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Biometrics Interoperability profiles — Best Practices for slap tenprint captures

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National foreword

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Interopérabilité des profils biométriques - Recommandations pour la capture de dix empreintes digitales à plat

Profile für die biometrische Interoperabilität - Optimales Vorgehen bei Erfassung aller Finger mittels gleichzeitigem Auflegen

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Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (CEN/TS 16428:2012) has been prepared by Technical Committee CEN/TC 224 “Personal identification, electronic signature and cards and their related systems and operations”, the secretariat of which is held by AFNOR.

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1 Scope

The main goal of this Technical Specification is to give guidelines to follow during the acquisition process of slap tenprints in order to obtain fingerprints with the best quality possible in acceptable time constraints.

NOTE Non-cooperative users are out of the scope of this Technical Specification.

When using ten-fingerprint sensors, it is fundamental to know how to use them and how to proceed during the acquisition. This Technical Specification describes how to capture fingerprints correctly by specifying best practices for slap ten-print captures.

This Technical Specification gives guidance on the following topics:

1) Recommendations on the hardware of the fingerprint sensor and its deployment,

2) Recommendations on user guidance,

3) Recommendations on the enrolment process including a sample workflow,

4) Recommendations for developers and system integrators on application software,

5) Recommendations on processing, compression and coding of the acquired fingerprint images,

6) Recommendations on operational issues and data logging,

7) Recommendations on the evaluation of a solution and its components.

Although this Technical Specification primarily focuses on reaching optimal data quality for enrolment purposes, the recommendations given here are applicable for other purposes. All processes which rely on good quality tenprint slaps can take advantage of the best practices reported here.

2 Sensor hardware requirement

Image quality should comply with the quality specifications from ISO/IEC 19794-4:2011 [1]. EBTS/F corresponds to Annex B.1 and BSI TR-03121 corresponds to Annex B.3 of ISO/IEC 19794-4:2011 [1].

NOTE 1 This Technical Specification considers optical sensors based on the principle of total internal reflection. However, this does not mean that other technologies cannot be used for tenprint enrolment purposes. As soon as sufficient experiences are available and recommendations can be given on emerging technologies, they will be included in a future version of this document.

The sensor device should provide methods for re-calibration in the field by qualified service staff if the device technically supports it.

It is recommended that the compliance of a sensor device to the applicable quality standard can be verified at any time in the operational environment.

NOTE 2 The need for calibration or re-calibration depends on the sensor technology and calibration might not be necessary for all devices.

3 Acquisition software

3.1 Acquisition process

For the acquisition process, the highest quality images should be used. The acquisition of these images should be done automatically. The sequence of images having the highest quality should be used; if a timeout has occurred then these may be below the desired quality levels.

An example for an acquisition process design can be found in Annexes A and B, an example for a quality metric can be found in Annex C.

3.2 User feedback

The presence of a user interface is strongly advised to give feedback to the user.

Feedback can be given, for example, by:

- A screen attached in close neighbourhood to the sensor,
- Illuminated pictograms on the sensor,
- LED’s assigned to pictograms directly on the sensor.

The following information should be given to the user:

- Assistance to finger positioning with images and/or video on the screen and/or audio instructions (for instance to instruct the user to move its fingers to the left/right/top/bottom),
- Visual and/or audio notification when a successful acquisition has been completed,
- A Quality indicator for each acquisition. This indicator should be simple, for example a two-state logic (not good/good) or similar,
- If possible, the reason for a bad quality acquisition (e.g. wrong positioning of the hand).

Additional information (e.g. a poster or a video) can be used to illustrate to users how to use the system. This information can be displayed close to the sensor and additionally in the waiting zone.

Operators should be trained to give guidance to the users.

3.3 Acquisition check

The software linked to the sensor should take account of the following during the acquisition process in order to perform a better acquisition:

- Any feedback provided by the sensor software (background correction, quality evaluation, end of acquisition, etc.),
- A timeout for capturing the best available image in case the specified quality threshold is not reached,
- The inability of the subject to provide a full set of fingerprints. Acceptable images for certain fingers may not have been captured. This can be due to
  - missing fingers,
  - inability for the subject to interact with the sensor correctly,
  - temporary or permanent issues with the subject's fingerprints.
- The image quality of the captured images. This is to enable the system to finish the acquisition process after the preset quality level or a timeout has been reached,
- The subject's fingers have been removed from the sensor at the end of the acquisition process,
- All two consecutively captured slaps and captured thumbs are not identical. A duplicate check should also be performed to ensure that all expected fingers have been captured once and once only,

NOTE Due to computational time constraints this recommendation could also be enforced by the operator instead of the software.

