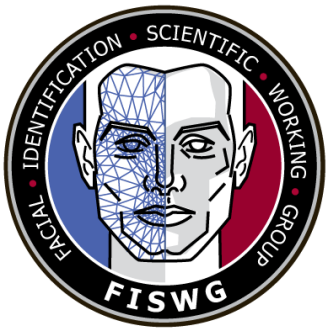

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Guidance for Tattoo Recognition Deployment

1. Scope

1.1 The scope of this document is to provide guidance that applies to deploying a Tattoo Recognition System (TRS). This document focuses on two operational aspects of image capture and image processing for enrollment and searching. It demonstrates how proper tattoo localization, enrollment, and search filters are critical to improving operational accuracy.

1.2 NISTIR 8078, 8109, and 8232 were last published in 2018. The recent advances in AI based technology are now being applied to tattoo recognition and should improve the operational accuracy. It is recommended to review these NIST documents on tattoo recognition. While they were posted before the AI revolution, they have many recommendations that are still valid in terms of basic operational principles.

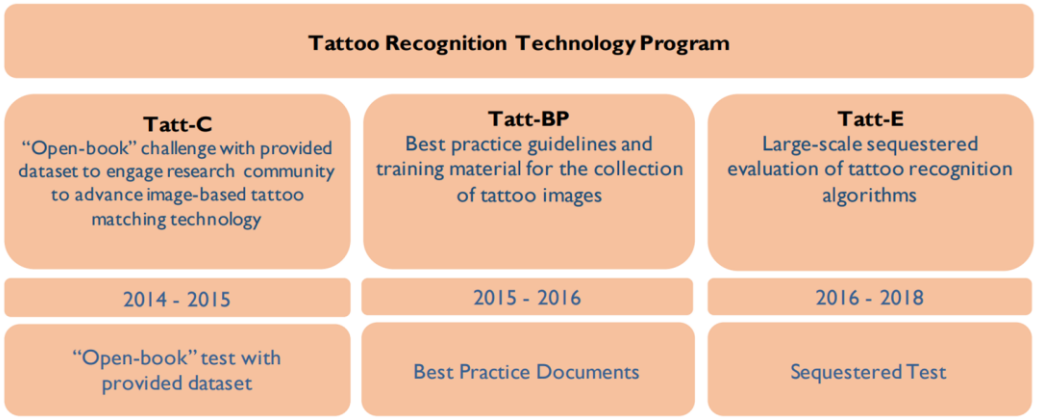


Figure 1: NIST Tattoo Summary[1]

1.3 This document outlines a process where various iterations of manual localization techniques were applied to tattoo images followed by accuracy testing. Higher accuracy was observed when the manual localizations were segmented by discrete body parts and then localized into dominant tattoo regions. See Figure 2 for CMC rank 1 retrieval improvement for three data cohorts-based accuracy improvements.

[1] https://nvlpubs.nist.gov/nistpubs/ir/2018/NIST.IR.8232.pdf

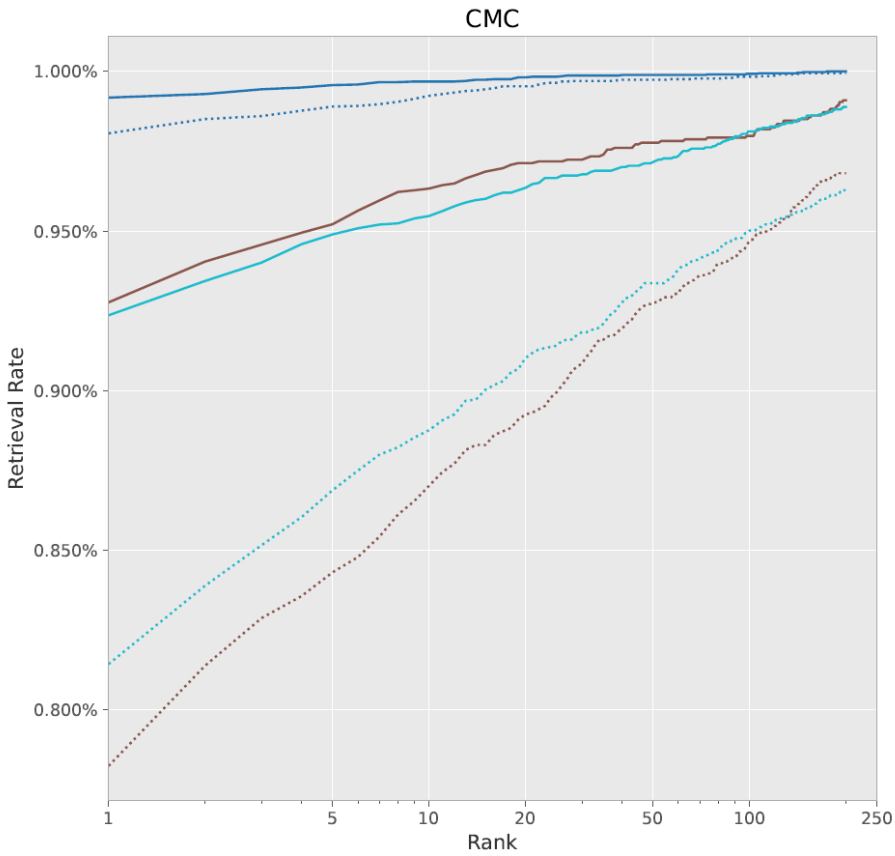


Figure 2: Increase in CMC Performance

1.4 A TRS can offer additional identification opportunities which include:

1.4.1 Complementing a facial investigative lead as a potential secondary means of identification

1.4.2 Understanding and identifying well-known gang affiliations or tattoos that signify a moniker or increased threat

1.4.3 Identifying human remains where a suitable facial image or other biometric modalities are unavailable

1.4.4 Investigating cases where only a tattoo is available

1.5 All aspects defined here require close collaboration with the tattoo algorithm vendor or integrator, the agency examiners, and any applicable local, state, or federal laws.

