OSAC PROPOSED STANDARD 2024-N-0005
Standard Training Guideline for Iris Image Examiners

Facial & Iris Identification Subcommittee
Digital/Multimedia Scientific Area Committee (SAC)
Organization of Scientific Area Committees (OSAC) for Forensic Science



OSAC Proposed Standard

OSAC 2024-N-0005
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Prepared by Facial & Iris Identification Subcommittee
Version: 2.0
December 2024

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Standard Training Guideline for Iris Image Examiners

1. Scope

1.1 This guide defines a minimum set of criteria for training of personnel who will conduct iris image comparisons. It may be expanded upon per agency specific operations and needs.

1.2 This standard does not purport to address all the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ISO/IEC 2382-37:2022 (en) Information technology – Vocabulary – Part 37: Biometrics

2.2 ASTM E2917-19a, *Standard Practice for Forensic Science Practitioner Training, Continuing Education, and Professional Development Programs*.

2.3 ASTM WK72441, *New Guide for Standard Guide for Developing Discipline Specific Methodology for ACE-V.*

3. Terminology

3.1 Definitions:

3.1.1 Analysis, *n*: the first step of the ACE-V method. The assessment of an image to determine suitability for comparison.

3.1.2 Comparison, *n*: the second step of the ACE-V method; the examination of two or more samples to establish similarities and dissimilarities.

3.1.3 Evaluation, *n*: the third step of the ACE-V method; where an examiner assesses the value of the details observed during the analysis and comparison steps and reaches a conclusion. Ascertaining the value of dissimilarities and similarities between two images.

3.1.4 Iris, *n*: a thin, colored, approximately circular structure surrounding the pupil of the eye that contains features used for identification of individuals.

3.1.5 Iris Image, *n*: an image of a human eye that contains the iris which constitutes a biometric sample of the human eye.

3.1.6 Iris Recognition System, *n:* an automated machine-based system used to compare images based on iris characteristics and quantitatively assess their similarity.

3.1.7 Iris Image Comparison, *n*: an assessment of the similarities/dissimilarities of a pair of iris images.

3.1.7.1 Discussion - Iris images will typically include features of the periocular region such as eyelids, eyebrows, eyelashes, and canthi.

3.1.8 Iris Image Examiner, *n*: a person who conducts iris image comparisons.

3.1.9 Verification, *n*: (1) the final step of the ACE-V method; the review and independent analysis of the conclusion of another examiner. (2) In a biometric system, determining the validity of a biometric claim.

3.1.9.1 Discussion - Verification may be followed by some level of review as specified by agency policy.

4. Acronyms

4.1 ACE-V: Analysis, Comparison, Evaluation, and Verification

4.1.1.1 Discussion - Methodology used by forensic practitioners primarily when conducting feature comparisons.

5. Significance and Use

5.1 Individuals conducting iris image comparisons require training. Training must cover the topics necessary to establish competency for an iris image examiner. This document provides minimum training topics for an iris image examiner curriculum.

5.2 The intended audience for this document includes all personnel involved in iris image comparisons.

6. General

6.1 Topics reflect the level of comprehension the trainee is expected to achieve for each topic. For this document, four levels of comprehension are defined. These levels of comprehension are derived from Bloom's Taxonomy which is described further in Annex A1: Remember, Understand, Demonstrate, and Integrate.

6.2 **Remember**

6.3 Topics at the "Remember" level require the trainee to retrieve the relevant information from long-term memory. Topics for this level of comprehension contain the following keywords: define, identify, indicate, list, recall, recite, and recognize

6.4 **Understand**

6.5 Topics at the "Understand" level require the trainee to construct meaning from the information presented. Topics for this level of comprehension contain the following keywords: describe, discuss, explain, and summarize.

6.6 **Demonstrate**

6.7 Topics at the "Demonstrate" level require the trainee to understand the overall structure and purpose of the information they have learned and apply this information in exhibition and explanation. Topics for this level of comprehension contain the following keywords: apply, articulate, assign, categorize, check, collect, communicate, compare, contrast, declare, demonstrate, detect, determine, display, distinguish, document, exclude, exploit, follow, include, indicate, interpret, maintain, operate, prepare, respond, search, and select.

6.8 **Integrate**

6.9 Topics at the "Integrate" level require the trainee to assimilate information from multiple sources to predict arguments, evaluate strengths and weaknesses, and justify opinions. Topics for this level of comprehension contain the following keywords: assess, anticipate, consider, debate, evaluate, formulate, predict, relate, support, and weigh.