- Residual traces have not been acquired,
- The fingerprint images are as originally acquired. Optionally, segmented images can be produced,
- Hand inversion between left and right slap has not occurred. This check can be based on the different physical characteristics of the shapes of both hands.

3.4 Image processing

3.4.1 Segmentation

Independently of physical resolution of the sensor and the image acquired, the resolution of the fingerprint image should be at least 197 ppcm (500 ppi) and, therefore, can differ from the scan resolution.

Depending on the call to capture one, two, three or four fingerprints, this number of individual fingerprints should be extracted from the input image and provided as single fingerprints generated by a segmentation process which takes into account fingers reported to be missed.

For this segmentation process, the following criteria should be fulfilled:

- Ability to accept rotated fingerprints having the same direction in an angle up to 45°
- Rotated fingerprints having the same direction should be corrected to be vertical
- Segment the first part over the finger (first phalanx)
- Segmentation should be performed on uncompressed data.

Recommended size for fingerprint images is given in ISO/IEC 19794-4:2011, D.1.

NOTE Size limitation is done in order to prevent performance issues.

3.4.2 Compression

Fingerprint images should be compressed according to the recommendations in ISO/IEC 19794-4:2011, section 8.3.17 “Image compression algorithm”.

NOTE 1 The compression ratio should not be too high, a maximum compression ratio of 15 is recommended.

NOTE 2 The WSQ compression is mainly used for fingerprint compression; it has been optimized to be compatible with minutiae calculation.

The implementation of the used WSQ algorithm should be certified by the FBI and should be referenced by the respective certificate number (coded in the WSQ header).

Multiple lossy compressions should be avoided as they harm image quality.

4 Logging and evaluation of data

4.1 General

Logging and evaluation data might be subject to European Union or national legal constraints and should be handled accordingly.

4.2 Logging data

The purpose of the logging data is not to track people but to give guidance to the staff in charge of the enrollment and to maintain a constant quality of the acquisition process.

The following data, or parts of it, should be logged:

- Transaction ID
- Timestamp of acquisition
- Duration of biometric acquisition process
- Number of captured images
- Number of successful captures
- Quality scores for all captured fingerprints
- Overall quality score of captured slap or ten prints sets (if present)

— Information about vendor, software, hardware and versions

— Information about the origin (e.g. Agency Identifier)

— Information about errors (e.g. about uniqueness check, segmentation, etc)

— Size of acquired data

— Testing flags (if applicable)

— Demographic data on the subject (gender, age).

NOTE It might be appropriate to have a regular logging workflow and an evaluation mode logging workflow with more comprehensive logging data. The latter one could be used for regular or incident-based checks of the whole process.

When used in a verification or identification scenario, it is recommended to also log results of the verification and identification process.

4.3 Useful statistical evaluations

Conducting regular (e.g. every month, every three month, every year) evaluations on the acquired logging data is recommended.

As a minimum, the following basic set of evaluations should be conducted:

— Quality scores distribution

— Error code distribution

— Average enrolment duration

— Distribution of enrolment duration

— Distribution of gender and age, especially in relation to quality scores

When used in a verification or identification scenario, it is recommended to also evaluate the accumulated results of the verification or identification attempts.

5 Operational process

5.1 General user guidance

The presence of a user interface is strongly advised to support better acquisition.

The following placement recommendations should be applied:

— The user should set down the fingers flat on the sensor and in particular their tips but not set down only the tips (see Figure 1) or the sides of the fingers (see Figure 2).

Figure 1 — Tips of the fingers

Figure 2 — Sides of the finger

— The user should position his fingers straight, parallel to the edges of the sensor (see Figure 3) and avoid any rotation unless a rotation is the only way to place all fingers on the acquisition surface of the sensor (see Figure 4).

Figure 3 — Prefer parallel fingers in relation to the edges

Figure 4 — Avoid rotated fingers in relation to the edges

— The user should position the thumb(s) straight, parallel to the edges of the sensor (see Figure 5) and avoid any rotation.

