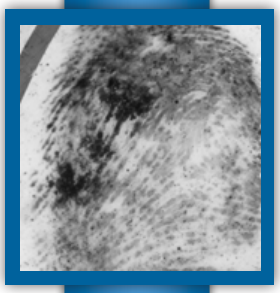


Extended Feature Set Training Tool

COMPILED TEXT AND IMAGES

June 2013

Developed by Noblis, Inc. jointly for the:
Law Enforcement Standards Office (OLES) at NIST, under Cooperative Agreement No. 70ANB11H030
and FBI Criminal Justice Information Services Division, Biometric Center of Excellence, under NPITSS Task Order 12,
Biometric Standards Development and Scientific Support

Introduction

After completing this training you will:

1. Learn the Extended Feature Set and its application to AFIS searching
2. Practice manual markup of minutiae and other friction ridge pattern features
3. Expand knowledge to perform markup on a variety of examples while complying with EFS specifications

Background

This training tool is an interactive guide to markup in the Extended Feature Set (EFS). The EFS is designed for Automated Friction ridge Identification System (AFIS) searches as well as for the interchange of latent print annotation among examiners as part of casework. EFS includes a broad and complete set of friction skin features that is familiar to all latent examiners. It was defined in cooperation with all of the major AFIS vendors and is intended to be used without modification across different AFIS systems that are EFS compatible.

The Training Tool describes how the features are organized into groups called Search Profiles, which allow the examiner to choose trade-offs between search accuracy and mark-up time.

Guiding You Through

Navigate with the tabs at the top of the webpage. The feature training modules are inside Quick Minutiae Search and Detailed Markup Search. The Resources tab clarifies vocabulary and points to outside references, and Help contains instructions about using the site. The tool addresses the following EFS features:

Quick Minutiae Search:

Region of interest (ROI), Orientation, Pattern classification, Cores, Deltas, Minutiae

Detailed Markup Search:

Ridge quality map, Dots, Incipients, Distinctive features, Center point of reference, Core-delta ridge counts, Ridge flow map

Objectives

- Provide an interactive tool for learning the Extended Feature Set
- Present a range of image clarity and difficulty to provide growth opportunities even for experienced examiners
- Use markup consistent with best AFIS accuracy
- Develop a framework for future expansion of examiner training
- Foster greater consistency in latent print markups
- Further the use of a common markup method for the latent print identification community
- Provide a training tool that is independent of proprietary AFIS rules

Search Profiles

Basics

Extended Feature Set Profiles define groups of features to be used for different purposes, notably different levels of detail for AFIS searches.

EFS Profiles are designed to be interoperable among AFIS systems. The EFS Profiles allow a range of tradeoffs between examiner time and matcher accuracy. The profiles in the EFS Training Tool include:

0. Image-Only Profile: no examiner markup
1. Minimal Markup Profile: low level of examiner markup to improve the accuracy of image-only matching
2. Quick Minutiae Search Profile: includes the fundamental features common to the various AFIS vendors; compatible with interchange standards from FBI, Department of Defense, Prüm, and INTERPOL.
3. Detailed Markup Profile: includes features that can be used to increase search accuracy in systems that implement this optional profile. These require an additional level of examiner effort.

Additional profiles (not addressed in this Tool) include features used by some AFIS vendors such as skeletons or ridge counts, as well as profiles designed to document friction ridge features for potential use in legal proceedings or exchange between latent examiners.

The FBI CJIS Electronic Biometric Transmission Specification (EBTS) corresponds directly to Profiles 0 (Image-Only Profile), 1 (Minimal Markup Profile), and 2 (Quick Minutiae Search Profile).

Profiles 0 (Image-Only Profile) and 2 (Quick Minutiae Search Profile) are designed to be available in all interoperable systems.

Advanced

EFS Profile 0: Image-only profile

The Image-only profile may be used if the image has no obscuring background or multiple impressions, and visually appears to be within approximately ±15° of upright.

