

M1/04-0625

Response on

Comment on Multi-dimensional Characterization of Modality

In response to

M1/04-0461, Call for Comment on N647, Text of Working Draft 24722, Technical Report on Multi-Modal Biometric Fusion

References:

- 1) M1/04-0497, Mitretek Systems: Comments in response to M1/04-0461, Call for Comment on N647, Text of Working Draft 24722, Technical Report on Multi-Modal Biometric Fusion
- 2) ISO/IEC JTC 1/SC 37 Biometrics N647, *Text of (Working Draft) Technical Report on Multi-Modal Biometric Fusion*
- 3) *Common Biometric Exchange Framework Format (CBEFF)*, DRAFT Revised CBEFF NIST/BC Biometric WG V7, September 30, 2002

Introduction

Reference 1 contains comments on Reference 2, *(Working Draft) Technical Report on Multi-Modal Biometric Fusion*. Reference 1 comments were reviewed at the Ad Hoc Group on Evaluating Multi-biometric Systems (AHGEMS), Meeting #5, on Wednesday, August 18, 2004 and an action item was generated to develop a White Paper on the Reference 1 comment on multi-dimensional characterization of modality. This White Paper is provided in response to that action item and describes:

- Background
- Multi-dimensional Characterization of Modality
- CBEFF Characterization of Modality
- Recommendation

The recommendation is that “modality” be defined in a consistent manner with the Reference 3, CBEFF (Draft) standard. The recommendation is “modality” be defined as a 2-tuple, (x, y), where

- x is the Biometric Type, an “Indication of biometric type”, characterizing the physical, behavioral, or physiological characteristic or trait
- y is the (optional; otherwise, NULL) description of the Biometric Feature, to “Indicate a choice within a biometric type” characterizing the technology or sensor or device type used to capture x

Background

Reference 2, Section 4, discusses biometric “modalities” and includes tabulated information from three sources that identified biometric modalities. The reference states:

“The primary motivation for specifically defining these modalities was to allow distinction between face recognition techniques using 2-D or texture information from techniques using 3-D or depth information, and defining these as individual modalities. Note also that face thermography is yet a third modality related to the same (face) body part.”

In the biometrics domain, the term “modality” commonly refers to the use of biometric samples associated with a specific body part, characteristic, or trait, or, sometimes, the “type” of biometric samples (e.g., face, fingerprint, iris, etc.), to recognize individuals. “Face” recognition is viewed as one “modality” in the same manner as “fingerprint” recognition is viewed as one “modality”. This perspective is the familiar, one-dimensional, characterization of “modality”.

Multi-dimensional Characterization of Modality

Oftentimes, for a given “modality”, biometric samples can be obtained by using more than one technology, sensor or device type. That is, a “modality” can be effected in different ways or, possibly the word "instantiation" might be another suitable term. In this regard, the above Reference 2 text suggests at least three modalities should come under the heading of “face” recognition. Extending this idea leads one to consider defining “modality” as a 2-tuple, (x, y) , where

- x is a physical, behavioral, or physiological characteristic or trait-
- y is the technology or sensor or device type used to capture x

In discussing “modalities”, one may choose to take a “one-dimensional” perspective, say using terms such as face, fingerprint, etc or a more comprehensive, “two-dimensional perspective” incorporating the capture device.

Such a 2-tuple definition allows for the characterization of numerous multi-dimensional “modalities”. For example, the three face recognition technologies mentioned in the Reference 2 text then represent three modalities. Also, in the area of fingerprint recognition, the 2-tuple definition implies the use of optical, capacitive, and ultrasonic technologies in capturing biometric samples represents three different modalities.

When a specific biometric system is discussed, besides the method of signal capture (i.e., technology, sensor, or device type), the matching algorithm itself and possibly the employed hardware and software (e.g., signal processing) enhancements may also be addressed. Hence, extending the above line of reasoning further, one might consider including, for example, the type of algorithm employed in the definition of “modality”. A more comprehensive definition of “modality” would allow for “modality” to be defined as a 3-tuple, (x, y, z) , where

- x is a physical, behavioral, or physiological characteristic or trait-
- y is the technology or sensor or device type used to capture x
- z is the algorithm used to process x

However, such a 3-tuple definition implies that the use of one set of biometric samples in two different algorithms represents two different modalities. However, such a representation is not what is generally referred to as two different “modalities” and, indeed, the representation is what is meant by the term “multi-algorithmic” in Reference 2 (Section 2.6). Consequently, the 2-tuple definition is preferred to the 3-tuple definition.

CBEFF Characterization of Modality

Reference 3, CBEFF, accommodates a 2-tuple characterization of a modality. CBEFF is an evolving standard for characterizing biometrics and grew out of series of workshops cosponsored by the Information Technology Laboratory of the National Institute of Standards and Technology (NIST) and the Biometric Consortium. The participants identified the need for a “technology-blind” biometric format that would facilitate the handling of different biometric types, versions, and biometric data structures in a common way. This common format would facilitate exchange and interoperability of biometric data. The participants suggested that, for the time being, the content of the biometric data structures (e.g., raw or processed biometric data) would not be defined in the common framework format. A Technical Development Team, formed as a result of these Workshops, developed CBEFF (Draft). To ensure that the biometric data format would be in agreement with other biometric industrial efforts, the development was coordinated with industrial organizations.