1.6 The intended audience for this document is organizations and agencies considering, deploying, or managing a TRS.

2. Referenced Documents

2.1 *NIST Standards*:

NISTIR 8232 Tattoo Recognition Technology - Evaluation (Tatt-E) Performance of Tattoo Identification Algorithms[2]

NISTIR 8109 Tattoo Recognition Technology – Best Practices (Tatt-BP) Guidelines for Tattoo Image Collection[3]

NISTIR 8078 Tattoo Recognition Technology – Challenge (Tatt-C) Outcomes and Recommendations[4]

ANSI/NIST-ITL-1-2011 Update 2015: Data Format for the Interchange of Fingerprint, Facial and Other Biometric Information[5]

2.2 *NCIC Documents*:

[2] https://nvlpubs.nist.gov/nistpubs/ir/2018/NIST.IR.8232.pdf
[3] https://nvlpubs.nist.gov/nistpubs/ir/2016/NIST.IR.8109.pdf
[4] https://nvlpubs.nist.gov/nistpubs/ir/2015/NIST.IR.8078.pdf
[5] https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.500-290e3.pdf

NCIC Code Manual as of December 31, 2023[6]: Pages 49-52

3. Terminology

3.1 *Acronyms:*

3.1.1 *AI, n*—Artificial Intelligence

3.1.2 *CMC, n*—Cumulative Match Curve

3.1.3 *DET, n*—Detection error tradeoff

3.1.4 *EBTS, n*—Electronic Biometric Transmission Specification

3.1.5 *FAR, n*—False acceptance rate

3.1.6 *FRR, n*—False reject rate

3.1.7 *ROC, n*—Receiver Operating Characteristic Curve

3.1.8 *SDK, n*—Software Development Kit

3.1.9 *TRS, n*—Tattoo Recognition System

4. Summary of Practice

4.1 Tattoos are an image-based modality similar to friction ridge, facial, or iris. The tattoo modality has critical differences from these legacy modalities that require specific

[6] https://www.wsp.wa.gov/wp-content/uploads/2024/01/NCICCodeManual-December-2023-1.pdf

attention and careful management for a successful TRS deployment. This is due to the nature of variance in tattoo content and tattoos being placed across the human body. Examples of this are shown in Appendix 1:

4.2 A TRS will have similar operational workflows like any other image based biometric modality which may include:

4.2.1 Image Capture

4.2.2 Image enrollment

4.2.3 Image search

4.2.4 Search result examination

4.2.5 Final opinions from the forensic examination

5. Background Knowledge

5.1 “NCIC Code Manual as of December 31, 2023” contains the NCIC codes for tattoo location. A sample of this is in Figure 3.

TAT: TATTOOS

Code	Item/Location
TAT ABD0M	ABDOMEN
TAT L ANKL	ANKLE, LEFT
TAT ANKL	ANKLE, NONSPECIFIC
TAT R ANKL	ANKLE, RIGHT
TAT L ARM	ARM, LEFT
TAT LF ARM	ARM, LEFT, LOWER
TAT UL ARM	ARM, LEFT, UPPER
TAT ARM	ARM, NONSPECIFIC

Figure 3: NCIC Tattoo Location Codes

5.2 “ANSI/NIST-ITL-1-2011 Update 2015: Data Format for the Interchange of Fingerprint, Facial and Other Biometric Information” defines how tattoo images can be stored and described in Type 10 image records. See fields 10.040 through 10.043 in Figure 4. Also note the reference to NCIC code table in field 10.040.

Field Number	Mnemonic	Content Description	Cond Code	Character			Value Constraints	Occurrence	
				Type	Min #	Max #		Min #	Max #
10.039	T10	TYPE-10 REFERENCE NUMBER	D	N	1	3	1 ≤ T10 ≤ 255 positive integer	0	1
10.040	SMT	NCIC SMT CODE	D					0	1
		Subfields: Repeating values	M↑	AS 156	3	10	values from Annex D: NCIC code table	1	3
10.041	SMS	SMT SIZE OR SIZE OF INJURY OR IDENTIFYING CHARACTERISTIC	D					0	1
	HGT	height	M↑	N	1	3	positive integer	1	1
	WID	width	M↑	N	1	3	positive integer	1	1
10.042	SMD	SMT DESCRIPTORS	D					0	1
		Subfields: Repeating sets of information items	M↑					1	9
	SMI	SMT code indicator	M↑	A	3	8	value from "Field 10.042 SMT Code" column of Table 71	1	1
	TAC	tattoo class	D	A	4	8	value from Table 80	0	1
	TSC	tattoo subclass	D	A	3	11 160	value from Table 80	0	1
	TDS	tattoo description	D	U	1	256	none	0	1
10.043	COL	TATTOO COLOR	D					0	1
	Subfields: repeating values in the same order as those of SMD							1	9
	TC1	tattoo color code 1	M↑	A	3	7	values from Table 81	1	1
	TC2	tattoo color code 2	O↑	A	3	7	values from Table 81	0	1
	TC3	tattoo color code 3	O↑	A	3	7	values from Table 81	0	1
	TC4	tattoo color code 4	O↑	A	3	7	values from Table 81	0	1
	TC5	tattoo color code 5	O↑	A	3	7	values from Table 81	0	1
	TC6	tattoo color code 6	O↑	A	3	7	values from Table 81	0	1

