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Section 4.3 Metadata Usage

Facial Recognition System: Metadata Usage

This document provides information on **Metadata Usage** as it applies to deploying or operating a Facial Recognition System (FRS). The goal of this document is to provide background, definitions, and guidance for utilizing metadata to increase the likelihood of obtaining a true match in the candidate list for a submitted probe within a 1:N search. Please refer to FISWG document "Section 4.2 Methods & Techniques" for an overview of other processes to meet this aim. The intended audience of this document is anyone involved in the design, deployment, operational support, or operational usage of a FRS.

Metadata

While there are many different definitions of the term "metadata," for the purposes of this document, metadata is any information associated with, but excluding, the facial image and may include a numeric identifier. It is important to note that systems may be person centric or encounter centric. For person centric systems, the numeric identifier should be unique to the individual and replicated across each encounter. For encounter centric systems, a separate numeric identifier will be generated for each encounter.

Metadata usage can be broken down into two main areas: system setup of the metadata by the system administrators and actual usage of the metadata by the system users.

Metadata system setup is a phase where the metadata accessible for FRS usage is defined and categorized. This requires the metadata fields (e.g., demographic, biographic, contextual, etc.) associated with the facial images to be defined as pick lists, numeric ranges, dates, or free text.
Significant consideration should be given to metadata fields and their definitions. Fields that require a subjective assessment or free text may result in reduced consistency in those fields.

Metadata Categories

A metadata field can be categorized as one of the following:

- A **pick list** is a specific list of selections that define a discrete set of options. These usually include an "unknown" selection or a none-of-the-above entry. For example, the National Crime Information Center (NCIC) has a rich set of these lists that are widely used. An example of this is gender where male is assigned as 'M,' female is assigned as 'F,' and "unknown" is assigned as "U."
- A **numerical value** is some quantitative value such as height or weight.
- A **date** specification incorporates the values of year, month, and day. The format must remain consistent within the system. Date is typically designated as the four digit year (YYYY), the month (MM), and the day of the month (DD). However, formatting may vary by system. For example, one system may encode date 20131120 while another may encode the same date as 20-11-2013 and another as 20-NOV-2013. The use of a consistent date format will promote interoperability.
- A **derived value** is a grouping of a wide range of items into smaller, well managed, and easily described groups. Derived values may be automatically, semi-automatically or manually determined. An example may be assigning a text label to an age range such as:
    - Infant – 0-3 years
    - Child – 4-10 years
    - Adolescent – 11-14 years
    - Teenager – 15-19 years
    - Adult – 20-40 years

- Another example is information derived from the image such as
    - Number of pixels between the eyes
    - A vendor's facial quality metric

- **Free text** is unformatted text information that allows for key terms that can be queried. For example, data contained in a free text field could be search key words or terms such as "attack," or "threat" or a specific case number.

Examples of metadata include, but are not limited, to:

- Image file metadata: e.g., filename, encoding, resolution, size, bit depth, EXIF, date(s)

- Capture device metadata: e.g., make, model, serial number
- Acquisition metadata: e.g., location (GPS), date, time, user
- Personal metadata: e.g. name, date of birth (DOB), gender, eye colour
- Machine-readable data: e.g MRZ data on a passport
- Image content data: Pixels between the eyes, quality metric