7. Summary of Practice

7.1 These topics are intended as a minimum set of criteria for the development of a training program for iris image examiners.

7.1.1 The time for a trainee to complete the training program shall be defined by specific agency policies.

7.2 History

7.2.1 Recall iris throughout history

7.2.1.1 Iris divination

7.2.1.2 Iridology

7.2.2 List pioneering practitioners and their contributions to iris recognition

7.2.2.1 Alphonse Bertillion

7.2.2.1.1 Use of iris pigmentation

7.2.2.2 Frank Burch

7.2.2.2.1 First to mention that complex patterns in the iris could be used as an "optical fingerprint"

7.2.2.3 J.H. Doggart

7.2.2.3.1 First to recognize, in writing, that the structure of the iris could be used for identification

7.2.2.4 Leonard Flom and Aran Safir

7.2.2.4.1 Wrote first patent for iris recognition

7.2.2.5 John Daugman

7.2.2.5.1 Created the algorithm used in iris recognition

7.2.3 Recognize landmark events and major deployments

7.2.3.1 United Arab Emirates ID (UAEID)

7.2.3.2 United Kingdom Project Iris Recognition Immigration System (IRIS)

7.2.3.3 Unique Identification Authority of India's (UIDAI) Aadhaar system

7.2.3.4 Canadian Passenger Accelerated Service System (CANPASS)

7.2.3.5 Identity for All in Africa (ID4Africa)

7.2.3.6 The Afghan Girl

7.2.3.7 The Brown Sisters

7.3 Biology

7.3.1 Describe embryological and postnatal development

7.3.1.1 Embryological development

7.3.1.2 Iris layer formation and timing

7.3.1.3 Changes that occur postnatal

7.3.2 Evaluate iris and periocular structure

7.3.2.1 Mechanical structure of the iris

7.3.2.2 Persistence of the iris structure

7.3.3 Assess and weigh stability of iris patterns

7.3.3.1 Changes due to aging

7.3.3.2 Changes due to disease and injury

7.3.3.3 Changes that occur postmortem

7.3.4 Articulate differences between irises, intrapersonal and interpersonal

7.3.4.1 Genetic and epigenetic influences on the resulting appearance of the iris, with specific emphasis on:

7.3.4.1.1 The biological origin and nature of iris variability

7.3.4.1.2 Similarities and differences between monozygotic twin iris structures

7.3.5 Evaluate biological distortions

7.3.5.1 Pupil dilation and contraction

7.4 Iris Image Recognition Systems

7.4.1 Describe iris image acquisition

7.4.1.1 Methods of iris image capture (e.g., near-IR)

7.4.1.2 Control measures needed to achieve quality iris images

7.4.1.3 Procedures for addressing missing eyes, injuries, and image recapture

7.4.2 Recall image science basics

7.4.2.1 Photonics

7.4.2.2 Wavelengths

7.4.2.3 Spectral reflectance

7.4.2.4 Optics

7.4.2.5 Sensors

7.4.2.6 Specularities

7.4.3 Articulate the function and use of agency specific algorithms

7.4.3.1 Processes related to acquisition, searching, storage, retrieval, matching, and reporting of iris image records.

7.4.3.2 System quality controls to ensure completeness, image quality, and data integrity.

7.4.4 Summarize performance assessments of iris recognition systems

7.4.4.1 IREX-10

7.4.4.2 Black box studies of algorithms

7.4.4.3 Effect of pupil dilation on algorithm results

7.4.4.4 Differences that visible light images, near infrared images, and other multispectral images have on results

7.5 Human Iris Image Comparison

