Identifying the Origin of Iris Images Based on Fusion of Local Image Descriptors and PRNU Based Techniques

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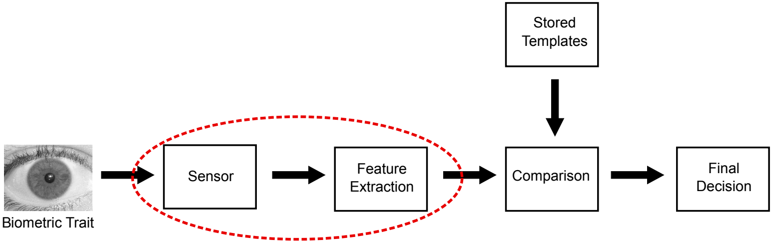
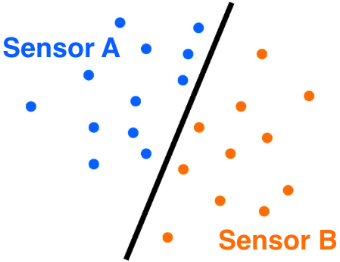
Outline



- Knowing the image origin offers several advantages in a biometric system:
  - Forensic applications, e.g. prevent insertion attack by ensuring authenticity and integrity of images
  - Non-Forensic applications, e.g. selective processing of iris images[1]
- Analyse intrinsic traces in images without need for additional information (Digital image forensics)

[1] S. S. Arora et al. “On iris camera interoperability”. In: *2012 IEEE Fifth International Conference on Biometrics: Theory, Applications and Systems (BTAS)*. 2012, pp. 346–352

Classification Techniques



- Goal: Find origin of image (unit/model)
- Train a classifier with features extracted from images
- Determine sensor/data set for each query image using this classifier

- Two different techniques:
  1. PRNU based sensor identification (PSI)
  2. Image texture classification (ITC)

PRNU Based Sensor Identification (PSI)

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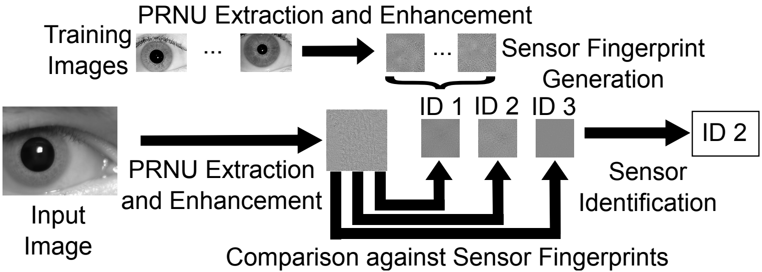
PRNU

- Photo-response non-uniformity
- Variations in quantum efficiency among pixels
- PRNU noise residual $W_I = I - F(I)$
- PRNU fingerprint $\hat{K} = \frac{\sum_{i=1}^{N} W_I^i I^i}{\sum_{i=1}^{N} (I^i)^2}$

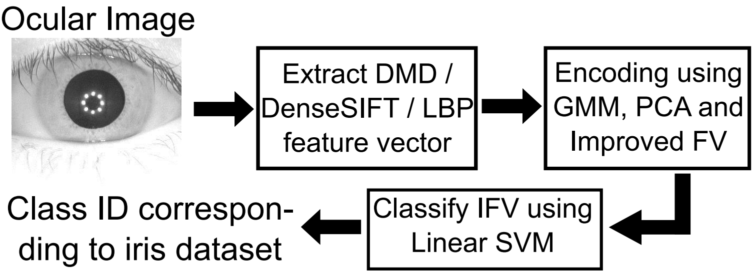
where I... Image, F... Denoising Filter, i... i-th Image,N... # of images



Iris Texture Classification (ITC)

Features

- Dense SIFT (DSIFT): Local descriptor for keypoints based on a region around it, which are distributed on a dense grid
- Dense Micro-block difference (DMD): Pairwise differences of random small blocks of the image capturing its micro-structure
- Local Binary Pattern (LBP): Variations of pixels in a local neighborhood



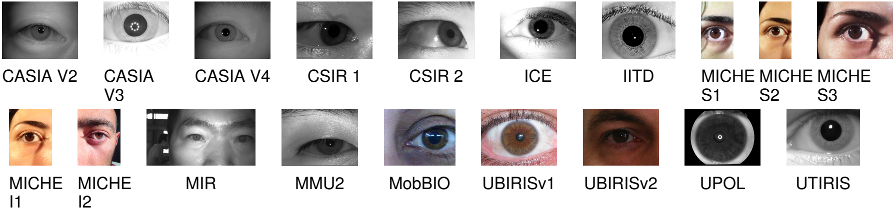
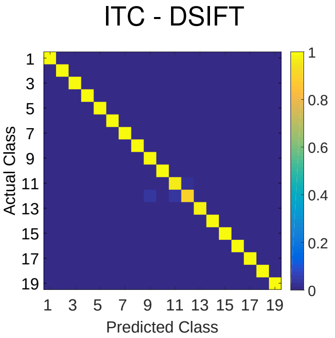
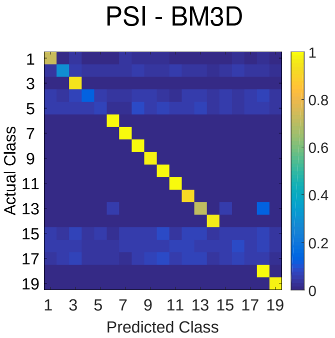


Figure: Sample images from the 19 investigated iris datasets.