EFS Profile 1: Minimal markup profile

The Minimal markup profile should be used instead of the Image-only profile if the image has an obscuring background, contains multiple impressions, or orientation is not upright or is unknown. It includes the following features:

Feature	When to Mark
Region of Interest	Mark if there are multiple impressions, a complex background, or if only a portion of the print is to be selected
Orientation	Mark if the impression is not upright (visually within ±15° of upright), or if the orientation cannot be determined
Finger/Palm Position(s)	Indicate finger/palm position if known; indicate finger segment if all or part of the medial or proximal finger segments are present (fingerprint only), indicate off-center fingerprint if an extreme tip or extreme side (fingerprint only)
Pattern Class	
Core(s)	If present
Delta(s)	If present

EFS Profile 2: Quick minutiae search profile

The Quick minutiae search profile adds minutiae to the Minimal markup profile. In terms of examiner effort, it is roughly equivalent to most current manual markups.

Feature	When to Mark
Minutiae	Always
Evidence of Fraud	If present

(All features from Profile 1 - Minimal Markup)

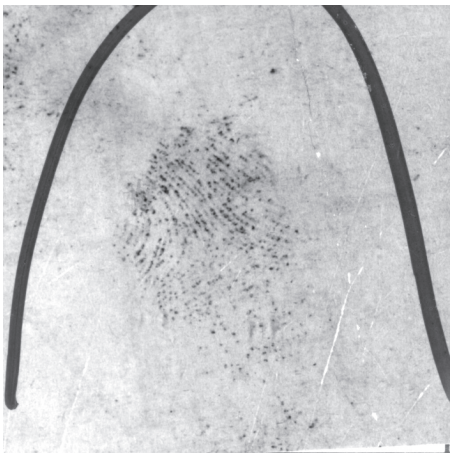
EFS Profile 3: Detailed Markup Profile

The Detailed Markup Profile includes features used by some AFIS vendors to increase accuracy, but that require additional examiner time. It includes the following features:

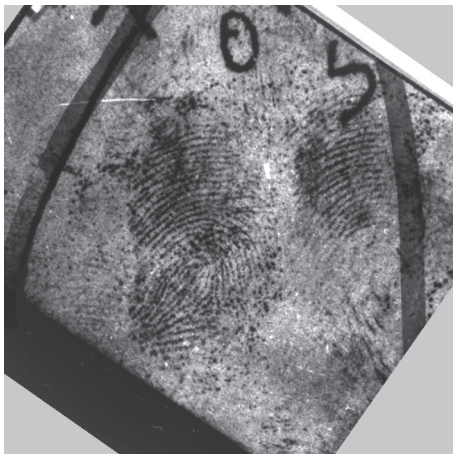
Feature	When to Mark
Ridge Quality Map	Always
Ridge Flow Map	Always
Center Point of Reference	If known (does not apply to palms or plantars)
Distinctive Features	If scars or other physical abnormalities (e.g. warts or dysplasia) are present, other distinctive features optional)
Dots	If present
Core(s)	If present

(All features from Profile 1 - Minimal Markup and Profile 2 - Quick Minutiae Search)

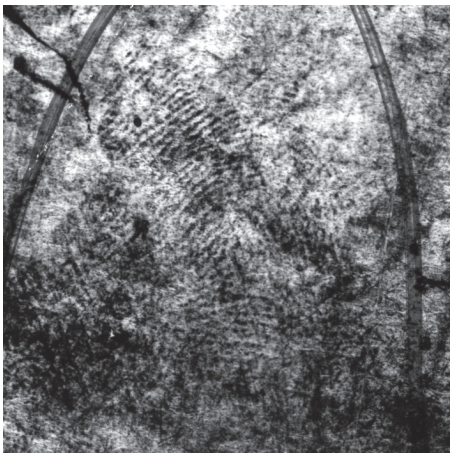
Search Profiles Section Images



Appropriate for Image-Only Search (Profile 0)



Appropriate for Minimal Markup Search (Profile 1)



Requires Quick Minutiae Search or Detailed Markup Search (Profile 2 or 3)

Quck Minutiae Search Profile

Region of Interest

Description

The Region of Interest (ROI) is a polygon that bounds the area of the original image containing a single friction ridge impression, separating it from the background and any other friction ridge data present in the image. Using an ROI is strongly recommended when the overall image contains multiple impressions or when differentiating between the friction ridge detail and the background is difficult.

