Iris Image Quality Metrics

Jim Cambier
November 2007

Overview for Iris Quality

- Motivation
- Overview
- Quality Philosophy
- Iris Algorithms
- Quality Factors
- Quality Impact
- Further Work

Market Motivation

- Image Capture
  - Quality measurement in image capture loop minimizes time and resources spent on storing and processing substandard images
- Enrollment
  - Remote enrollment without matching
  - Offline and inaccessible
  - Quality assures usability of enrollment data
- Fusion
  - Quality predicts match performance
  - Higher quality => heavier weighting

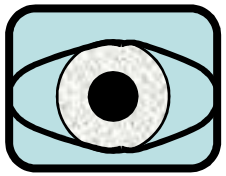
Technical Motivation

- Image Capture
  - Quality measurement in image capture loop determines when capture is acceptable
  - Speed vs accuracy tradeoff
- Enrollment
  - Best image quality optimizes segmentation and recognition performance, especially FNMR
  - Emphasis on accuracy
- Fusion
  - Quality predicts match performance
  - Higher quality => heavier weighting

Description

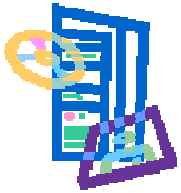
- The Auto Capture process is composed of several sub processes…

Sample Capture



Rapid Segmentation

Rapid Quality



Decision Process

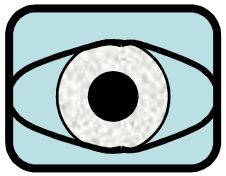
User Interface

CROSSMATCH® TECHNOLOGIES

Sample Capture

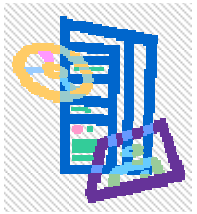
- An imaging system takes a series of “photographs” at a given frame rate.
- Depends on many factors
  - Sensor Electronics
  - Capture Time
  - Sensor Dynamic Range
  - Image Resolution
  - Field of View
  - Imaging Size
  - Computer Interface

Sample Capture



Rapid Segmentation

Rapid Quality



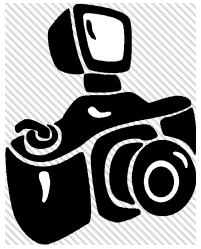
Decision Process

User Interface

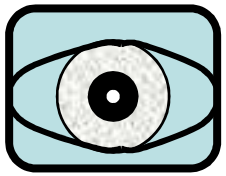
CROSSMATCH® TECHNOLOGIES

Rapid Segmentation

- Pupil boundary and specular reflection localized to estimate gaze angle and motion blur
- Iris boundary localized for use (with pupil boundary) to assess image focus and contrast
- Desirable to localize eyelids to estimate iris exposure
- Spectral reflections in iris area may be localized

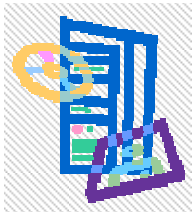


Sample Capture



Rapid Segmentation

Rapid Quality

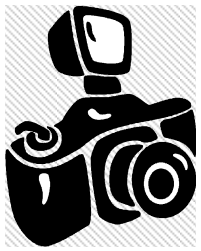


Decision Process

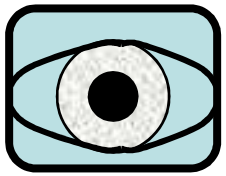
User Interface

Rapid Quality

- Position of specular reflection relative to pupil boundary provides indication of gaze angle
- Pupil and iris edge contrast/sharpness indicate focus quality
- Size of specular reflection indicates focus quality and motion blur
- Distance between upper and lower lid can be compared to iris diameter to estimate iris exposure
- Presence of specular reflections outside pupil may indicate obscuration of iris area

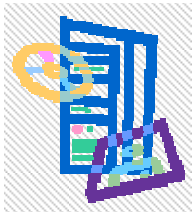


Sample Capture



Rapid Segmentation

Rapid Quality



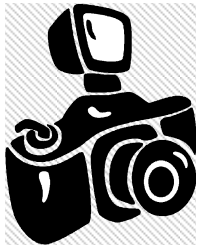
Decision Process

User Interface

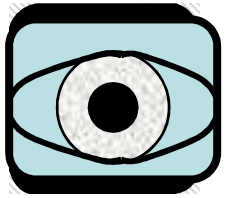
CROSSMATCH® TECHNOLOGIES

Decision Model

- Find Iris
- Assess Motion Blur
- Assess Focus Quality
- Weighted Sum of Quality Elements