7.5.1 Integrate Analysis

7.5.1.1 Assess the quality, quantity, and rarity of visible iris and periocular features

7.5.1.2 Properly determine correct orientation and differentiate between right and

left irises

7.5.1.3 Document observations and quality determination

7.5.2 **Integrate Comparison**

7.5.2.1 Morphological Analysis

7.5.2.2 Effective target group selection

7.5.2.3 Explainable and unexplainable difference in features

7.5.2.4 Document comparison observations

7.5.3 **Integrate Evaluation**

7.5.3.1 Weigh proper use of opinion scale

7.5.3.2 Agency specific source opinion

7.5.3.3 Document opinion determination

7.5.4 **Integrate Verification**

7.5.4.1 Methods of verification used by the discipline

7.5.4.1.1 Blind verification

7.5.4.1.2 Non-blind verification with justification

7.5.4.2 Importance and limitations of each method

7.5.5 **Prepare Agency Specific Reporting**

7.6 Attributing Factors

7.6.1 Assess for Iris Anomalies

7.6.1.1 Disease and temporary conditions

7.6.1.2 Traumatic injury

7.6.1.3 Drug and alcohol effects

7.6.1.4 Surgical effects

7.6.1.5 Patterned contacts/cosmetics enhancements

7.6.1.6 Iris Presentation Attack and Detection (PAD)

7.6.1.7 Generative Adversarial Network (GANS)/Deepfakes

7.7 Human Factors for Iris Image Examiners

7.7.1 Recognize and mitigate effects of bias in comparisons

7.7.1.1 Cognitive bias

7.7.1.2 Contextual bias

7.7.1.3 Confirmation bias

7.7.2 Recognize psychological stressors

7.7.2.1 Impact and importance of psychological well-being on examiners

7.7.2.2 Time pressure and fatigue

7.7.2.3 Exposure to traumatic events

7.7.2.4 Adversarial environments

7.8 Legal Considerations

7.8.1 Understand the role of empirical testing of human judgment and accuracy

7.8.1.1 Black box studies

7.8.1.2 White box studies

7.8.2 Recall legal admissibility and landmark cases

7.8.2.1 U.S. vs. Frye (1923)

7.8.2.2 Daubert vs. Merrell Dow Pharmaceuticals (1993)

7.8.2.3 Kumho Tire vs. Carmichael (1999)

7.8.2.4 Brady vs. Maryland (1963)

7.8.3 Demonstrate effective courtroom testimony

7.8.3.1 Using justifiable, scientifically based statements

7.8.3.2 Importance of transparency

7.8.3.3 Use of common-sense terminology

7.8.3.4 Verbal and non-verbal communication

7.8.3.5 Personal appearance

7.8.3.6 Vocal volume and inflection

7.8.4 Understanding of jurisdiction's rules about reference to notes or other materials

7.9 Performance Assessments

7.9.1 Evaluate training retention and agency specific practices

7.9.1.1 Training topics

7.9.1.2 Iris image comparisons

7.9.1.3 Agency specific mentorship

7.10 Post Training

7.10.1 Maintain and develop examiner performance

7.10.1.1 Annual Proficiency Testing

7.10.1.2 Continued Training in Field

7.10.1.3 Professional Development

ANNEX

(Mandatory Information)

A.1 BLOOM'S TAXONOMY

1A1.1 The levels of comprehension in this training standard: Remember, Understand, Demonstrate, Integrate, are modeled after Blooms Taxonomy. Bloom's Taxonomy was created in 1956 and modified in 2001 as a framework for categorizing educational goals. Bloom's Taxonomy defines 6 levels of comprehension, while this standard has modified that model to four levels of comprehension for easier application among trainers.[1]