There can be only one ROI for a given image. All other features marked must be within the ROI, with the exception of the Center point of reference/CPR.

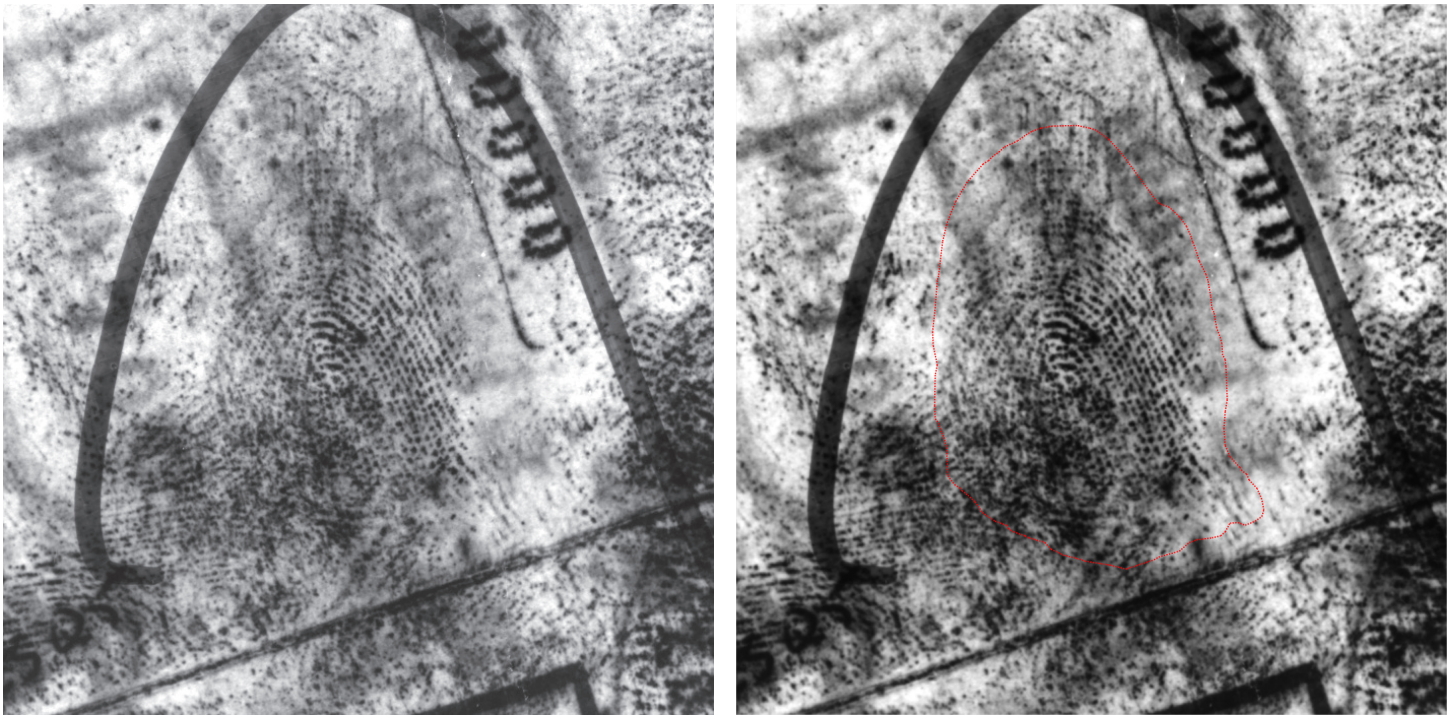
An ROI includes only one impression made by a single or contiguous portion of friction ridge skin.

Simultaneous impressions or other images containing multiple impressions must mark each impression on a separate duplicate of the image. In the case of overlapping fingerprints, the ROI may include the area where impressions are superimposed.