- Experimental Set-up:
    - 5-fold cross validation with averaging of results
    - Random split of datasets in training set (TR) and test set (TE)
    - Different patch sizes: 64×64 up to 512×512
    - Score level fusion: Different Score normalisations and fusion schemes
    - Evaluation of Results: Accuracy (ACC) and average precision (AP)

Experiment 1: Iris Dataset Discrimination

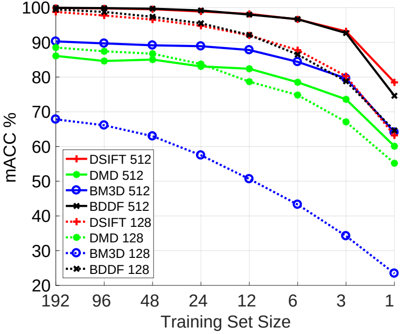




	ITC			PSI			FUSION
	DSIFT	DMD	LBP	BM3D	Li	FS	BDDF
mACC	98.78	88.51	91.96	67.82	65.92	60.20	**99.48**
mAP	99.51	91.23	95.05	67.93	65.26	40.72	**99.86**

Table: Mean accuracy (mACC) and mean average precision (mAP) for all 19 datasets. Patch size 128, TS size 192, TE size 192.

Experiment 2: Impact of Patch & Training Set Size



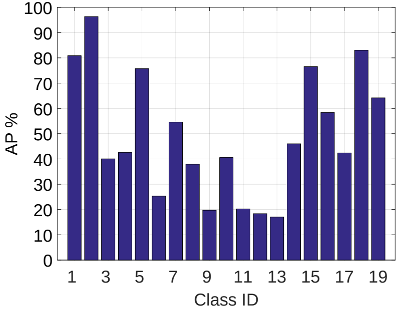


Figure: Accuracy for selected patch sizes and different training set sizes (left). Average precision plots for BDDF with patch size 64 and training set size 1 (right).

Experiment 3: Unit Level Discrimination

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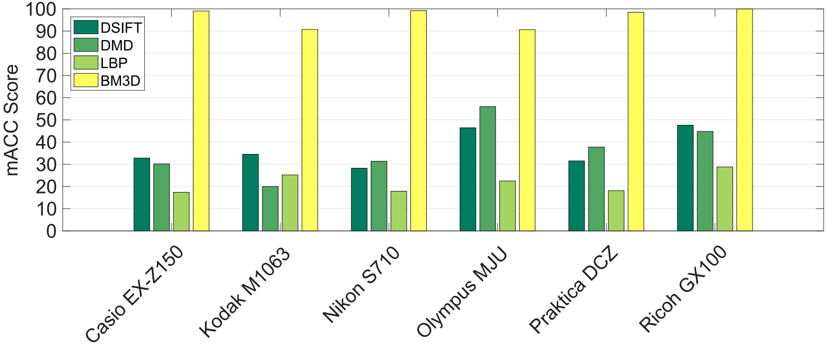

Figure: Results for the 6 camera models with 5 instances each from the Dresden DB[2]. Natural images have been used instead of iris images because of lack of comparable iris data.

[2] Thomas Gloe and Rainer Böhme. "The Dresden Image Database for benchmarking digital image forensics". In: *SAC 2010: Proceedings of the 2010 ACM Symposium on Applied Computing*. 2010, pp. 1584–1590

- Selective iris image processing:
  - Discrimination at model level is sufficient
  - ITC yields very good results
  - PSI works well only with larger patch sizes
  - Fusion of ITC and PSI yields even better results, especially for low number of training images and small patch size
- Insertion attack detection:
  - Discrimination at unit level is required
  - PSI works well, but has weaknesses (patch size, cropped and resized images)
  - ITC is not able to discriminate multiple units of same model in this scenario
  - Fusion of both ITC and PSI is beneficial to overcome individual weaknesses

Conclusion and Future Work

- Examination of approaches to deduce origin from iris images
- Images from 19 different iris data sets/sensors, 5 units from 6 camera models from Dresden DB
- Evaluation of impact of different training and patch sizes
- Both techniques show good performance in determining the origin of the images, but each one has its advantages and drawbacks:
  - PSI is able to distinguish the origin at unit level, but only for larger patch sizes
  - ITC works almost perfect to distinguish origin at model level, but fails at unit level
  - Fusion of both approaches helps to improve results, especially in worst case scenario

Future work: Performance at unit level with biometric data

- No dataset with multiple units of the same iris sensor model exists $\rightarrow$ Establish such a data set for this investigation
- Perform extended tests at unit-level with both approaches and fusion

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Thank you for your attention!