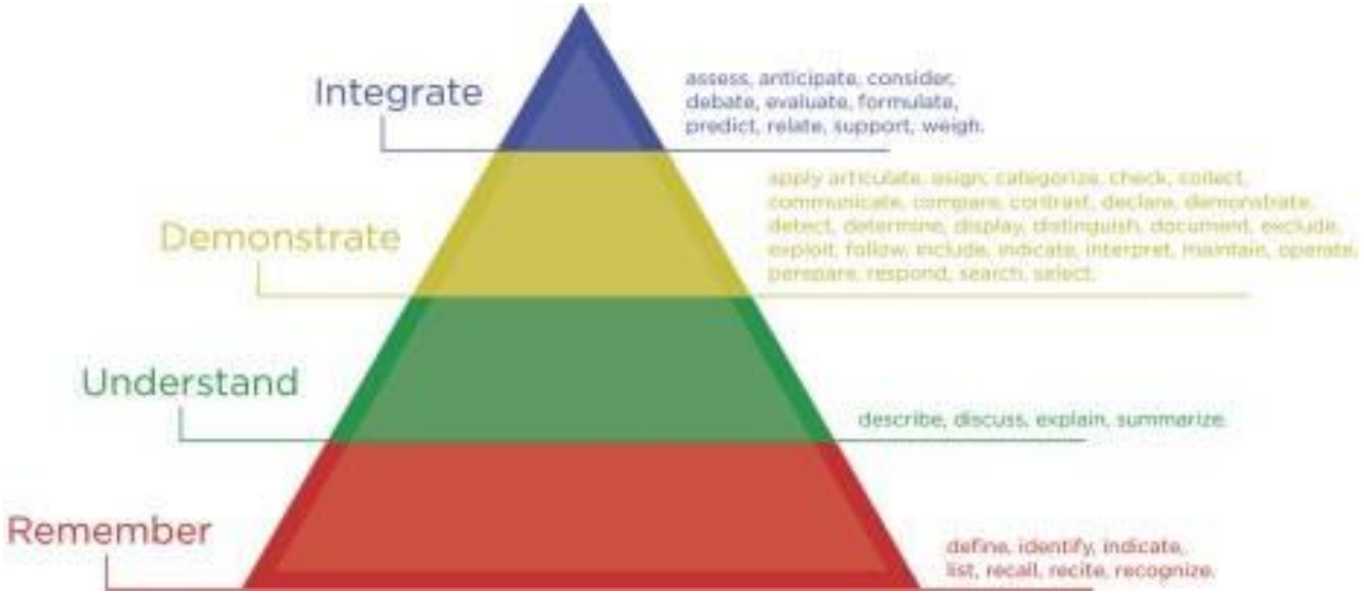


Image 1: modified from Bloom's Taxonomy

[1] https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

APPENDIX

(Nonmandatory Information)

X1. Example Recommended Readings

X1.1 The literature below is current as of this writing but is changing rapidly and agencies should incorporate new developments. The following bibliography is not intended to be an all-inclusive list, review, or endorsement of literature on this topic. The goal of the bibliography is to provide examples of publications addressed in the standard.

X.1 History

X.1.1 Bertillon, A. 1896. Signaletic Instructions: Including the Theory and Practice of Anthropometrical Identification. (R.W. McClaughry, Trans.) Chicago: The Werner Company. Second Part, Chapter I., Section A, pp. 130 – 147

X.1.2 Daugman, J. 2001. “Iris Recognition”. American Scientist. Sigma Xi, The Scientific Research Society, vol. 89. pp. 326-329.

X.1.3 Daugman J. 2004. "How iris recognition works." IEEE Trans. Circuits and Systems for Video Technology 14(1), pp. 21 - 30.

X.1.4 Duke-Elder, S., Wybar, K. 1961. The Anatomy of the Visual System. vol. 2, St. Louis: The C.V. Mosby Company. Chapters 1, 2

X.1.5 Flom, L., Safir, A. 1987. Iris Recognition System. US 4641349. United States Patent Office

X.1.6 Daugman, J. 1994. Biometric Personal Identification System Based on Iris Analysis. US 5291560. United States Patent Office

X.1.7 Matey, J., et al. 2020. Analysis of Iris Images in Nicholas Nixon: The Brown Sisters, NIST Technical Note 2098.

X.1.8 Matsushita, M. 1999. Iris Identification System and Iris Identification Method. US 005901238A. United States Patent Office.

X.1.9 Wildes, R., et al., 1994. A System for Automated Iris Recognition, IEEE Publication, Applications of Computer Vision, 1994 Workshop, pp. 121-128

X.2 Biology

X.2.1 Aslam, T., Tan S., Dhillon, B. 2009. “Iris recognition in the presence of ocular disease.” Journal of The Royal Society, vol. 6, pp. 489-493.

X.2.2 Boyd, A., Yadav, S., Swearingen T., Kuehlkamp, A., Trokielewicz, A., Benjamin, E., Maciejewicz, P., Chute, D., Ross, A., Flynn, P., Bowyer, K., Czajka, A. 2020. “Post-Mortem Iris Recognition — A Survey and Assessment of the State of the Art,” in IEEE Access, vol. 8, pp. 136570-136593

X.2.3 Gold, D., Lewis, A. (Eds.) 2011. Clinical Eye Atlas. 2nd ed. New York, NY: Oxford Press. pp. 396-400.

X.2.4 Johnson, M., Yambay, D., Rissacher, D., Holsopple, L., Schuckers, S. 2018. A longitudinal study of iris recognition in children. 2018 IEEE 4th International Conference on Identity, Security, and Behavior Analysis (ISBA).

X.2.5 Roizenblatt, R., Schor, P., Dante, F., Roizenblatt, J., Belfort, R. 2004. "Iris recognition as a biometric method after cataract surgery." BioMedical Engineering Online. Vol. 3.

