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Modelling of the verification by iris scanning by Generalized nets

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Abstract: The present paper describes the process of the verification by Iris scanning. For the purpose we use Generalized Nets. The model describes an algorithm using phase-based image- an image matching technique using only the phase components.
Keywords: Generalized nets, Iris scanning, Modelling.

Introduction

Iris patterns become interesting as an alternative approach to reliable visual recognition of persons when imaging can be done at distances of less than a meter, and especially when there is a need to search very large databases without incurring any false matches despite a huge number of possibilities [4-10, 12-14]. Although small (11 mm) and sometimes problematic to image, the iris has the great mathematical advantage that it's pattern variability among different persons is enormous. In addition, as an internal organ of the eye, the iris is well protected from the environment, and stable over time. As a planar object its image is relatively insensitive to angle of illumination, and changes in viewing angle cause only affine transformations; even the nonaffine pattern distortion caused by pupillary dilation is readily reversible. Finally, the ease of localizing eyes in faces, and the distinctive annular shape of the iris, facilitate reliable and precise isolation of this feature and the creation of a size-invariant representation.

Iris colour is determined mainly by the density of melanin pigment in its anterior layer and stroma, with blue irises resulting from an absence of pigment: long wavelength light penetrates and is absorbed by the pigment epithelium, while shorter wavelengths are reflected and scattered by the stroma. The striated trabecular meshwork of elastic pectinate ligament creates the predominant texture under visible light, whereas in the near infrared (NIR) wavelengths used for unobtrusive imaging at distances of up to 1 meter, deeper and somewhat more slowly modulated stromal features dominate the iris pattern. In NIR wavelengths, even darkly pigmented irises reveal rich and complex features.

GN-model

The paper models the process of verification by iris scanning. For the purpose we use Generalized Nets (GNs) [1, 2]. In [3, 11] was constructed the GN models of image processing, pattern and face recognition.

The model describes an algorithm using phase-based image - an image matching technique using only the phase components.

The generalized nets are introduced by the set of transitions [1, 2]:

$$A = \{Z_1, Z_2, Z_3, Z_4, Z_5, Z_6\},$$

where the transitions describe the following processes:

Z_1 - Iris localization;
Z_2 - Normalization;
Z_3 - The process of eyelid masking;
Z_4 - The normalization of the iris' contrast;
Z_5 – The process of matching.

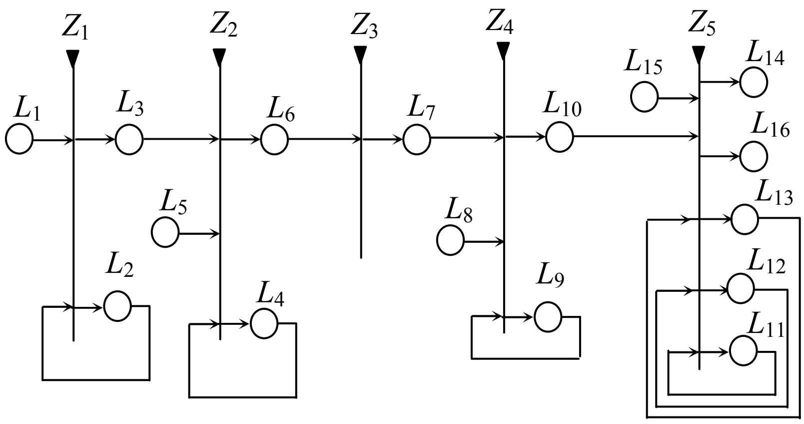

Figure 1. The GN model of the process of verification by iris scanning

Initially in places L_{11}, L_{12} and L_{13} stay the next tokens:

- in place L_{11} – one token with characteristic
"Database about size";
- in place L_{12} – one token with characteristic
"Database about rotation";
- in place L_{13} – one token with characteristic
"Database about iris".

These tokens will be in their own places during the whole time during which the GN functions.

This step is to detect the inner (iris/pupil) boundary and the outer (iris/sclera) boundary in the original image. Let (l_1, l_2) be the lengths of the two principal axes of the ellipse, (c_1, c_2) be its center, and θ be the rotation angle. We can find the optimal estimate (l_1, l_2, c_1, c_2, θ) for the inner boundary by maximizing the following absolute difference:

$$|S(l_1 + \Delta\, l_1, l_2 + \Delta\, l_2, c_1, c_2, \theta) - S(l_1, l_2, c_1, c_2, \theta)|$$

Here, $\Delta\, l_1$ and $\Delta\, l_2$ are small values necessary for the localization of the iris.

The forms of the transitions are the following.