Figure 5 — Correct thumbs position

Figure 6 — Wrong thumbs position

— The user should put down all the fingers simultaneously on the sensor (do not roll them on the sensor or do not put down one finger after the other on the sensor)

— The user should not spreading fingers too much (see Figure 7) and cross his fingers (see Figure 8)

Figure 7 — Spread fingers

Figure 8 — Crossed fingers

— The user should center the hand or the thumb(s) on the sensor acquisition surface

— The user should not position his fingers on the borders of the sensor acquisition surface in order to avoid to cut or miss a part of the slap (see Figure 9)

Figure 9.a — Mind the top border of the sensor

Figure 9.b — Mind the low border of the sensor

— The user should position the fingers on the sensor such that as much as possible of the fingers is placed on the scanning area. If the user has placed the hand on the sensor wrongly, it should be ensured that the hand is removed before putting it down again on the sensor as moving the hand directly on the sensor could cause distortions.

5.2 Acquisition process recommendations

Visual instructions should be provided to the user to understand how to position the fingers on the sensor correctly. It is recommended to instruct the user to look at these instructions carefully, listen to the advice given by the operator in a supervised context and to follow the instructions of the sensor (led, beeps, etc.) after each step of the process.

NOTE 1 Samples of pictograms, icons and symbols are currently developed in the ISO/IEC CD 24779-2 [7].

NOTE 2 A study conducted by the National Institute of Standards and Technology (NIST) shows that best results are obtained by combining audio and video rather than by using written instructions only [2].

— The user should move in front of the sensor and place the indicated finger(s) with great ease on the prism surface.

— The user should wipe his fingers if they are wet (see Figure 10) or moisten them if they are too dry (see Figure 12).

Figure 10 — Example of a wet finger

Figure 11 — Example of a correct quality finger

Figure 12 — Example of a too dry finger

NOTE 3 Different sensor technologies adapt differently to wet or dry fingers. User guidance should consider such technology information, too.

NOTE 4 Especially with an automatic system, the user should be notified when the acquisition procedure begins. Visual and/or audible feedback may be given depending on the scanner. Furthermore, step-by-step guidance should be given on the slap or the thumbprint(s) to be actually presented.

— The required hand (for a right/left slap) or thumb(s) (for individual or simultaneous thumbprint) should be directed vertically towards the sensor. The direction of the hand movement should be perpendicular to the sensor acquisition surface (see Figure 13).

Figure 13 — Vertical movement of the hand

Figure 14 — Oblique pressure on the sensor

NOTE 5 Directing the hand obliquely toward the sensor and pressing on it in an oblique way causes distortion (see Figure 14).

— The hand or thumb(s) should be placed correctly on the sensor (see Figure 15 and Figure 16). The live feedback should be used (if any provided) to handle this operation at best. The term “correctly” refers to recommendations described in Clause 4.

Figure 15 — Fingers correct placement

Figure 16 — Thumbs correct placement

— Sufficient pressure should be applied on the sensor for the acquisition (in order to cover enough surface of the finger) but no over-pressure (otherwise fingerprint structures get lost in the image). The user can be encouraged to use the other hand to apply pressure on the hand to be enrolled if necessary. The user should then take care that the finger(s) of his other hand do not touch the sensor surface.

— Leave the hand or the thumb(s) on the sensor until asked to release by the sensor or the operator. In case the fingers of a user are very dry, he should be encouraged to moisturize them. In some cases the scanning process may take a significant amount of time, so the user should be notified on not releasing the hand or finger(s) until requested.

— The hand or the thumb(s) should not be moved during the acquisition. Once the acquisition is done, the user should be notified. Then, the next slap or the next thumbprint(s) to be acquired according to the implemented workflow should be indicated.

— The user should remove his hand or the thumb(s) completely from the sensor before recapturing, moving to the next capture step or ending the process.

6 Operational issues

6.1 Placement recommendations

The placement of the device is a critical issue for a correct acquisition.

— Give access to the sensor so that the user is able to position himself/herself with great ease in order to place his/her hands and thumbs on it.

— Place the sensor in its best working way in accordance with manufacturer recommendations [3].

— Specify the height range of people to be captured. Perform own tests on the best placement. Ideal height for acquisition is elbow height.

— Ensure that any strong light sources do not directly illuminate into the sensor prism. This includes all direct lights. However, ensure appropriate environmental illumination allowing user and operator a good view on the sensor.