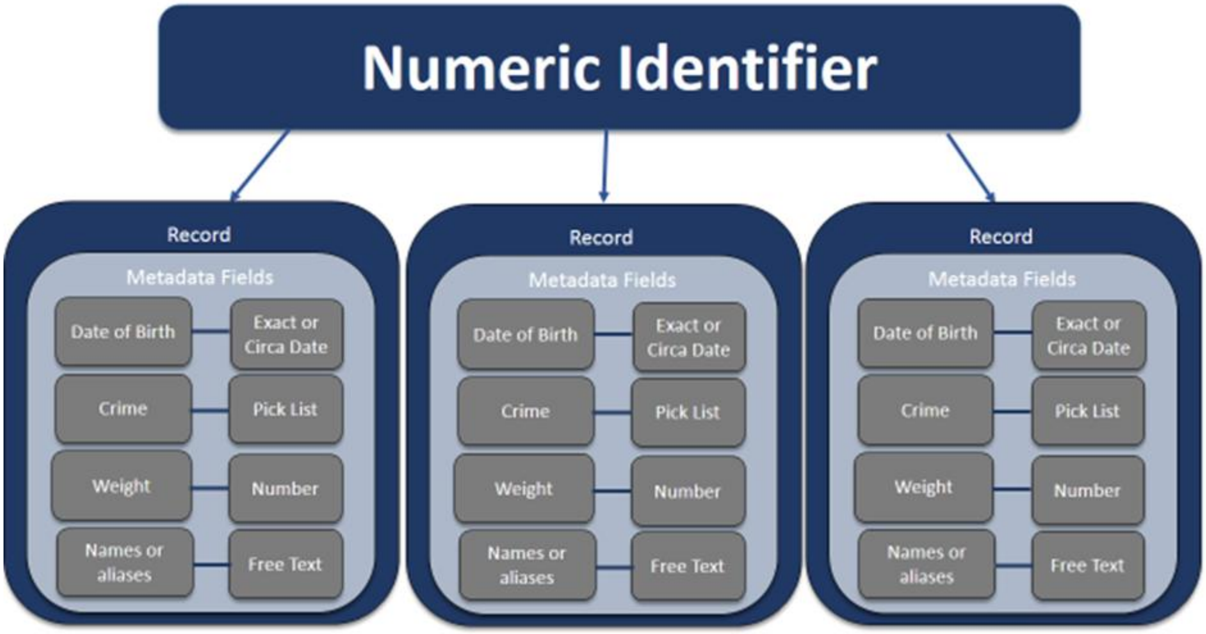

Figure 1: Pictorial representation of metadata fields and categories for records associated with a numerical identifier

The metadata fields may be decided at an agency level or by adopting a biometric exchange standard. Anexample of a standard is the ANSI/NIST-ITL 1-2011[1]Data Format for the Interchange of Fingerprint, Facial& Other Biometric Information. The metadata fields of the Type-1 record in this standard are described in Table 1.

[1]http://www.nist.gov/itl/iad/ig/ansi_standard.cfm

Field Number	Mnemonic	Content Description
1.002	VER	Version Number
1.003	CNT	Transaction Content
1.004	TOT	Type of Transaction
1.005	DAT	Date
1.006	PRY	Priority
1.007	DAI	Destination Agency Identifier
1.008	ORI	Originating Agency Identifier
1.009	TCN	Transaction Control Number
1.010	TCR	Transaction Control Reference Number
1.011	NSR	Native Scanning Resolution
1.012	NTR	Nominal Resolution
1.013	DOM	Domain Name
1.014	GMT	Greenwich Mean Time
1.015	DCS	Character Encoding
1.016	APS	Application Profile Specifications

Table 1: ANSI/NIST-ITL 1-2011 Type 1 metadata fields

Usage of the metadata can be broken down into binning and filtering. This is an efficient approach that utilizes the metadata to store facial images in appropriate bins upon enrollment and to refine a search through reducing the size of the search database.

Binning is undertaken at the point of enrollment where data is analyzed, sorted, transformed and prepared for enrollment. There may be two types of binning: physical and logical.

- Physical binning: metadata is used to decide where to store something in a specific and separate gallery within the same biometric solution:
    - An image on an elevated threat Watchlist.
    - All files associated with a particular type of crime may be binned together.

- Logical binning: metadata is used to alter processing within a storage paradigm. For example, in a DMV facial recognition system, the images could be binned according to their capture location.
    - In fingerprint biometric systems, an integral part of the search process is to automatically infer fingerprint position and use this as metadata to limit the search to only corresponding fingerprint positions. It is important to note that fingerprint position is not user defined, it is part of the fingerprint storage paradigm.