X.2.6 Saerwein, K., Saul, T., Steadman, D., Boehnen, C. 2017. "The Effect of Decomposition on the Efficacy of Biometrics for Positive Identification." Journal of Forensic Sciences. vol. 62, no.
6. pp. 1599-1602.

X.2.7 Snell, R.S, and Lemp, M.A. (eds), 1998. Clinical Anatomy of the Eye. 2nd ed. Oxford UK: Blackwell Science [ISBN 0-632-04344-X]. Chapters 1, 3, 5, 6.

X.2.8 Trokielewicz, M., Czajka, A., Maciejewicz, P. 2019. "Iris Recognition After Death". IEEE Transactions on Information Forensics and Security. vol. 14, no. 6, pp. 1501-1514, June 2019, doi: 10.1109/TIFS.2018.2881671.

X.2.9 Safa BN, Bahrani Fard MR, Ethier CR. 2022. "*In vivo* biomechanical assessment of iridial deformations and muscle contractions in human eyes". J R Soc Interface. 19(192):20220108. doi: 10.1098/rsif.2022.0108. Epub 2022 Jul 6. PMID: 35857902; PMCID: PMC9257589.

X.2.10 Trokielewicz M., Czajka A., Maciejewicz P. 2016. "Implications of Ocular Pathologies for Iris Recognition Reliability," *Image and Vision Computing*, vol. 58, pp. 158–167, Elsevier, doi: 10.1016/j.imavis.2016.08.001.

X.3 Iris Image Recognition Systems

X.3.1 Daugman, J. 2004. "How Iris Recognition Works." IEEE Transactions on Circuits and Systems for Video Technology. vol. 14, no. 1

X.3.2 Daugman, J. 2007. “New Methods in Iris Recognition”. IEEE Transactions of Systems, Man, and Cybernetics – Part B: Cybernetics. vol. 37, no. 5.

X.3.3 Hollingsworth, K., Bowyer, K., Flynn, P. 2009. “Pupil dilation degrades iris biometric performance.” Computer Vision and Image Understanding. vol. 113. pp. 150-157.

X.3.4 NIST. “IREX 10: Identification Track.” https://pages.nist.gov/IREX10/

X.3.5 Quinn, G., Grother, P., Matey, J. 2019. IREX IX Part Two: Multispectral Iris Recognition. NISTIR 8252 pg. 1-2, Section 1, Section 2.2, Section 3.

X.4 Human Iris Comparison

X.4.1 Chen, J., Feng, S., Chen, D., Flynn, P. 2016. “Iris Recognition Based on Human-Interpretable Features.” IEEE Transactions on Information Forensics and Security. vol.11, no. 7, pp.1556-6013.

X.4.2 Edwards, M., Cha, D., Krithika, S., Johnson, M., Parra, E.J. 2016.” Analysis of iris surface features in populations of diverse ancestry.” London: Royal Society Publishing, vol 3., issue 1

X.4.3 Hollingsworth, K. P., Darnell, S. S., Miller, P. E., Woodard, D. L., Bowyer, K. W., & Flynn, P. J. (2011). Human and machine performance on periocular biometrics under near-infrared light and visible light. *IEEE transactions on information forensics and security*, *7*(2), 588-601.

X.4.4 McGinn, K., Tarin, S., Bowyer, K. W. 2013. “Identity verification using iris images: performance of human examiners.” IEEE Sixth International Conference on Biometrics: Theory, Applications and Systems (BTAS) pp. 1-6.

X.4.5 Muron, A., Pospisil, J. 2000. The Human Iris Structure and Its Usages. In Acta Univ. Palacki. Physica, vol. 39. pp. 87-91

X.4.6 Shen, F., and Flynn, P. 2012. “Iris Matching by Crypts and Anti-crypts.” IEEE Conference on Technologies for Homeland Security. pp. 208-213.

X.4.7 Vanderkolk, J. 2009. R Forensic Comparative Science: Comparative Quantitative Source Determination of Unique Impressions, Images, and Objects. London: Elsevier Academic Press. Chapter 6.