NOTE 1 As light can change, the operator should be aware of this change in luminosity and react accordingly.

— The room temperature should be set to avoid a large temperature difference between sensor surface and finger(s). Failure to do this could cause halo effects due to condensation in the captured images. Some sensors are able to work under far larger temperature constraints, e.g. because they have heated prisms. Furthermore, for other than indoor uses the chosen sensors should be able to operate under other (usually rougher) environmental constraints.

NOTE 2 A complex operational scenario is currently developed in ISO/IEC CD 29197 [8].

NOTE 3 This document is primarily intended for enrolment applications, but may partly also be applicable to field-level verification procedures or similar.

— Make sure that the sensor is correctly fixed and stable in order to prevent any movement during the acquisition of the prints.

NOTE 4 In order to address accessibility concerns (e.g. people in wheelchairs), temporarily detachable devices can be useful.

6.2 Calibration recommendations

The following recommendations apply:

— Clean the acquisition surface of the sensor before its initialization in accordance with the manufacturer recommendations for best results with products recommended by the manufacturer. Failure to do this can result in ghost images.

— Carry out the sensor calibration if applicable (refer to the instructions given by the sensor manufacturer). During this calibration process, no object should be on the sensor, and the surface should be clean.

NOTE Check if the sensor needs to be covered with a lid during calibration. Information as to whether this is necessary will be provided by the sensor manufacturer.

6.3 Cleaning recommendations

The following recommendation applies:

— Clean the acquisition surface of the sensor in accordance with manufacturer recommendations for hygienic reasons, with products recommended by manufacturer. Good capturing software should be able to deal with minor pollution, as it is not realistic that for every user the sensor can be cleaned in high throughput applications.

6.4 Operator recommendations

The following recommendations apply:

— Provide dry soft tissue if necessary in order to wipe the fingers if they are wet or sweaty.

— Provide humidifying pads if necessary in order to moisten the fingers if they are too dry or cold. The need for drying or humidifying fingers mostly depends on the environmental conditions and on the sensor characteristics. Disinfecting towels can be provided to address hygienic issues.

In the case of enrolment, the acquisition quality is even more important than in the case of verification. Therefore, training operators involved in the acquisition process is crucial. Operators should be trained in order to make them effective in helping users during the enrolment and verifying that this enrolment is done correctly. Operator training should be repeated frequently to maintain the operator's capabilities and to provide new information to them.

Operators shall assure that the person acquiring fingerprints does not use any finger dummies, fakes or something similar. Therefore, a direct view to the sensor is necessary. It is recommended that the person shows his fingers to the operator before starting the acquisition process.

Annex A
(informative)

Example of acquisition process

This annex explains how an acquisition of ten slap fingers is made in a general way.

At first, one capture of the hand is performed. Then, the quality of each captured fingerprint is checked. If the quality of all fingers is good enough, the acquisition is successful. Otherwise, the acquisition is performed again (with a maximum of 3 attempts in this example).