Filtering is undertaken at the point of search. The user may wish to filter the database based on some properties of the probe image. For example, if the probe image depicts a male with blond hair and blue eyes, the user may filter on the gender, hair and eye color metadata fields in order to reduce the size of the database searched against. The user can also decide to filter search results after a search is complete. In this case the user is altering how the search results are displayed to the user based on metadata within the search results.

Risks Associated with Metadata Usage

Proper use and application of metadata requires a thorough understanding and appropriate balance of the risks and benefits of its use. It is critical to understand the metadata well, its level of consistency, and on what it is based (its reliability). Filtering or binning may result in the true match being left out of the potential candidate list. For example, if the probe image is male and the search is filtered on males, but the true match is entered as female, then it will not be returned in the candidate list.

The risks associated with metadata usage can be mitigated through repeated measure of the metadata consistency.

Measuring Metadata Consistency

In this document the term “consistency” will be used to describe the repeatability by which metadata fields are recorded. For example:

- If a person’s gender is repeatedly recorded in the same way for every encounter then it is considered to be consistent. Gender assignment generally has a high level of consistency.
- If a person’s eyes are repeatedly recorded as green for every encounter, regardless of their true colour, then the data is considered to be consistent. If however, on one encounter the eye colour is recorded as “green,” but on another encounter the eye colour is recorded as “hazel,” then the data has a level of inconsistency.
- Because hair colour can be easily altered, there is an expectation that this metadata field would have a low level of consistency.
- Data entry errors from users will occur.

Terms such as accuracy, error, or correctness will **not** be used because in this context, all that can be derived is how consistent the metadata attributes are assigned to each encounter.

In order to determine the consistency of the metadata of a system, records must be reconciled using either another biometric identifier or a numeric identifier.

It is not uncommon that in a person centric system, face images are associated with a corresponding fingerprint record, which generates a numeric identifier. For each additional encounter, face and fingerprints are captured. The fingerprints are searched against the existing database to consolidate records and reconcile identity.

Examples of using a numeric identifier to reconcile records are given below.

Metadata Consistency Example: Structured Data Entry

Metadata fields from the Computerized Criminal History System (CCH) were extracted, analyzed and stored in a structured manner. The data extracted from this CCH system included a numeric identifier, in this case a State Identification number (SID) that was assigned through fingerprint biometrics. The SID allowed all the CCH information to be assigned to a single identity. This provided a powerful tool that allowed the metadata to be profiled for consistency.

Examples of the metadata fields from the CCH include:

- race, gender, skin tone, teeth descriptions
- height, weight
- eye color, eye characteristics
- facial hair, hair color, hair length, hair style
- complexion
- county code, location ID
- date of birth, place of birth
- charge and arrest date
- SMT Scar, Mark, & Tattoo (SMT) information

After metadata categories are determined then the ranges and values can be reviewed. Examples of this include (not all values for all categories are shown):

- Gender gave two selections:

- 20% Female
- 80%Male

- Eye color gave nine selections (only four shown):
  - 74% Brown
  - 13% Blue
  - 8% Hazel
  - 3% Green
- Hair gave twelve selections (only four shown):
  - 53% Black
  - 6% Blonde
  - 2% Grey
  - 2% Bald
- Facial Hair gave ten selections (only three shown):
  - 41% None
  - 18% Beard/moustache
  - 4% Goatee
- Complexion gave six selections (only three shown):
  - 91% Clear
  - 2% Acne
  - 2% Ruddy
- Skin tone gave three selections (only three shown):
  - 48% Light
  - 34% Brown
  - 16% Dark
- Charge gave sixteen selections (only four shown):
  - 23% Drugs
  - 15% Assault
  - 2% Robbery
  - 2% Prostitution

The SID was used to determine the level of consistency of the demographic data by a cross comparison of all metadata fields under a single SID.