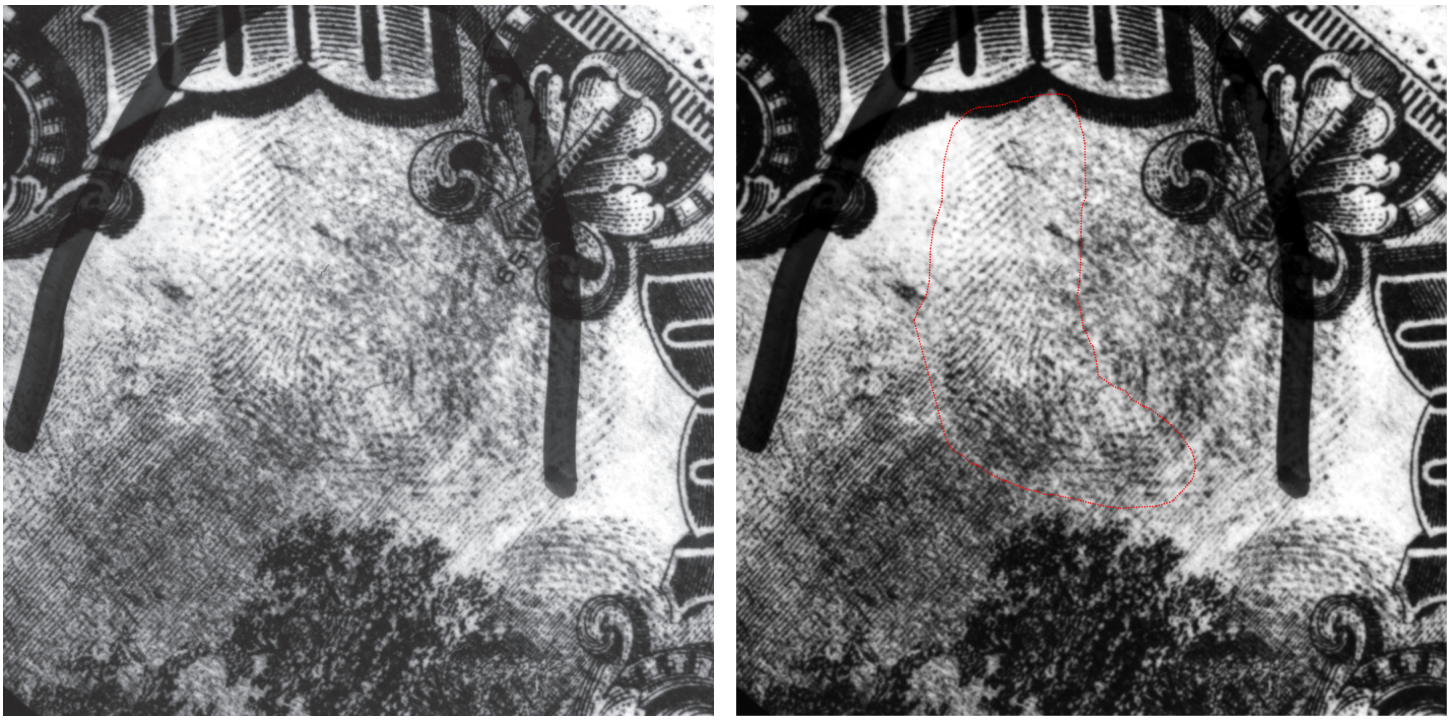
Exercise Instructions

Click down at any point around the region of interest's border, and drag around that area to lasso the region of interest. Clicking in the canvas again, or clicking on the Trash button, will erase the previous outline. Choose Check My Answer on the bottom left to compare your solution to an example of expert markup.