Figure 4: ANSI/NIST-ITL Type 10 Tattoo Fields

6. Significance and Use

6.1 Tattoo Recognition

6.1.1 Tattoo Recognition involves several distinct areas:

6.1.1.1 Capture

6.1.1.2 Localization

6.1.1.3 Recognition

6.1.1.4 Identification

6.2 Capture

Summary of Recommendations

This section provides a brief summary of the recommendations presented earlier on how to collect good quality tattoo images.

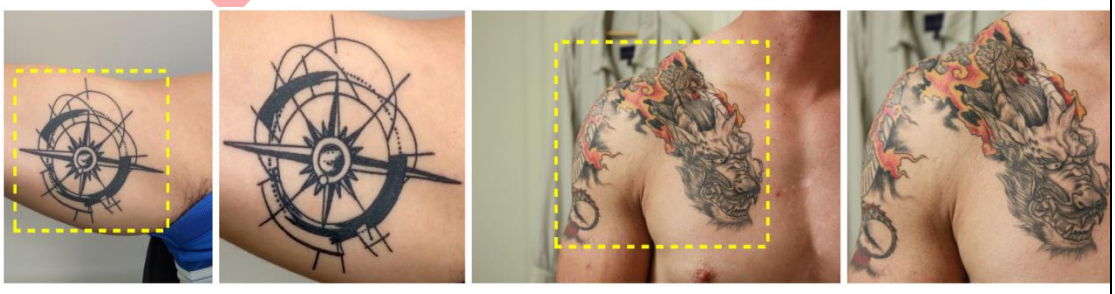
- **Capture Environment**: Ensure there is adequate, uniform, diffuse lighting (ideally with a minimum of two point-balanced light sources and lighting level of 500 lux). The background should be a plain, solid color and does not contain any background clutter.
- **Prior to Capture**: Verify the camera is set to collect images at a resolution of 5 megapixels or higher. Ensure there is a minimum of one meter (approximately 3.3 feet) between the subject and the camera. Instruct the subject (if able) to stand upright with both forearms pointing

towards the ground and remain still. Ensure the entire tattoo is within the camera's field of view.

- **During Capture**: Ensure the camera is held still and properly aligned to capture the tattoo parallel to the sensor plane. For each tattoo, collect a minimum of two photographs - one that is far enough away to include the body location and one close-up photo where the tattoo occupies at least 75% of the image, with the entire tattoo visible within the camera's field of view, and ideally does not include any irrelevant body hair or background clutter. For tattoos that span multiple body locations, collect multiple images from different location viewpoints with overlap where possible. For full-body tattoos, collect an image of the entire tattoo, then separate photos of smaller areas of interest.
- **Post-Capture**: Ensure the tattoo is in focus, with good illumination and contrast against the skin. Ensure there are no large shadows or reflections over the tattoo.

Figure 5: Recommendations from NISTIR 8109 (Page 8)

6.3 Localization for Enrollment



- There are notable accuracy improvements for almost all algorithms when cropping the probe around the primary tattoo content prior to search

- The improvement from cropping and hit rates going up is due to assistance with localization, which shows that detection/localization still remains a problem on a percentage of tattoos even in the moderately controlled collection of tattoo images used in this test. The implication to improve tattoo match ability is to maximize the primary tattoo content area in the photo and avoid capturing large area photos with small tattoos, which is covered in the Tatt-BP guidelines for proper collection of tattoo images.

Figure 6: Recommendations from NISTIR 8232 (Pages 12 and 13)

6.3.1 The tattoos need to be localized from the full tattoo image like facial localization is done in facial images. Some tattoo algorithms may use the entire tattoo, specific portions of the tattoo, or both in the localization and encoding process.

6.3.2 Tattoo images can be very complex so it is assumed a single large tattoo could be localized into individual images that are singularly distinct for example:

6.3.2.1 Faces of a person

6.3.2.2 Flags

6.3.2.3 Religious symbols

6.3.2.4 Animals, plants, or flowers

6.3.2.5 Sports team logo

6.3.2.6 Text or numbers

6.3.2.7 Weapons

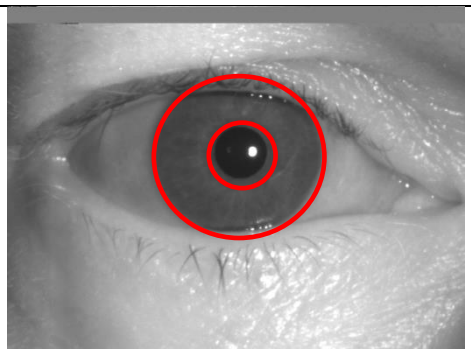
6.4 Localization Principles

6.4.1 Localizing individual tattoos is very similar to how multiple finger slap images or palm images are processed when segmenting the images into single fingers or palm segments. The premise is that multiple fingers in the slap images need to be segmented and extracted into individual images:

6.4.1.1 For a right hand the left-to-right finger order is index, middle, ring, and little. For a left hand it's the reverse order.