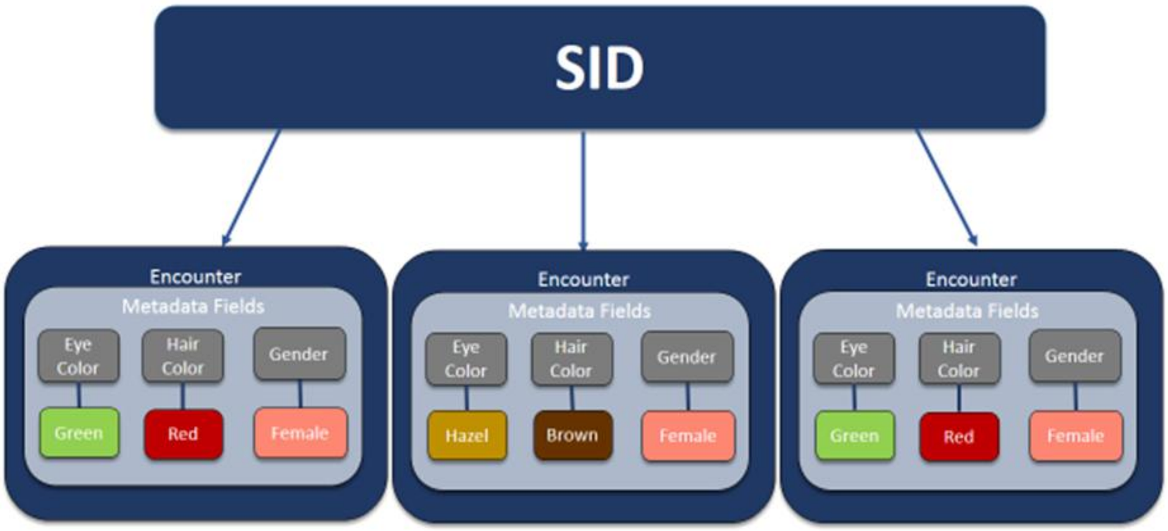

Figure 2: Pictorial representation of how metadata fields may be inconsistently recorded for a single identity

Metadata Attribute	Consistency (%)
Gender	99
Race	97
Teeth	95
Place of Birth	92
Eye Color	88
Complexion	80
Hair Color	68
Skin Tone	62
Location ID	62
Hair Length	54
Hair Style	51
Facial Hair	41

Table 2 – % Measure of metadata consistency

Date fields may have to be analyzed as a range. In this specific example the consistency of the date of birth field was determined by calculating age with a given tolerance.

- Age ± 10 years was 97% consistent
- Age ± 5 years was 93% consistent

The higher the consistency in the metadata fields, the greater confidence is provided by the filter. Gender has a high consistency (implying gender is repeatedly entered correctly) while facial hair has a low consistency (implying recording of facial hair is subjective and differs between encounters of the same individual).

These consistency rates are specific to the database profiled and may not be representative of consistency in other databases. Therefore, FISWG recommends that each agency profile the metadata associated with their facial recognition system database.

Measuring Metadata Consistency: Unstructured Data Entry

Table 3 presents metadata consistency information extracted from a system with less stringent data entry processes. It provides an understanding of consistency in a system that lacks a rigid and structured demographic entry process. The percentages of unknown, inconsistent and consistent are clearly discernible.

Demographic Field	Unknown %	Inconsistent %	Consistent %
Race	25%	8%	65%
Gender	14%	1%	84%
Place of Birth	5%	7%	87%
Eye	24%	7%	67%
Hair	24%	3%	71%
Citizenship	44%	6%	49%

Table 3: – Example of metadata consistency for uncontrolled entry

The images in Figure 3 were enrolled into a non-operational FR system containing ~6.5M images.