Region of Interest Example Images

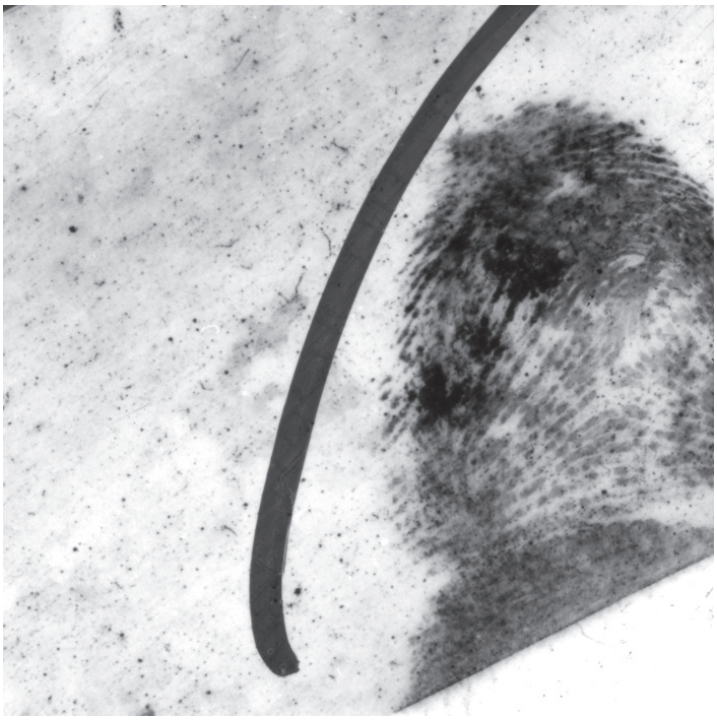


Designating a region of interest separates the latent print of interest from the surrounding impressions



This impression needs to be distinguished both from other friction ridge impressions and from background noise

Latent impression is not obscured by other prints or disruptions, so region of interest does not need to be specified manually



Latent impression is not obscured by other prints or disruptions, so region of interest does not need to be specified manually

Orientation

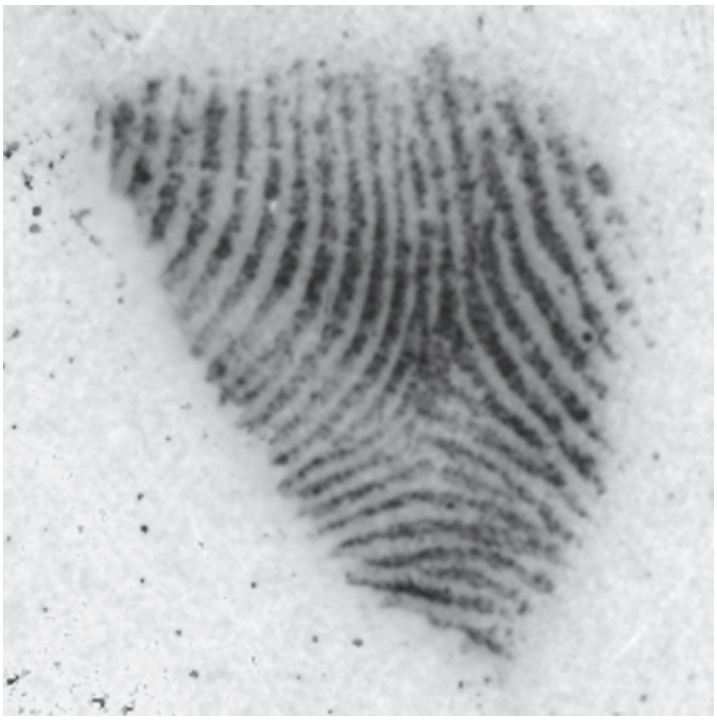
Orientation indicates the direction towards the tips of the fingers. There are three options for indicating orientation: upright, unknown, and specific orientation.

- Upright indicates that the impression is upright ("tip up") within about ±15°. This is the default if not otherwise indicated.
- Unknown indicates that the orientation cannot be determined.
- Specific orientation indicates that the orientation can be determined and the impression is not upright. If the orientation is approximate, optional bounds of uncertainty may be indicated.

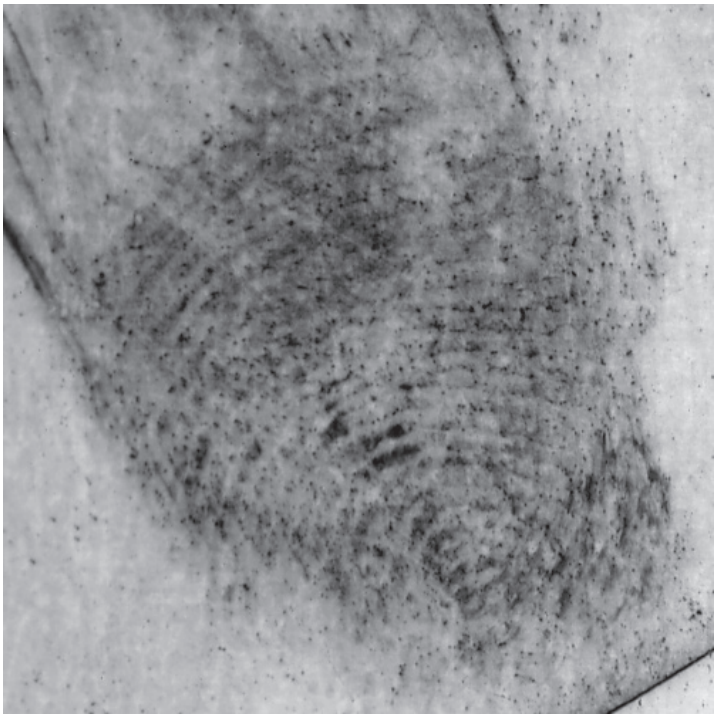
Exercises are not provided for the Orientation feature.