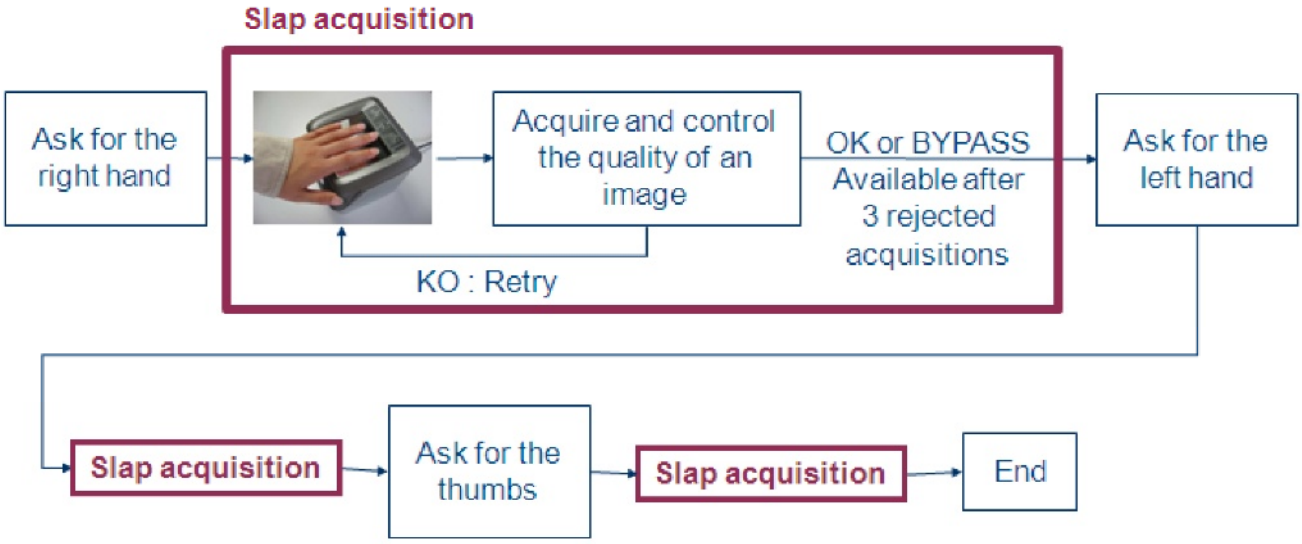

Figure A.1 – Overview of a 10-slaps enrolment

The process begins with the acquisition of fingerprints of the right hand. In the standard process, a multi-finger acquisition is applied. Therefore, multiple fingerprints are captured at once. The quality of all fingerprints of this hand is checked. If this quality is not sufficient, then the right hand is captured again. The process should prefer the slap with the best overall quality.

If the required quality cannot be achieved for all fingerprints within the 3 attempted captures, there are two alternatives:

— Attempting another capture (operator will decide how many captures he wants before stopping the process)

— The system keeps the image with the best average quality and continues with the next slap.

After the acquisition of fingerprints from the slap of the right hand, the fingerprints from the slap of the left hand and finally of the thumbs are captured.

In addition to the set of ten fingerprints, this process also delivers complete slap images including the angles between fingers.

NOTE The need for complete slap images depends on the application.

Annex B
(informative)