6.4.1.2 Hand or palm segmentation is also similar to this with the multiple fingers, Interdigital, Thenar, and Hypothenar segments in a hand or palm image.

6.4.1.3 This also applies to locating a single person's face in an image and isolating an iris from an image.



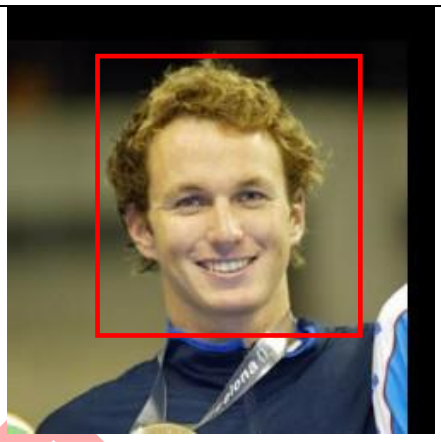


Figure 7: Examples of non-tattoo imagery that need to be localized

6.4.2 The tattoo SDK may have specific options or features that control how a large image with many tattoos is localized into individual tattoos. Specific examples of the parameters could include:

6.4.2.1 Number of individual tattoos to extract

6.4.2.2 The minimum size of the localized tattoo

6.4.2.3 A localization confidence or image quality threshold for each localized tattoo

> During photo capture, use software that makes image quality assessments (e.g., illumination, contrast, focus, existence of distracters around tattoo image) and determines whether to accept or reject the image.

Figure 8: Recommendations from NISTIR 8078 (Page ii)

6.4.3 The tattoo SDK may have specific metrics that define what individual tattoos were localized. Specific examples of the features could include:

6.4.3.1 The pixel locations of each localized tattoo within the larger tattoo image

129 6.4.3.2 The localization confidence

130 6.4.3.3 The quality of the localized tattoo image

131 6.4.3.4 Whether all the individual tattoos should be combined into a single

132 consolidated tattoo template

133 6.4.4 Simple localization

A very simple tattoo: • Upper right arm • Single tattoo • Simple symbol	

Tattoo localization	
Localized and cropped tattoo for enrollment or searching	

Figure 9: Simple Tattoo Localization

6.4.5 Complex localization

How many individual tattoos should be localized in this image?	
A localization of ten tattoos.	

A localization of twenty tattoos.	
Examples of some of the twenty localized and cropped tattoos	

Figure 10: Complex Tattoo Localization

6.5 Enrollment

6.5.1 Once a tattoo is localized, the tattoo body part should be entered so this can effectively be used for search-based filtering. See NCIC codes for detailed examples of these. Agency specific categorizations of body parts can also be defined and used effectively as examples shown below:

6.5.1.1 Head

6.5.1.2 Neck

6.5.1.3 Chest

6.5.1.4 Back

6.5.1.5 Leg (non-specific), left or right leg

6.5.1.6 Arm (non-specific), left or right arm

6.5.1.7 Foot (non-specific), left or right foot

6.5.1.8 Hand (non-specific), left or right hand

6.5.2 The functionality for selecting body parts should utilize a multi-select option as a tattoo may cover more than one body part.

6.5.3 A localized tattoo can also be enrolled with other contextual information that can be used for search-based filtering:

6.5.3.1 Personal demographics

6.5.3.2 Encounter context:

- Agency defined arrest type or severity
- The location of where the tattoo image was captured
- Other agency-specific information that could be used when searching

6.5.4 If the tattoo description can be entered this can be used for search-based filtering. See the NCIC codes for detailed examples of this or the FISWG document “Facial Recognition System: Metadata Usage”.

6.5.5 Some tattoo algorithms may be able to determine and extract an assumed body part and tattoo description. This should be discussed with the algorithm vendor or integrator.

6.6 Recognition

6.6.1 Tattoo images for searching should be localized similar to tattoo enrollment.

6.6.2 Tattoo image quality should be determined with pre-deployment testing by the algorithm vendor or integrator:

6.6.2.1 Some tattoo images may not meet a defined image quality threshold for searching

6.6.2.2 Image quality thresholds for enrollment localization and searching may be different as some tattoo deployments may require a higher level of image quality for enrollment than for searching

6.6.3 Search filters can effectively be used if available and supported by agency policy:

6.6.3.1 Personal demographics

6.6.3.2 Encounter context: single or multi-select option

6.6.3.3 Body part: single or multi-select option

6.6.3.4 Other information that the agency could use when searching

6.6.4 Default search result candidate sizes should be derived from pre-deployment testing and algorithm vendor, integrator, and examiner interaction.

6.7 Identification

6.7.1 Once an agency has determined that a TRS will be deployed or updated, the agency needs to gather Mission and legal requirements that the solution must address and should develop appropriate policies and procedures. Refer to “Facial Recognition Technology Implementation Guidelines” to assist in this process.