Orientation Example Images

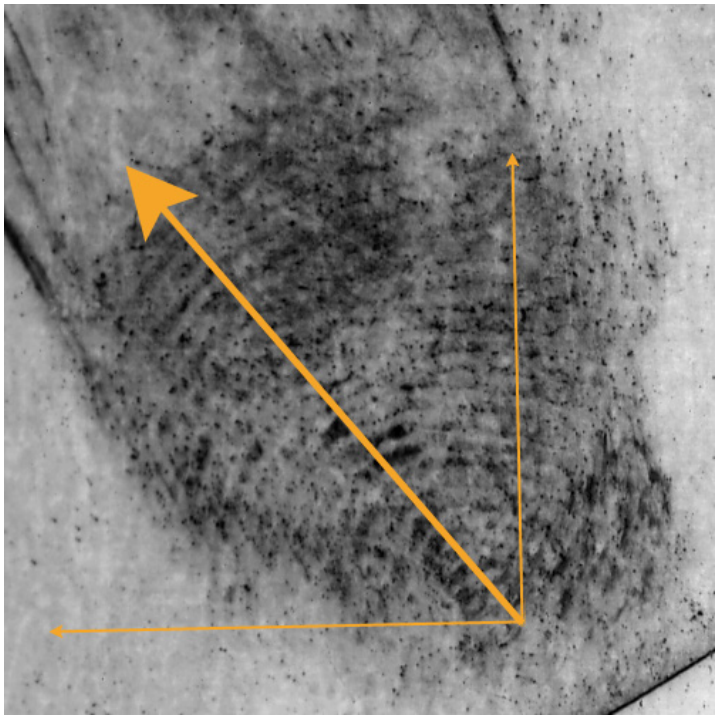
Tip up



Unknown: Orientation cannot be determined



Orientation is not upright and should be specified



Orientation and uncertainty bounds indicated

Pattern Classification

Basics

Fingerprint impressions can be usefully clustered into several pattern types: arches, loops, and whorls, with subclasses inside each. Pattern classifications are used for fingerprint images only, and do not apply to palms, lower joints, extreme tips, or plantar impressions.

Pattern classification of fingerprints follows the NCIC Classification, an extension of the Henry system. The table below summarizes the possible classes and subclasses of fingerprint patterns, and when to mark special cases. In broad terms, patterns are divided into three types: arches, loops, and whorls. Detailed instructions on pattern classification can be found in the Science of Fingerprints handbook and the Fingerprint Training Manual, and are further discussed in The Fingerprint Sourcebook.

A loop is a friction ridge flow pattern in which one or more ridges enter upon one side, recurve, touch or pass an imaginary line between delta and core, and pass out upon the same side the ridges entered. In the Extended Feature Set, loops are divided into two subclasses: left slant loops and right slant loops. Left loops have recurving ridges that point downward and to the left of the core, while right loops have recurving ridges that point downward and to the right of the core. Loops always have at least one intervening ridge between the core and the delta. The innermost recurve defines the presence of a core.

Arches have two subclasses: plain and tented. Plain arches have ridges which enter on one side of the impression and flow out the other with a rise or wave in the center. Tented arches possess either an angle, an upthrust, or two of the three basic characteristics of a loop. Cores may be marked on tented arches if an innermost recurving ridge is present above the delta, so that the sides of the recurving ridge extend to either side of the delta. Tented arches should have deltas marked, if such a structure is present. Note that tented arches may be similar to a loop, except that they lack one of the three requirements (recurve, delta, or ridge count).

