Impact of sensor ageing on iris recognition

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Abstract

Similar to the impact of ageing on human beings, digital image sensors develop ageing effects over time. Since these imager’s ageing effects (commonly denoted as pixel defects) leave marks in the captured images, it is not clear whether this affects the accuracy of iris recognition systems. This paper proposes a method to investigate the influence of sensor ageing on iris recognition by simulating an iris test database. A pixel model is introduced and an ageing algorithm is discussed to create the test database. To establish practical relevance, the simulation parameters are estimated from the observed ageing effects of a real iris scanner over the timespan of 4 years.

Introduction

Some researchers claim that iris-related information is stable or relatively stable over time, while others observe significant changes. They mostly conclude these age-dependent changes in iris texture by observing changes in a system’s iris-recognition rate.

For this reason, one would need to have long-term data from the same imager to investigate the sensor’s or the subject’s physical condition. Therefore, there are not enough data in the iITD to observe significant changes. One possible way to overcome this obstacle is to model some of the age-related changes in the iris by simulating the effects of ageing on the imager. This would allow creating a test database that can be used to evaluate the performance of iris recognition systems.

Generation of virtually aged data

Defect types that develop over time as the sensor ages are:

- Stuck pixels: pixel with constant offset
- Hot pixels: extremely high dark current
- If a pixel is once defective, it remains defective

A partially-stuck or hot pixel (1) and two stuck pixels (2) in an iris image (enhanced for visualization).

After omitting negligible factors the pixel output model is defined as

\[ Y(x, y) = \begin{cases} C(x, y) & \text{if } C(x, y) \neq 0; \\ I(x, y) + D(x, y) & \text{otherwise}, \end{cases} \]

with \( Y, C, I, D \in \{ Z : |0; 255| \} \) for \( x, y \in \mathbb{Z} \). where \( Y \) is the resulting pixel output, \( I \) the incident light, \( C \) stuck and \( D \) partially-stuck pixels.

Parameter estimation from iris database

Defect growth rates and amplitudes are retrieved from a database captured with a real iris scanner. Because the image content correlates with age, the parameters are estimated from uncorrelated regions, i.e. regions showing skin.

- Stuck pixels \( \rightarrow \) constant pixel value in multiple images
- Hot pixel \( \rightarrow \) offset between median-filtered and original mean grey image

The offset image’s logarithmic histogram shows normal distribution due to PRNU. The decision threshold is chosen in a way that only outliers are declared as partially-stuck pixels.

Experimental setup

- Sensor: Irisguard H100 IRT
- Iris texture images acquired in 2009 and 2013
- Tested algorithms with generated aged data sets (based on IITD data base):
  - Rathgeb and Uhl \((cb, cr, dct)\)
  - Ko et al. \((ko)\)
  - Monro et al. \((dg)\)
  - Ma et al. \((qsw)\)
  - LogGabor-1D method by Masek \((lg)\)

Results

EERs of the algorithms of Masek (top) and Ko et al. (bottom) with CAHT-segmentation for aged data sets.

Conclusion

- Sensor ageing influences the accuracy
- Sensitivity to spiky noise \((e.g. \ \text{pixel defects})\)
- No trend observable
- System’s accuracy depends on current physical condition of the sensor
- Texture ageing experiments based on evaluation of accuracy changes \((e.g. \ \text{the EER})\) are therefore not entirely reliable