Example of an acquisition process based on composite records

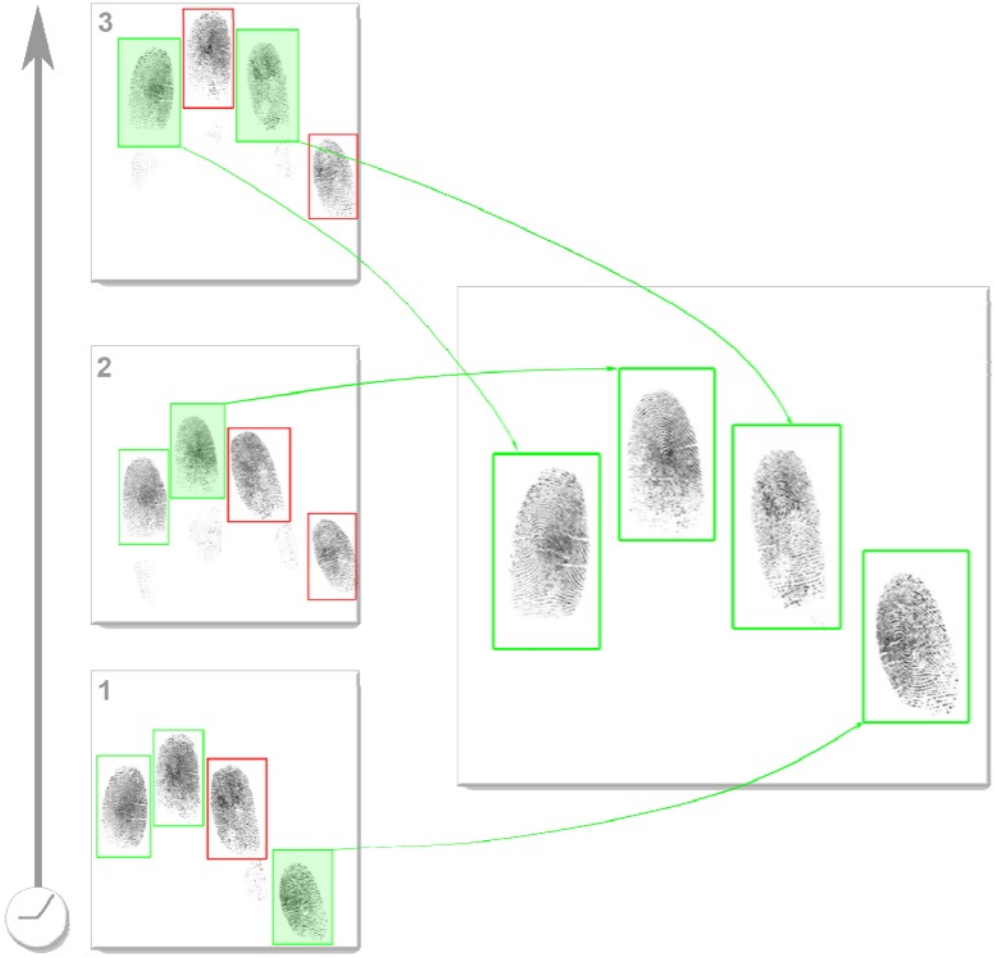

Figure B.1 – Concept of composite records

This annex explains how to build composite records based on cross matching.

NOTE This process only applies to ten print sets without corresponding control slaps of images.

Multiple captures (3 times in this example) are performed. For every single finger out of the set, the three fingerprints are matched against each other and the one that matches best against the other two is chosen for the composite record.

If the acquisition of specific fingers is too difficult in multi-finger capture, the process should switch to single-finger capture for those.

If the acquired fingerprints have poor quality at least one repetition of the appropriate process should be enforced before accepting lower quality fingerprints.

