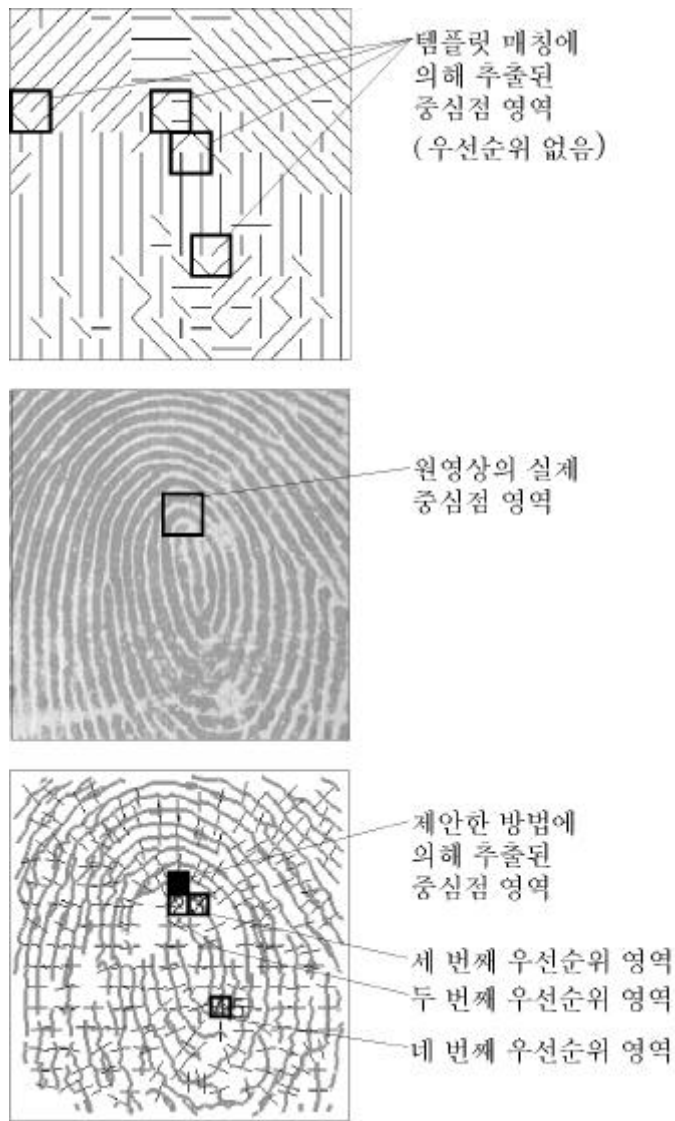
가

가

.

.

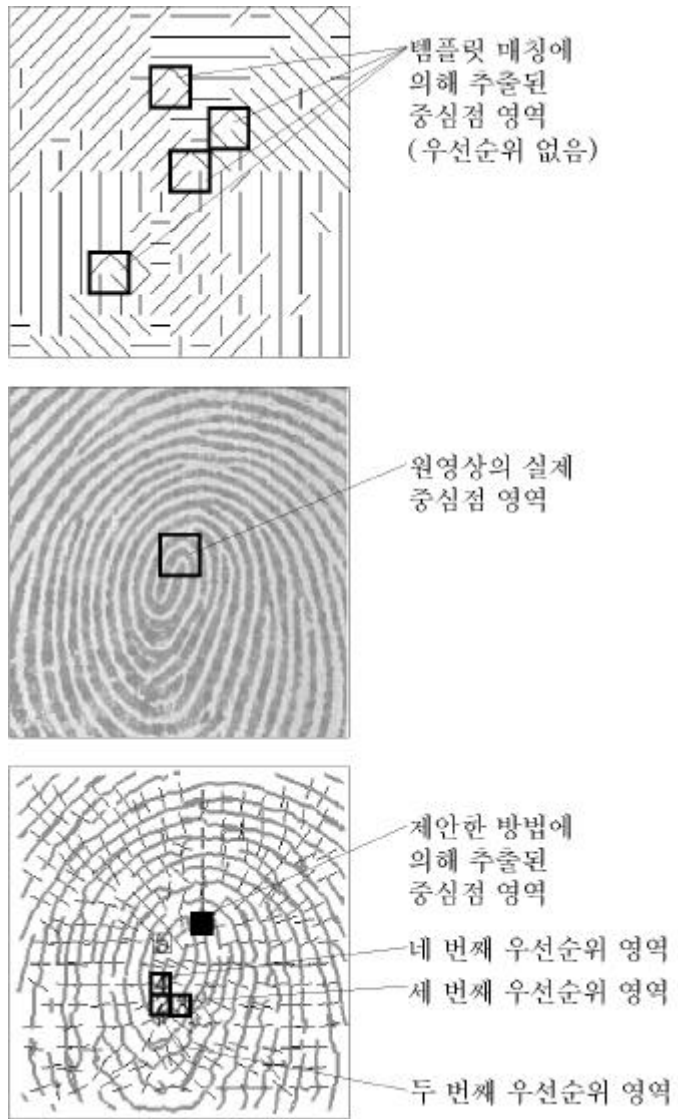
.