6.7.2 One-to-one examination opinions should align with appropriate agency policies in terms of standard forensic disciplines, opinion scales, documentation, and multiple examiner reviews.

7. Tattoo SDK Topics

7.1 Individual tattoo images should be localized, segmented tattoos shown, and localization boxes manually reviewed so the desired tattoo templates can be correctly updated before final template creation is done prior to enrollment or searching.

7.1.1 Some operational scenarios may involve a sequential tattoo capture process where tattoos are captured, the person being booked returned to a safe area away from the booking officer, and then manual image processing done using an application to

properly localize and enroll the tattoos. If manual processing is performed the tattoo algorithm vendor should be consulted to see if rotation of the tattoo is suggested.

7.1.2 Pre-deployment testing should be followed for tattoo deployments like testing performed for other biometric modalities including:

7.1.2.1 FAR and FRR scoring curves

7.1.2.2 DET and ROC curves

7.1.2.3 CMC curves

7.1.2.4 Determination of candidate list sizes

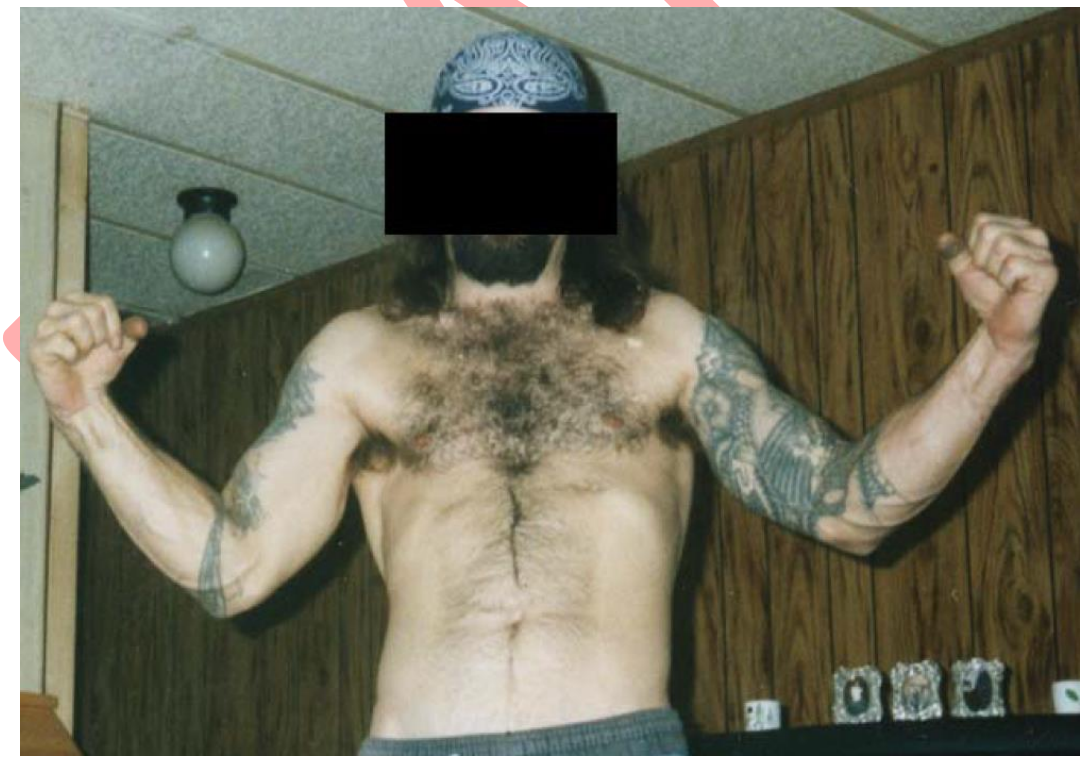
7.1.2.5 Determination of scoring thresholds