X.4.8 Moreira D., Trokielewicz M., Czajka A., Bowyer K. and Flynn P. 2019. "Performance of Humans in Iris Recognition: The Impact of Iris Condition and Annotation-Driven Verification," IEEE Winter Conference on Applications of Computer Vision (WACV), pp. 941-949, doi: 10.1109/WACV.2019.00105

X.5 Iris Anomalies

X.5.1 Boyd, A., Fang, Z., Czajka, A., Bowyer, K. 2020. “Iris Presentation Attack Detection: Where Are We Now?” Pattern Recognition Letters, Vol. 138, pp. 483–489

X.5.2 Czajka, A., Bowyer, K. 2018. “Presentation Attack Detection for Iris Recognition: An Assessment of the State of the Art,” ACM Computing Surveys, Vol. 51, No. 4, pp. 86:1–86:35

X.6 Human Factors

X.6.1 Growns, B., Martire, K. 2020. “Human factors in forensic science: The cognitive mechanisms that underlie forensic feature-comparison expertise.” Forensic Science International: Synergy. Vol 2., pp 148-153.

X.6.2 National Commission on Forensic Science. 2015. Ensuring That Forensic Analysis is Based Upon Task-Relevant Information. https://www.justice.gov/archives/ncfs/page/file/641676/download

X.6.3 OSAC. 2020. Human Factors in Validation and Performance Testing of Forensic Science. Technical Series Publication 0004. https://doi.org/10.29325/OSAC.TS.0004

X.6.4 Dror, I. E. (2020). Cognitive and Human Factors in Expert Decision Making: Six Fallacies and the Eight Sources of Bias. *Analytical Chemistry*, *92*(12), 7998–8004. https://doi.org/10.1021/acs.analchem.0c00704

X.7 Logic, Probability, and Statistics

X.7.1 Center for Statistics and Applications in Forensic Evidence. Statistics for Forensic Practitioners. https://forensicstats.org/course-statistics-for-forensic-practitioners/

X.7.2 Daugman, J. 2003. “The importance of being random: statistical principles of iris recognition”. Pattern Recognition. vol. 36, pp. 279-291

X.7.3 European Network of Forensic Science Institutes. 2015. Guideline for Evaluative Reporting in Forensic Science. https://enfsi.eu/wp-content/uploads/2016/09/m1_guideline.pdf

X.7.4 Lindley, D. 2014. Understanding Uncertainty. 2nd ed. Hoboken, NJ: Wiley. Chapters 1 and 6.

X.7.5 Moore, S., McCabe, G., Craig, B. 2016. Introduction to the Practice of Statistics. 9th ed. Virginia: Macmillan Learning. Chapters 1, 2 and 4

X.8 Legal Considerations

X.8.1 Chisum, J., Turvey, B. 2004. Crime Reconstruction. Elsevier Academic Press. Chapter 13.

X.8.2 Executive Office of the President, President’s Council of Advisors on Science and Technology (PCAST). 2016. Panel on Forensic Science, Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_forensi c_science_report_final.pdf

X.8.3 Holder, E., Robinson, L., Laub, J. 2011. The Fingerprint Sourcebook. US Department of Justice, Office of Justice Programs, National Institute of Justice. Chapter 12, skip sections 12.2.4, 12.2.14, 12.2.16.2, 12.2.17; Chapter 13, sections 13.1 (skip 13.2.2.3), 13.2, 13.3,1, 13.5;
Chapter 15

APPENDIX

(Non Mandatory Information)

X2. Example Training Program

These topics are intended as a suggested starting point for the development of a training program for iris image examiners.

X.1 History

X.1.1 Beliefs about the iris throughout history

X.1.2 Iris divination

X.1.2.1 Iridology

X.1.3 Contributions made by individuals to iris recognition

X.1.3.1 Alphonse Bertillion

X.1.3.2 Frank Burch

X.1.3.3 J.H. Doggart

X.1.3.4 F.H Adler

X.1.3.5 Leonard Flom and Aran Safir

X.1.3.6 John Daugman

X.1.3.7 Richard P. Wildes

X.1.3.8 Mitsuji Matsushita

X.1.4 Landmark events and major deployments

X.1.4.1 Emirates ID

X.1.4.2 United Kingdom Project Iris Recognition Immigration System (IRIS)

X.1.4.3 Unique Identification Authority of India's (UIDAI) Aadhaar system

X.1.4.4 Canadian Passenger Accelerated Service System (CANPASS)

X.1.4.5 CLEAR

X.1.4.6 Identity for All in Africa (ID4Africa)

X.1.4.7 The Afghan Girl

X.1.4.8 The Brown Sisters

X.2 Biology

X.2.1 Embryological and postnatal development

X.2.1.1 Embryological development

X.2.1.2 Iris layer formation and timing

X.2.1.3 Changes that occur postnatal

X.2.2 Iris and periocular structure

X.2.2.1 Understand the mechanical structure of the iris and basis of the persistence of the iris structure.