(a) A

4.1

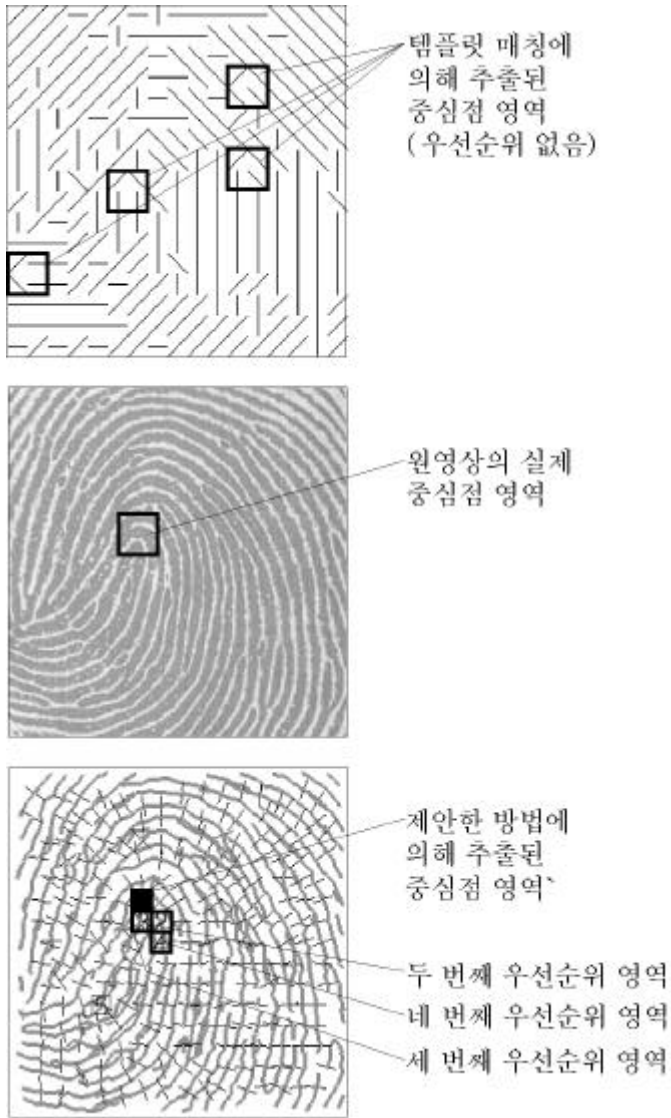
Fig. 4.1 Extracted cores by the template matching and the proposed method



(b) B

4.1

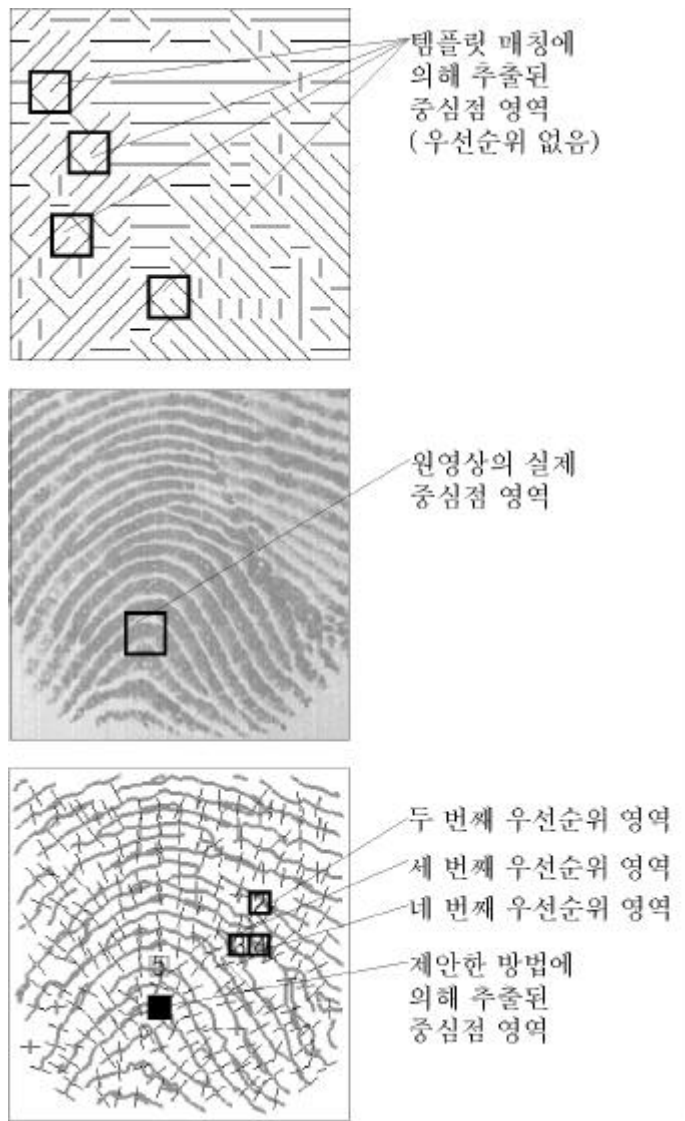
Fig. 4.1 ( Continued )