From place L_1 enter tokens with characteristic

"$l_1, l_2, c_1, c_2, \theta$".

$$Z_1 = < \{L_1, L_2\}, \{L_2, L_3\}, R_1, \vee(L_1, L_2) >$$

where:

$$R_1 = \begin{array}{c|cc} & L_2 & L_3 \\ \hline L_1 & True & False \\ L_2 & W_{2,2} & W_{2,3} \end{array},$$

$W_{2,2} =$ "The iris is not located",
$W_{2,3} = \neg W_{2,2}$.

The tokens entering place L_3 obtain characteristics

"The scanned iris".

Next step is to normalize iris to compensate for the deformations in iris texture.

From place L_5 enter tokens with characteristic

"Criterion for normalization".

$$Z_2 = < \{L_3, L_4, L_5\}, \{L_6, L_4\}, R_2, \wedge(L_5, \vee(L_3, L_4)) >,$$

where:

$$R_2 = \begin{array}{c|cc} & L_6 & L_4 \\ \hline L_3 & False & True \\ L_4 & W_{4,6} & W_{4,4} \\ L_5 & False & True \end{array},$$

$W_{4,6} =$ "The iris is not normalized",
$W_{4,4} = \neg W_{4,6}$.

The tokens from places L_3 and L_5 merge in a new token in place L_4. It generate new token, that enters place L_6 with characteristic

"The normalized iris".

To remove the iris region occluded by the upper eyelid and eyelashes, we use only the lower half.

$$Z_3 = < \{L_6\}, \{L_7\}, R_3, \vee(L_6) >$$

where:

$$R_3 = \begin{array}{c|c} & L_7 \\ \hline L_6 & True \end{array}.$$

The token that enters place L_7 obtains characteristic

"The normalized iris, Information about down half iris image".

In some situation, the normalized iris image has low contrast. In such a case, we improve the contrast by using local histogram equalization technique.

The token that enters place L_8 obtains characteristic

"Contrast".

$$Z_4 = < \{L_7, L_8, L_9\}, \{L_9, L_{10}\}, R_4, \wedge(L_8, \vee(L_7, L_9)) >,$$

where:

$$R_4 = \begin{array}{c|cc} & L_9 & L_{10} \\ \hline L_7 & True & False \\ L_8 & True & False \\ L_9 & W_{9,9} & W_{9,10} \end{array},$$

$W_{9,9} =$ "The iris contrast is not normalized",

$W_{9,10} = \neg\, W_{9,9}$.

The tokens from places L_7 and L_8 merge in a new token in place L_9. It generate new token, that enters place L_{10} with characteristic

"The normalized iris (ready for matching)".

Given a pair of normalized iris images to be compared, the purpose of this process is to extract effective regions of the same size from the two images. Rotation of the camera, head tilt and rotation of the eye within the eye socket may cause the displacements in normalized images.

The token that enters place L_{15} obtains characteristic

"New iris for database".

$Z_5 = \langle \{L_{10}, L_{11}, L_{12}, L_{13}, L_{15}\}, \{L_{11}, L_{12}, L_{13}, L_{14}, L_{16}\}, R_5, \vee (L_{10}, L_{11}, L_{12}, L_{13}, L_{15}) \rangle$,

where:

$R_5 =$

	L_{11}	L_{12}	L_{13}	L_{14}	L_{16}
L_{10}	*True*	*False*	*False*	*False*	*False*
L_{11}	*True*	$W_{11,12}$	*False*	*False*	$W_{11,16}$
L_{12}	*False*	*True*	$W_{12,13}$	*False*	$W_{12,16}$
L_{13}	*False*	*False*	*True*	$W_{13,14}$	$W_{13,16}$
L_{15}	*True*	*True*	*True*	*False*	*False*

$W_{11,12}$ = "There is the matching for the size",

$W_{11,16} = \neg\, W_{11,12}$,

$W_{12,13}$ = "There is the matching for the rotation",

$W_{12,16} = \neg\, W_{12,13}$,

$W_{13,14}$ = "There is the matching for the iris",

$W_{13,16} = \neg\, W_{13,14}$.

The tokens that enter places L_{14} and L_{16} obtains characteristics respectively:

"The iris is matched" and

"The iris is not matched".

Conclusion

Iris recognition is the most powerful biometric technology there is. No two irises are alike. There is no detailed correlation between the iris patterns of even identical twins, or the right and left eye of an individual. The amount of information that can be measured in a single iris is much greater than fingerprints, and the accuracy is greater than DNA.

The biometric technology works by photographing a passenger's iris patterns and storing the data in a database, together with their passport details. This system is in use in prisons, airports, home secure or work control.

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