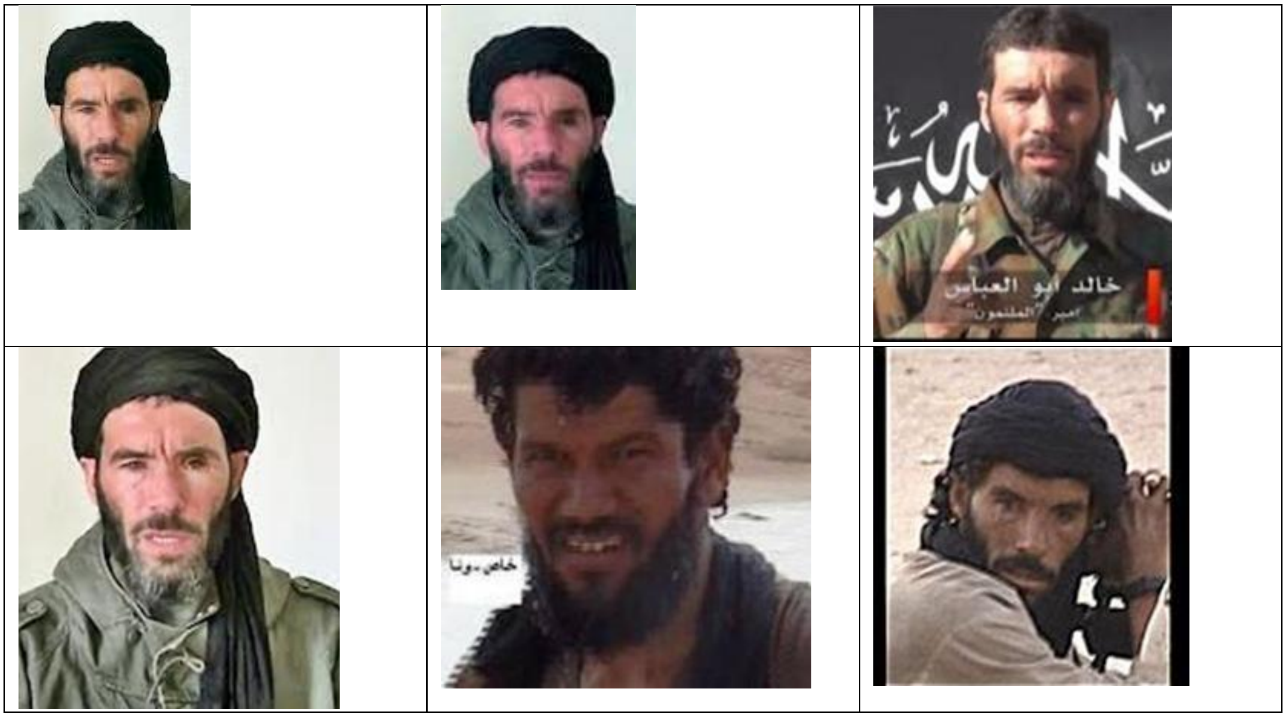

Figure 3: – Example of person enrolled in a non-operational facial gallery

Three images known to be of the same person were used as search probes. They cannot be shown here due to sensitivities of the data, but their image quality was very poor. When these probes were searched **without metadata filters**the matching facial images in Figure 3 were not returned in the candidate list.

When metadata filters were applied as follows: Gender=M, POB=Algeria, and DOB=1967-1977, five of the top seven results were true matchesas shown in Figure 4.