X.2.3 Stability of iris patterns

X.2.3.1 Changes due to aging

X.2.3.2 Changes due to disease and injury

X.2.3.3 Changes that occur postmortem

X.2.4 Differences between iris patterns, for same and for different people

X.2.4.1 Understand the genetic and epigenetic influences on the resulting appearance of the iris, with specific emphasis on:

X.2.4.2 The biological origin and nature of iris variability

X.2.4.3 Similarities and differences between monozygotic twin iris structures

X.2.5 Biological distortions

X.2.5.1 Pupil dilation and contraction

X.3 Iris Image Recognition Systems

X.3.1 Iris image acquisition

X.3.1.1 Describe methods of iris image capture (e.g., near-IR)

X.3.1.2 Understand control measures needed to achieve quality iris images

X.3.1.3 Understand procedures for addressing missing eyes, injuries, and image recapture

X.3.2 **Image science basics**

X.3.2.1 Photonics

X.3.2.2 Wavelengths

X.3.2.3 Spectral reflectance

X.3.2.4 Optics

X.3.2.5 Sensors

X.3.3 Iris image science basics

X.3.3.1 Iris albedo

X.3.3.2 Specularities

X.3.4 Function and use of iris algorithms

X.3.4.1 Phase structure algorithms (Iris2Pi)

X.3.4.2 Discrete features algorithms

X.3.4.3 Deep Neural Network algorithms (currently uninterpretable inferences)

X.3.4.4 Understand processes related to acquisition, searching, storage, retrieval, identification, and reporting of iris image records

X.3.4.5 Understand system quality controls to ensure completeness, image quality, and data integrity

X.3.5 Performance assessments of iris recognition systems

X.3.5.1.1 IREX-10

X.3.5.1.1.1 Black box studies of algorithms

X.3.5.1.2 Effect of pupil dilation on algorithm results

X.3.5.1.3 Differences that visible light images, near infrared images, and other multispectral images have on results

X.4 Human Iris Comparison

X.4.1 **The relationship between human iris image comparison and iris recognition systems**

X.4.2 **Visible iris and periocular features**

X.4.3 Analysis, Comparison, Evaluation, and Verification (ACE-V) methodology

X.4.4 Value determination for comparison

X.4.4.1 Understand the assessment of quality, quantity, and rarity of features

X.4.4.2 Understand the concept of sufficiency as it relates to drawing conclusions

X.4.4.3 Understand and demonstrate the ability to properly determine correct orientation and difference between right and left irises

X.4.4.4 Understand and demonstrate how to document observations

X.4.5 **Comparison of two images**

X.4.5.1 Understand how to select an effective target group

X.4.5.2 Understand and demonstrate how to assess the discriminability of features

X.4.5.3 Understand and demonstrate the ability to distinguish between an apparent dissimilarity and an actual difference in iris texture, for example:

X.4.5.3.1 Pupil dilation

X.4.5.3.2 Effect of aging, disease, surgery, post-mortem changes

X.4.5.3.3 Perceived differences caused by wavelength changes

X.4.6 **Source opinions**

X.4.6.1 Exclusion

X.4.6.2 Strong Support for exclusion

X.4.6.3 Support for exclusion

X.4.6.4 Inconclusive

X.4.6.5 Support for common source

X.4.6.6 Strong support for common source

X.4.7 **Quality assurance**

X.4.7.1 Understand the measures that should be taken to verify opinions

X.4.7.2 Understand the types of possible verifications: peer review, blind verification,

multiple verifiers, and group consensus

X.4.7.3 Understand the issues that may contribute to erroneous conclusions and safeguards that can help minimize their occurrence

X.4.8 Software tools supporting human examination of iris images

X.4.8.1 Inversion of geometric distortions caused by differences in pupil dilation

X.4.8.2 Rescaling

X.4.8.3 Rotation

X.4.8.4 Contrast Normalization

X.5 Iris Anomalies

X.5.1 **Disease and temporary conditions**

X.5.2 **Traumatic injury**

X.5.3 **Drug and alcohol effects**

X.5.4 **Surgical effects**

X.5.5 **Patterned contacts/cosmetic enhancements**

X.5.6 **Iris Presentation Attacks (IPAD)**

X.5.7 **Generative Adversarial Network (GAN) images/Deepfake**

X.6 Human Factors for Iris Image Examiners

X.6.1 Validation methods

X.6.1.1 Understand the role of human judgements in forensic science methods and necessity for empirical testing of human accuracy.