CBEFF describes minimum requirements for CBEFF compliance. However, CBEFF (Section 6, CBEFF Requirements for Compliance) recognizes that “new technologies may evolve that need new encoding rules and may require a new formatting. CBEFF describes a process to develop new formats.”

In the basic CBEFF data structure, CBEFF data elements are placed in “fields” within a CBEFF file. The fields are grouped in three major sections:

- Standard Biometric Header (SBH)
- Biometric Data Block (BDB)
- Signature Block (SB)

Each data element above is defined in Reference 3, CBEFF. The CBEFF SBH includes both required and optional fields. CBEFF includes the description of one field, Biometric Type, as an “Indication of biometric type”. For another field, Biometric Feature, CBEFF includes the description, “Indicate a choice within a biometric type”. The Biometric Type and Biometric Feature fields are optional. The Biometric Type field length may be 1 to 3 bytes and “defines the type of biometric technology”.

The currently defined types are shown in Reference 3, CBEFF Table 4, which is reproduced below in Table A. Note that CBEFF makes a distinction between thermal facial image and facial features obtained by other, non-thermal imaging, means. In a similar manner, CBEFF distinguishes between thermal hand image and hand geometry (features).

Table A. Reference 3, CBEFF, Table 4 – Biometric Type

Field Value Name	Biometric Type Value (hex)
Multiple Biometrics Used	'000001'
Facial Features	'000002'
Voice	'000004'
Fingerprint	'000008'
Iris	'000010'
Retina	'000020'
Hand Geometry	'000040'
Signature Dynamics	'000080'
Keystroke Dynamics	'000100'
Lip Movement	'000200'
Thermal Face Image	'000400'
Thermal Hand Image	'000800'
Gait	'001000'
Body Odor	'002000'
DNA	'004000'
Ear Shape	'008000'
Finger Geometry	'010000'
Palm Geometry	'020000'
Vein Pattern	'040000'

CBEFF explicitly accommodates the expansion of the list of Biometric Type values in future versions of CBEFF. CBEFF also states that an (optional) Biometric Feature field that represents the enrolled feature may be added in future revisions of CBEFF after industry has the opportunity to address the need for (and content of) such optional field. CBEFF mentions the left hand, ring finger, and left ear as examples. The Biometric Feature optional field (CBEFF mentions the field length may typically be 1 byte) is described as further defining the type of biometric data being placed in the file. Reference 3, CBEFF, presents two examples further defining biometric features for fingerprints. The Biometric Feature field could be used more generally for any Biometric Type included in the CBEFF Table 4.

Recommendation

The recommendation is that “modality” be defined in a consistent manner with the Reference 3, CBEFF (Draft) standard. The recommendation is “modality” be defined as a 2-tuple, (x, y), where

- x is the Biometric Type, an “Indication of biometric type”, characterizing the physical, behavioral, or physiological characteristic or trait
- y is the (optional; otherwise, NULL) description of the Biometric Feature, to “Indicate a choice within a biometric type” characterizing the technology or sensor or device type used to capture x

The above definition would then be consistent with the evolving standard contained in Reference 3. In particular, the Biometric Feature field would be used to further characterize the Biometric Type (i.e., the more common, 1-dimensional, colloquial characterization of “modality”). Examples are shown in the Table B below.

With the above definition, a more liberal use of the term, “multi-modal” (system), may arise. For example, a system comprised of, and combining inputs from, both 2-D and 3-D face recognition subsystems would be a multi-modal system. Also, a system comprised of, and combining inputs from, both capacitive and ultrasonic biometric fingerprint samples would be a multi-modal system.

Table B. Examples of Recommended Use of CBEFF field, Biometric Feature

Biometric Type Value (hex)	x = Biometric Type	y = Biometric Feature (Examples)
'000001'	Multiple Biometrics Used	Indicate 3-D face features and capacitive fingerprint images, using 2 index fingers
'000002'	Facial Features	Indicate 3-D face image
'000004'	Voice	Null
'000008'	Fingerprint	Indicate capacitive fingerprint image, using 2 index fingers.
'000010'	Iris	Null
'000020'	Retina	Null
'000040'	Hand Geometry	Null
'000080'	Signature Dynamics	Null
'000100'	Keystroke Dynamics	Null
'000200'	Lip Movement	Null
'000400'	Thermal Face Image	Null
'000800'	Thermal Hand Image	Null
'001000'	Gait	Null
'002000'	Body Odor	Null
'004000'	DNA	Null
'008000'	Ear Shape	Null
'010000'	Finger Geometry	Null
'020000'	Palm Geometry	Null
'040000'	Vein Pattern	Null