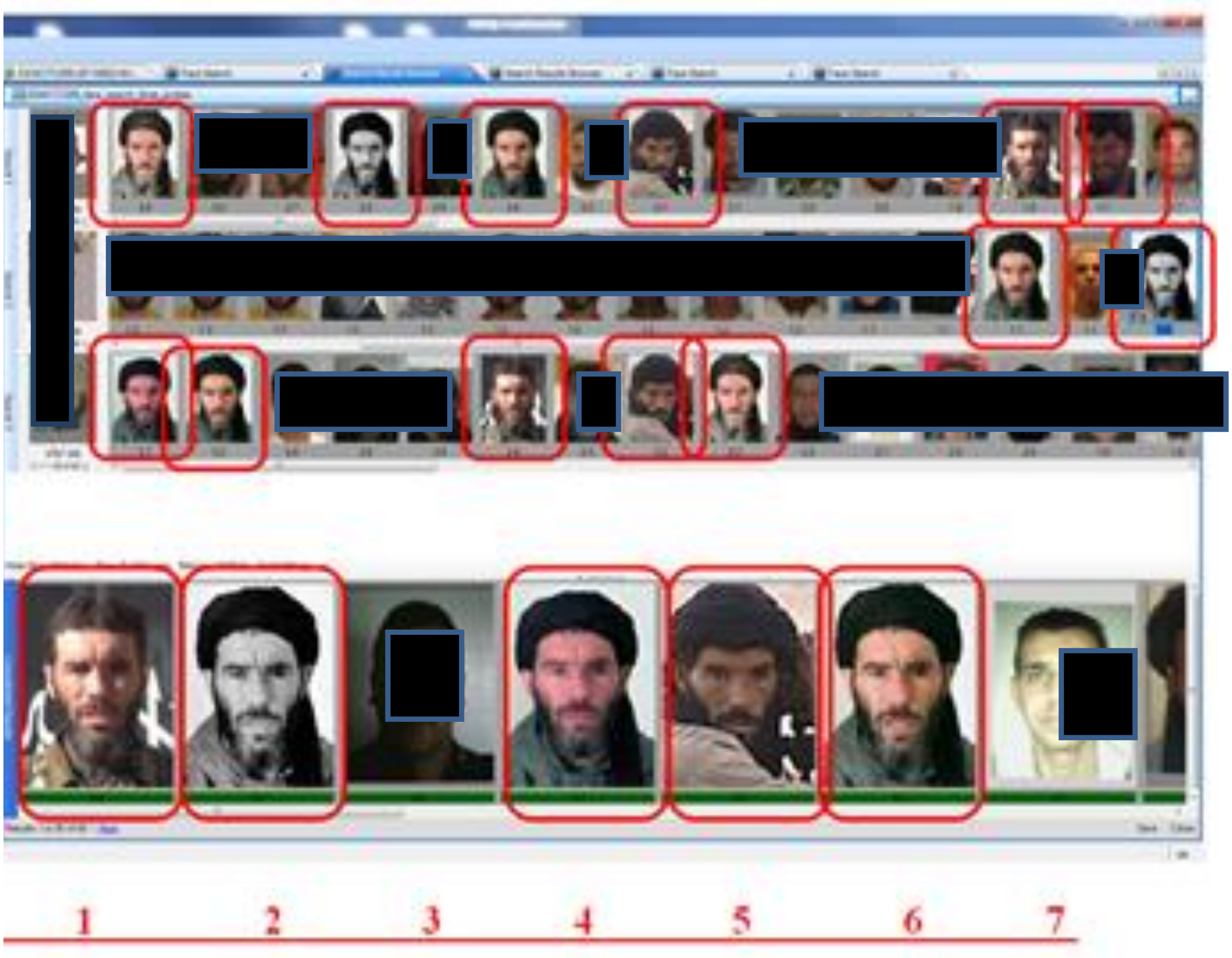

Figure 4: – Search results

Search Strategies

Metadata filters can be used to reduce the size of the database and the measured consistency can be used to determine which fields should be used for filtering.

Metadata can be queried in a number of different ways. Metadata filtering can be simple or more complex. Simple metadata filters might include searching only against male subjects. Complex filtering utilizes multiple fields, for example; Caucasian females with brown hair and green eyes.

Multiple or indirect relationships are possible. For example, in one dataset queried, an association was established demonstrating that those arrested for gun crime tended to also be arrested for drug crime. This can be used to inform your search strategy as you may want to establish a search protocol such that all gun crime submissions are also searched against the drug crime bin.

Agency policy should be used to govern at what point metadata filtering is used in the search process.

The operational mission of the FR system should be well understood and inform metadata search strategies. For example:

- An FR system designed for law enforcement may need to focus on arrest and geographic information because criminal behavior may be correlated to recidivistic behaviour and the geographic locations of the people involved.
- An FR system designed for the intelligence community may need to focus on group associations or regions of activity.
- An FR system designed for border control may need to focus on passport numbers or dates of entry or passage into specific regions.
- An FR system designed for DMV deployments may need to focus on personal descriptions of the people.

The measure of metadata consistency can be fed back to inform system setup of metadata fields. For example, if it is demonstrated that eye colour is highly inconsistent because that particular field is a free text category – changing the field to a pick list category may result in increased consistency.

Reference List

FISWG documents can be found at: www.FISWG.org