X.6.1.2 Black Box Studies

X.6.1.3 White Box Studies

X.6.2 Performance assessments

X.6.2.1 Understand the importance of examiner training, proficiency testing, quality assurance, and professional development.

X.6.3 Bias

X.6.3.1 Understanding and mitigating effects of bias in comparisons

X.6.3.1.1 Cognitive bias

X.6.3.1.2 Contextual bias

X.6.3.1.3 Confirmation bias

X.6.4 Reporting and testimony

X.6.4.1 Understand the importance of using justifiable, scientifically based statements

X.6.4.2 Understand the importance of transparency

X.6.4.3 Understand the importance of using common sense terminology

X.6.5 Psychological stressors

X.6.5.1 Understand the impact psychological well-being on examiners

X.6.5.2 Time pressure and fatigue

X.6.5.3 Exposure to traumatic events (e.g., violent crimes, disasters)

X.6.5.4 Adversarial environments

X.7 Logic, Probability, and Statistics

X.7.1 Logic and reasoning

X.7.1.1 Understand how inferences are formed using deductive, inductive, and

abductive logic.

X.7.1.2 Understand the different circumstances in which deductive, inductive, and abductive logic are utilized as well as the strengths and limitations associated with these resulting inferences.

X.7.2 Descriptive statistics

X.7.2.1 Understand the concepts of variables, data, frequency distributions, and statistics

X.7.2.2 Understand the statistics and displays for describing the central tendency and variability of data.

X.7.3 Probability Theory

X.7.3.1 Understand the axioms of mathematical probability and the definition of a probability function, and it's cumulative.

X.7.3.2 Understand the definition of conditional probability and why transposing the events or proposition in a conditional probability is not generally correct

X.7.3.3 Understand the difference between a likelihood and a probability

X.7.3.4 Understand the relationship between probabilities and odds

X.7.3.5 Understand the components of the odds form of Bayes' rule for binary variables and their relationship

X.7.3.6 Understand the definition of combinatorics: how feature comparison combinations generate probabilities.

X.7.4 Inferential Statistics

X.7.4.1 Understand the concept of a "probability distribution and its parameters"

X.7.4.2 Understand the difference between a sample statistic and a population parameter, including the estimation of a population proportion from a sample proportion

X.7.4.3 Understand and be able to explain the differences between the following terms and their use when describing the performance of an analytical technique:

X.7.4.3.1 Sensitivity (True positive rate, likelihood of correct detection of a match)

X.7.4.3.2 Specificity (True positive rate, Likelihood of correct rejection of a non-match)

X.7.4.3.3 False positive rate

X.7.4.3.4 False negative rate

X.7.4.3.5 Positive predictive value

X.7.4.3.6 Negative predictive value

X.7.4.3.7 False positive discovery rate

X.7.4.3.8 False negative discovery rate

X.7.5 Reporting Results

X.7.5.1 Understand the various methods of expressing the weight of evidence as they relate to iris image evidence.

X.7.5.1.1 Posterior probability

X.7.5.1.2 Likelihood ratio

X.7.5.1.3 Bayes Factor

X.8 Legal Considerations

X.8.1 Legal admissibility and landmark cases

X.8.1.1 U.S. vs. Frye (1923)

X.8.1.2 Daubert vs. Merrell Dow Pharmaceuticals (1993)

X.8.1.3 Kumho Tire vs. Carmichael (1999)

X.8.1.4 Brady vs. Maryland (1963)

X.8.2 Effective courtroom testimony

X.8.2.1 Understand the importance of verbal and non-verbal communication

X.8.2.2 Understand the importance of personal appearance

X.8.2.3 Understand the importance of vocal volume and inflection

X.8.2.4 Understand the jurisdiction's rules about reference to notes or other materials

X.8.3 Comprehensive description of iris recognition and forensic comparison concepts

X.8.3.1 Describe how iris algorithms function

X.8.3.2 Describe the comparison process of the evidence

X.8.3.2.1 Describe the strengths and weaknesses of ACE-V

X.8.3.2.2 Describe how tolerance is established for differences in appearance during analysis

X.8.3.3 Describe the research that measures the rarity of iris features

X.8.3.4 Describe the research that studies the persistence of iris features

X.8.3.5 Describe how likelihood ratio research is used to support conclusions

X.8.3.6 Describe how human factors can affect decision-making