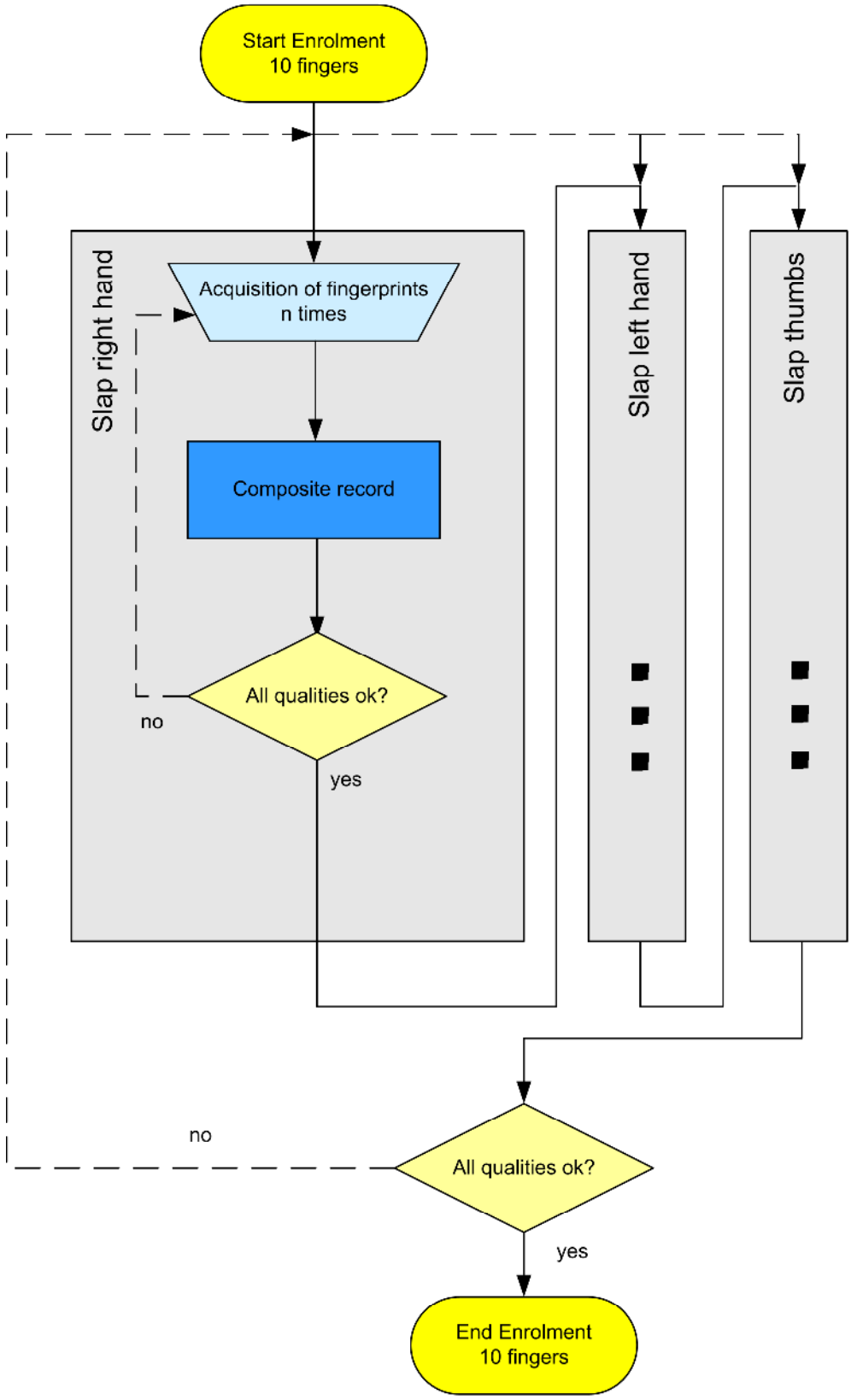

Figure B.2 – Overview of the enrolment of 10 fingers

Composite records based on cross matching:

— The process begins with the acquisition of fingerprints of the right hand. In the standard process multi finger acquisition is applied. Therefore, multiple fingerprints are captured at once while the sequence of fingerprint acquisition is repeated three times,

— Hardware or software should automatically activate the acquisition. Manual capturing methods should be possible (to cover failure to acquire issues as a back up in cases where the automated capture has not happened),

— The capture should select the highest quality image per finger of the sequence. All fingerprints of this hand that have been captured with the highest quality for the respective finger are combined to a composite record. After the acquisition of fingerprints from the slap of the right hand, the fingerprints from the slap of the left hand and finally the thumbs are captured,

— If adequate quality cannot be achieved for all fingerprints within a composite record, there are two alternatives to try to improve the quality for these fingerprints. The acquisition of fingerprints of this composite record can either be repeated or the best quality images from all three slaps of fingerprints can be taken.

Annex C
(informative)

Example of a quality metric for the acquisition process

Three images of every available finger have to be taken. Multi finger sensors may be used for faster capturing and thus segmentation of fingerprint slaps may be conducted in advance. After quality assurance there are independent fingerprint images of every finger of which the best one is chosen. Finally, of all selected fingerprint instances a composite record containing all fingerprints is generated. This quality assurance process and selection for every single finger is described in the following.

NOTE For performing this process, a fingerprint comparison algorithm is necessary. This TS does not give recommendations on specific algorithms to be used.

1) Three verifications between the individual fingerprint images A_i are executed, resulting in comparison scores S_{AiAj} for all i,j = 1, 2, 3 with i = j. As a result, three comparison scores are obtained as minimum of both directions comparisons

$$S_{A_1A_2} = \min\{S_{A_1A_2}, S_{A_2A_2}\}, S_{A_1A_3} = \min\{S_{A_1A_3}, S_{A_3A_1}\}, S_{A_2A_3} = \min\{S_{A_2A_3}, S_{A_3A_2}\}$$

2) A rating is performed to provide the comparison of quality of the captured fingerprints as the average of the comparison scores to the other prints of the same finger. For every captured image of a fingerprint the rating R_{A_i} is calculated according to the following formulas:

$$R_{A_1} = \frac{S_{A_1A_2} + S_{A_1A_3}}{2}$$

$$R_{A_2} = \frac{S_{A_1A_2} + S_{A_2A_3}}{2}$$

$$R_{A_3} = \frac{S_{A_1A_3} + S_{A_2A_3}}{2}$$

3) From the captured images of each fingerprint the one with the maximum rating R_{Ai} is chosen.

4) The rating is compared with the quality threshold $R_{A_i} \geq TH_R$. The result is a boolean information b (b=*true* if $R_{A_i} \geq TH_R$ and b=*false* if $R_{A_i} \geq TH_R$).

5) If b is true for the chosen fingerprint image A_i the fingerprint image is used for being added to the composite record.

   If b is false for the chosen fingerprint image A_i another two instances of this finger are captured. Rating is then conducted according to steps 1 to 4 of the newly captured fingerprint instances and the chosen fingerprint from step 3 (the one with the maximum rating).

6) If the best rating of the newly captured fingerprints exceeds the threshold as specified in step 4 this instance of the finger is used for being added to the composite record.

   If the best rating of the newly captured fingerprints does not exceed the specified threshold the instance with the best rating of all captured instances is added to the composite record.

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