7.1.3 Reference the multi-part FISWG documents on “Operational Assurance” on the FISWG website.

8. Tattoo Examples

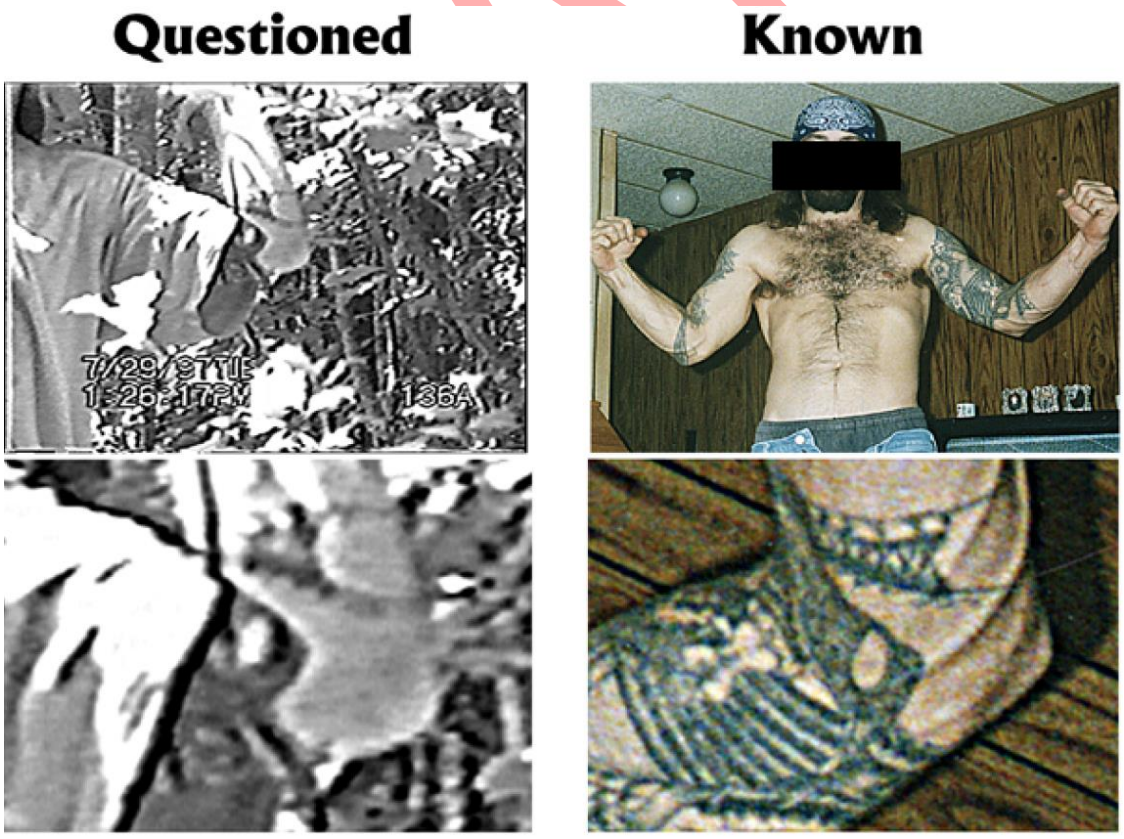
8.1 Example 1: from https://www.scribd.com/document/87378239/VorderBruegge-Face.pdf

Image of a person holding a marijuana plant



Known photo of the suspect

Left arm detail



Questioned vs. known imagery

Localization of tattoos from the known suspect image for enrollment: left and right arm