(c)

4.1

Fig. 4.1 ( Continued )



(d)

4.1

Fig. 4.1 ( Continued )

1

8

45

1

Table 1. Deviations of normal directions and average directions

(a)

( : )

1	(142, 112)	1406	50.21
2	( 97, 172)	1334	47.6
3	(112, 172)	1272	45.5
4	(127, 172)	1075	38.4
5	(112, 127)	679	24.2

(b)

( : )

1	(142, 112)	1407	50.25
2	(112, 172)	1256	44.9
3	(127, 172)	1244	44.4
4	(112, 157)	840	30
5	(112, 127)	655	23.4

2 45 4 ,  
180

.  
, 4

, ,  
.

2

Table 2. The comparison of extracted cores

		(%)		(%)
	37	20%	103	57%
	48	27%	41	23%
	95	53%	36	20%

:  
:  
:

가



4.2 4.3

. 가

가

4

가

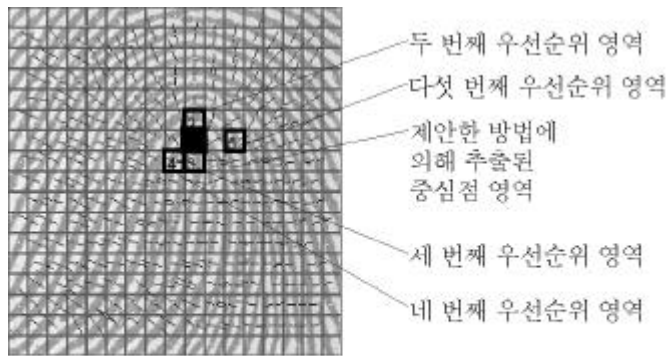
4.2

4.3

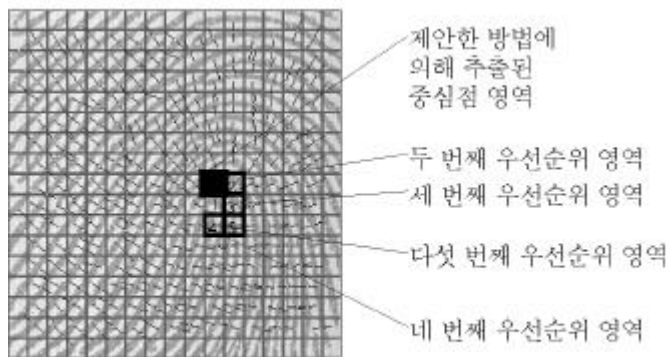
가

가

가



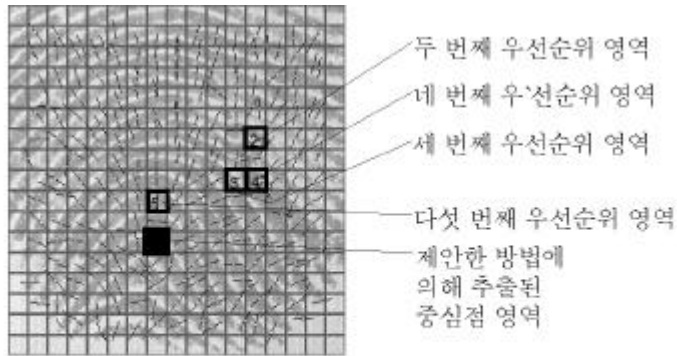
(a) 원영상 A



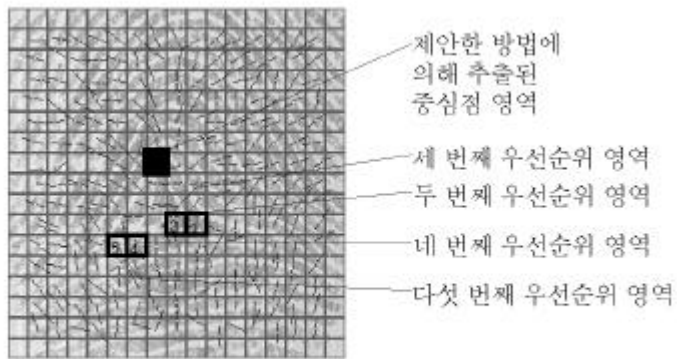
(b) 원영상 B

#### 4.2

Fig. 4.2 The extracted cores from same fingerprint with position displacement



(a) 완만한 분포를 가지는 지문 영상



(b) 품질이 떨어지는 지문 영상

4.3

Fig. 4.3 The candidate cores which are not relate with the real core

5

가 가  
가 가

가 가

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