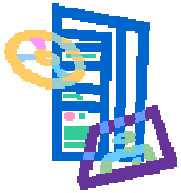


Sample Capture



Rapid Segmentation

Rapid Quality



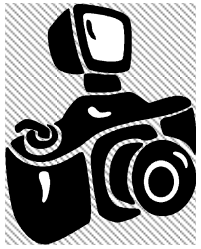
Decision Process

User Interface

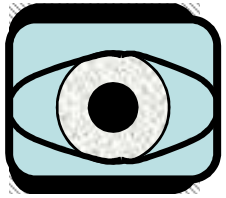
CROSSMATCH® TECHNOLOGIES

User Interface

- Frame Speed
- Fixation element – mirror or fixation target
- Display live and captured image for each eye
- Center and crop iris image

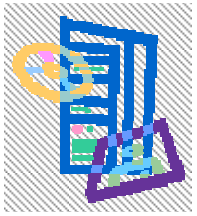


Sample Capture



Rapid Segmentation

Rapid Quality



Decision Process

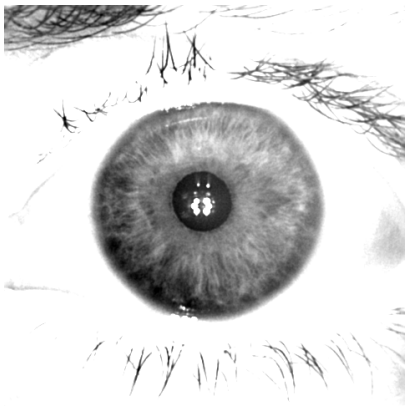
User Interface

CROSSMATCH® TECHNOLOGIES

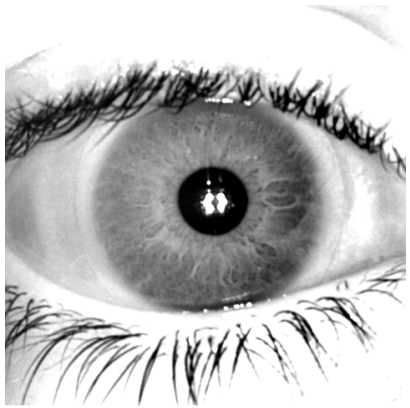
Captured Image Quality

- Assumes rapid quality assessment in capture loop has returned acceptable score
- Additional and more precise image quality metrics are applied, since more processing time is available
- Quality metrics may include:
  - Precise segmentation and determination of iris area based on eyelids, eyelashes, specular reflections, etc.
  - Focus assessment based on spatial frequency content – may be limited to iris area
  - Measurement of pupil/iris diameter ratio

Image Quality Examples

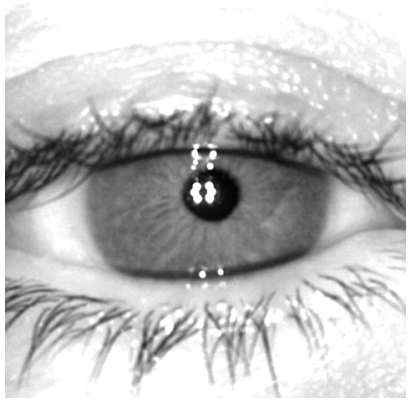


Q = 92

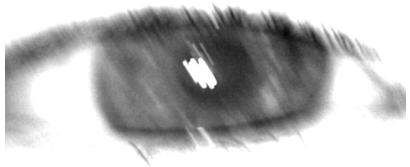


Q = 84

Q = 64



Q = 52



Q = 0

Q = 60

Image Quality and Match Performance

- Quality attributes impact authentic and imposter distributions.
- Effects on authentic and imposter distributions predict effects on match performance
- Analysis assumes iris texture encoding (wavelet, DCT, etc.) that gives rise to binary template and that matching is based on binary correlation e.g. Hamming distance.

Predicting Match Performance

Attribute	Authentic	Imposter	FNMR	FMR	Comment
Contrast (+)	No effect	No effect			Matching is based on phase
Focus Quality (+)	μ (-), σ (-)	σ (-)	(-)	(-)	More stat. independent samples
Iris Area (+)	μ (-), σ (-)	σ (-)	(-)	(-)	More stat. independent samples
Signal to Noise (+)	μ (-), σ (-)	σ (+)	(-)	(+)	Less stat. ind. samples
Gaze Angle (-)	μ (-), σ (-)	No effect	(-)		Lower authentic

Issues

- How to combine factors
- Weighted sum
- Weights proportional to effect on matching performance

$$d' = \Sigma w_i Q_i$$

$$= w_1 C + w_2 F + w_3 IA + w_4 SNR + w_5 GA$$

Future Work

- Sensitivity analysis to determine weights for quality factors
- Identification of additional factors
- Testing on large databases of varying quality

Summary

- Auto Capture is standard practice and improves capture speed
- Auto Capture GUI can provide useful feedback to operators and subjects
- Enrollment quality improves usability and value of remote or offline enrollments
- Accurate quality constitutes a critical input for multibiometric fusion
- Standardization of quality algorithms would enhance interoperability across cameras and algorithms