Manual localization of a potential search image

Figure 11: Example 1 Tattoo Images

8.1.1 Potential search parameters:

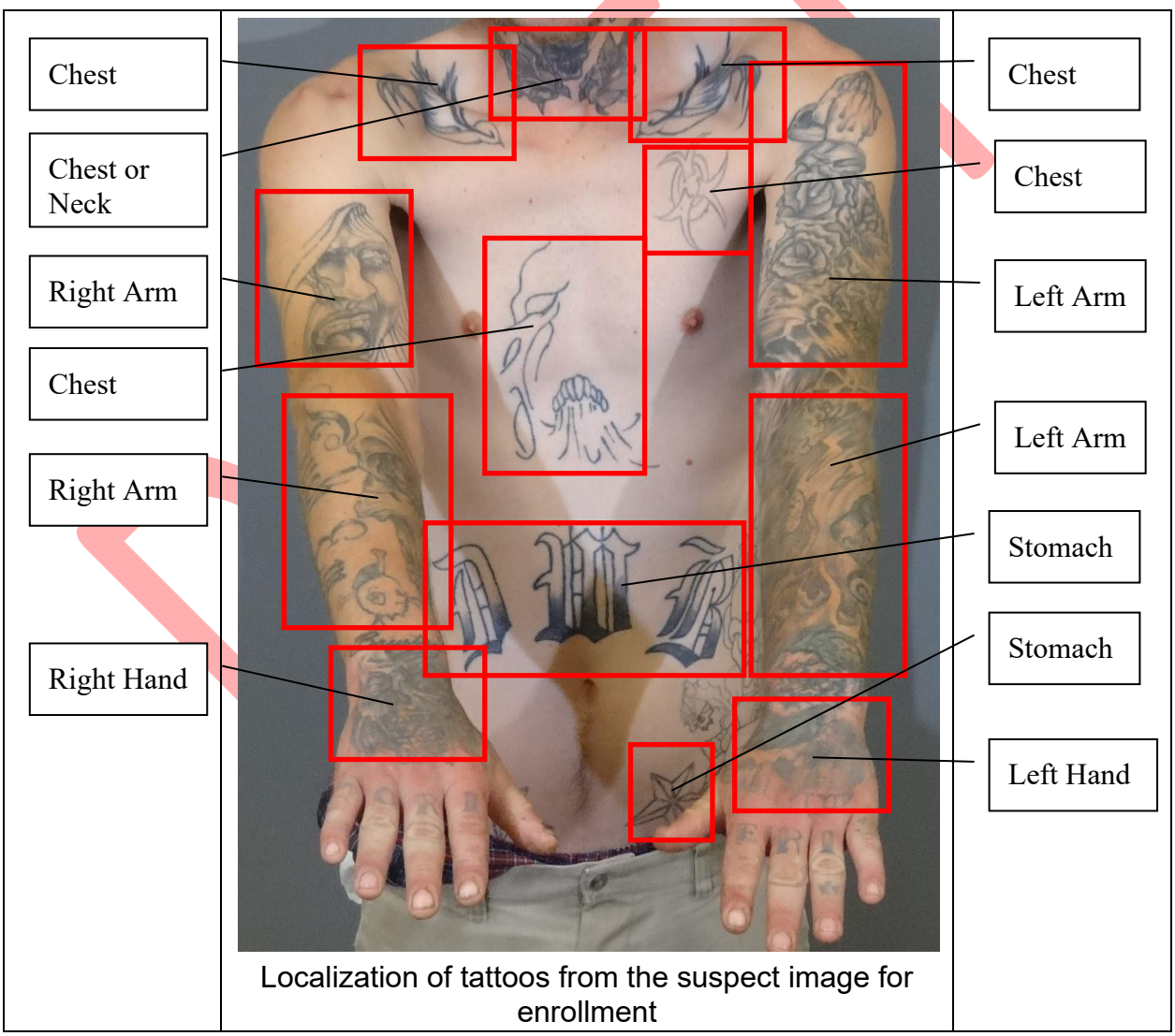
213 8.1.1.1 Body part: left arm

214 8.1.1.2 Sex: male

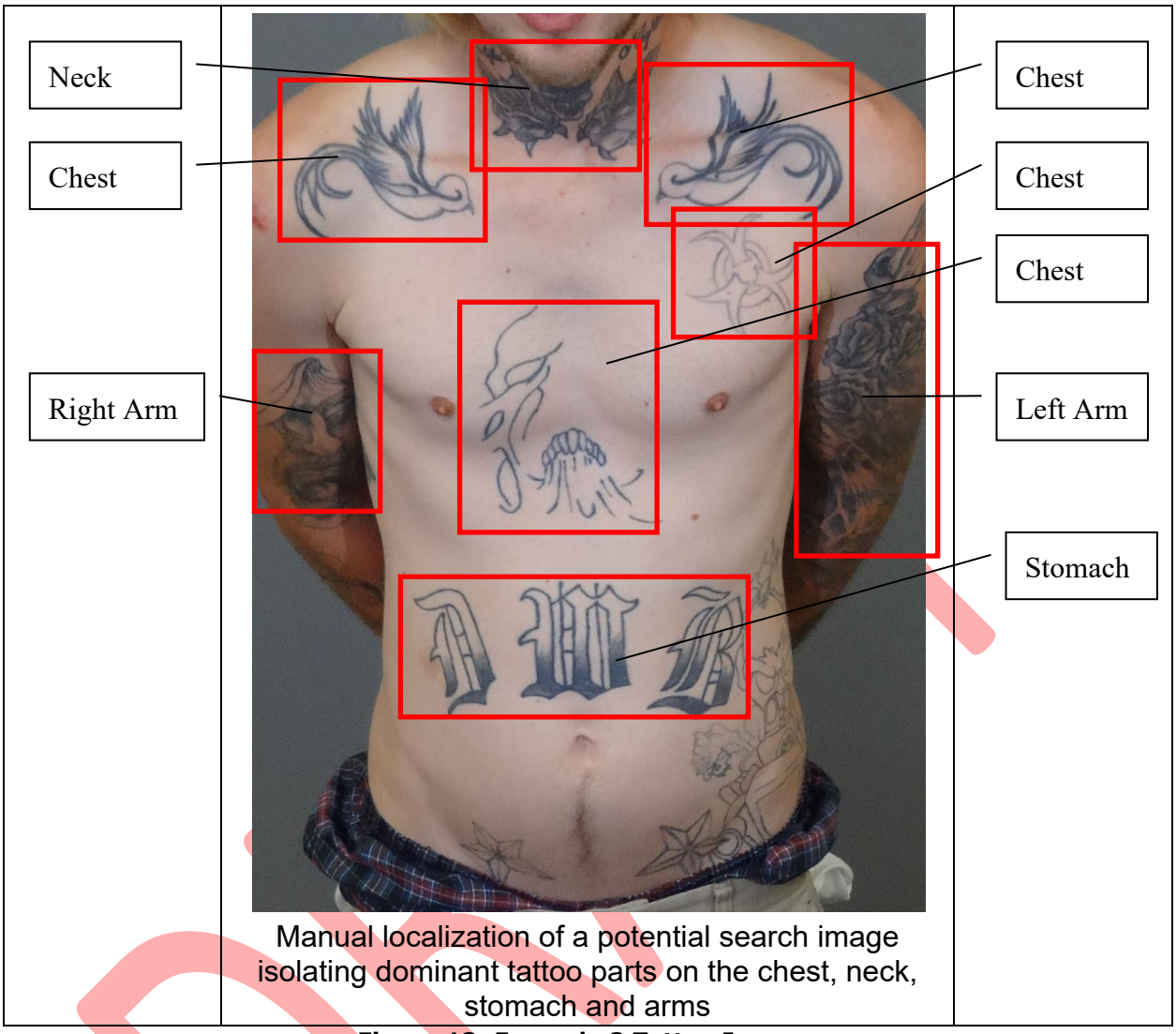
215 8.1.1.3 Age range: 30-45

216 8.1.1.4 Arrest context: drugs

217 8.2 Example 2: Complex tattoos



Localization of tattoos from the suspect image for enrollment



Manual localization of a potential search image isolating dominant tattoo parts on the chest, neck, stomach and arms

Figure 12: Example 2 Tattoo Images

8.2.1 Potential search parameters:

8.2.1.1 Body part: chest, neck, stomach, left or right arm

8.2.1.2 Sex: male

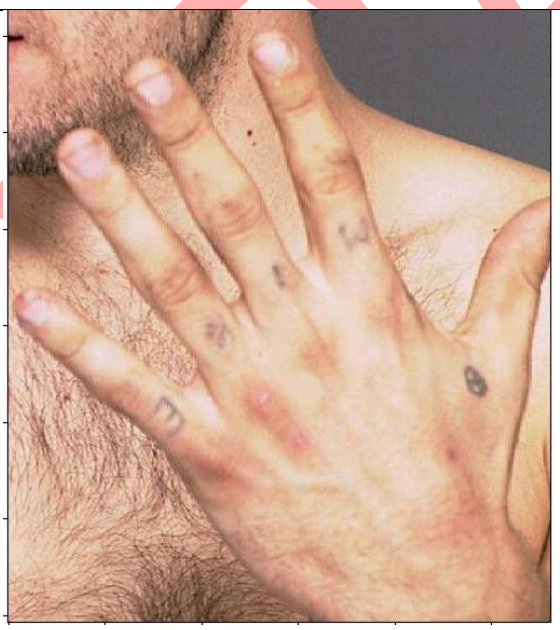
8.2.1.3 Age range: 25-40

8.2.1.4 Arrest context: unknown

224 8.3 Example 3: Images that may need rotation before enrollment

Figure 23: Example 3 Tattoo Images

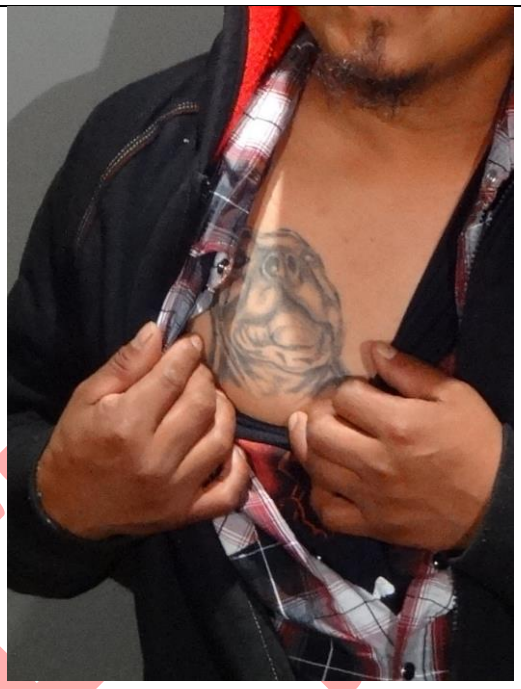
8.4 Example 4: Special tattoo cases



Tattoos on fingers may need to be individually localized

Partial tattoos may need to be ignored

Tattoos on hands and fingers may need to be individually localized



Tattoos that are close to clothing should be carefully localized to not include non-tattoo portions

Example of Changing Tattoos

Figure 14: Example 4 Tattoo Images

9. Images of Scars and Marks

9.1 The images of scars and marks may be of interest to a TRS (e.g., the ANSI NIST-ITL EBTS specifications do support scar and mark images as well as tattoos). If agencies are supporting images of scars and marks then proper care should be taken to identify whether a localized tattoo image is a tattoo, a scar, or a mark so this information can be leveraged when using search filters.

Figure 15: Examples of Scar Images

10. Recommendations

10.1 Review the current NIST documents on tattoo recognition. While they were posted before the AI revolution, they have many recommendations that are still valid in terms of basic operational principles.

10.2 Proper tattoo localization for tattoo enrollment and searching is critical to improve operational accuracy.

10.3 Using search filters is critical to improve operational accuracy.

10.4 Supporting scars and marks may require operational processes that do not use AI based technology.

10.5 Proper pre- and post-deployment accuracy testing should be performed like other biometric modalities.

10.6 Agencies should develop appropriate policies and procedures addressing agency-specific Mission and legal requirements that the solution must address.

10.7 All aspects require close collaboration with the tattoo algorithm vendor or integrator, the agency examiners, and any applicable local, state or federal laws.

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

APPENDIX

(Nonmandatory Information)

X1. Variance in tattoo content

X1.1 Variance in tattoo content

X1.1.1 Tattoos can be found on all body parts and can cover more than one body part.

X1.1.2 Tattoos have no assumed structure on the body.

X1.1.3 Tattoos can be changed over time:

X1.1.3.1 Added, removed, updated

X1.1.3.2 Age or changes in the body

X1.1.4 Similar tattoos exist on different identities

X1.1.5 Varying tattoo image sizes and image resolutions

X1.1.6 Imagery represented in a tattoo may be realistic, stylized, fictional, and have complete or partial contest

X1.1.7 Complex and non-standard content with obscure art

X1.1.8 Large color variations

X1.1.9 Uncontrolled rotation of the tattoo image

X1.1.10 Multiple languages used in the tattoo

X1.1.11 Distortion or missing portions of the tattoo image due to capture angle

X1.1.12 Obstruction of the tattoo due to clothing or body hair

X1.1.13 Aspect ratios change with different body parts:

X1.1.13.1 Chest tattoos tend to be flatter

X1.1.13.2 Tattoos on arms and legs have different image distortions based on the angle of the tattoo image capture and how the tattoo wraps around the body