The whorl is that type of pattern in which at least two deltas are normally present, with a recurve in front in each. (Some Accidental Whorls are exceptions and may not have two fully-defined deltas.) Subclasses of whorls are defined by the ridge flow within their cores:

- Whorl – Plain – A type of fingerprint pattern which consists of one or more ridges which make a complete circuit, with two deltas, between which, when an imaginary line is drawn, at least one recurving ridge within the inner pattern area is cut or touched. A plain whorl will have one core without any direction if the pattern is circular and two cores with direction if the pattern is elliptical.

- Whorl – Central Pocket Loop – A type of fingerprint pattern which at least one recurving ridge or an obstruction at a right angle to the line of flow. The pattern has two deltas between which, when an imaginary line is drawn, no recurving ridge within the inner pattern area is touched or cut. A central pocket loop whorl may have one or two cores depending on whether the pocket is circular or elliptical.

- Whorl – Double Loop – A type of fingerprint pattern that consists of two separate loop formations with two separate and distinct sets of shoulders, two cores, and two deltas.

- Whorl – Accidental – A fingerprint pattern consisting of two different types of patterns, with the exception of the plain arch, with two or more deltas; or a pattern which possesses some of the requirements for two or more different types; or a pattern which conforms to none of the definitions.

Classification must be conservative: if the pattern is known precisely, indicate only a single pattern; however, if there is any doubt as to the precise classification, include all possible patterns. If the pattern cannot be classified, but a pattern type can be definitively excluded, then indicate that by selecting all possible patterns. For example, if the image contains a delta, but the image cannot otherwise be classified, include all pattern classifications except the plain arch.

Details

The information summarized in the accompanying Table is further described as follows:

1. General Class indicates the basic pattern classifications (arches, whorls, loops).

2. Subclass indicates the subcategories of the general class, which applies only to arches and whorls. Indicate this information item only if the subclass can be determined precisely or if specific subclasses can be excluded.

3. Whorl Delta Relationship may optionally be used by a human examiner or automated system to provide the relationship between the deltas in a whorl. Include this information item only for whorls whose subclass is known and only if the whorl delta relationship can be determined precisely. Set this information item to I (Inner), O (Outer), or M (Meeting), following the Henry guidelines (detailed in The Science of Fingerprints (SOF), p. 67). The information item is Inner if the ridge emanating from the left delta passes three or more ridges above (inside) the right delta and is Outer if the ridge emanating from the left delta passes three or more ridges below (outside) the right delta; otherwise, it is Meeting.

Pattern Classification		General Class	Subclass	Whorl Delta Relationship
Arches	Arch, type not designated	AU		
	Plain Arch	AU	PA	
	Tented Arch	AU	TA	
Whorl	Whorl, type not designated	WU		
	Plain Whorl	AU	PW	I, O or M
	Central Pocket Loop	WU	CP	I, O or M
	Double Loop	WU	DL	I, O or M
	Accidental Whorl	WU	AW	I, O or M
Loops	Right Slant Loop	RS		
	Left Slant Loop	LS		
Unable to Classify	Unable to Classify	UC		
	Complete Scar	SR		
	Disassociated Ridges/ Dysplasia	DR		

Up to seven pattern classifications may be indicated (including subclasses).

If scars or dysplasia are present but do not prevent the classification of the print, use the regular pattern class. Only use the Complete Scar (SR) or Dissociated Ridges/Dysplasia (DR) codes if the fingerprint cannot be classified.

Exercise Instructions

Click the checkbox next to each pattern type that might describe the image at the right. The image may be clear enough that you can narrow it down to one pattern type, or you might only have enough information to eliminate some options. You may select between one and seven pattern types for each print. To check your answers, use the button at the bottom left.

EFS pattern classifications are defined as they are in the NCIC method (as documented in Science of Fingerprints and the Fingerprint Training manual). However, when the pattern classification is borderline, especially if the class would change due to the presence or absence of a “spoiled” innermost recurving ridge (a recurving ridge with an appendage or crossing ridge), both of the potential pattern classifications must be indicated.

Pattern Classification Example Images

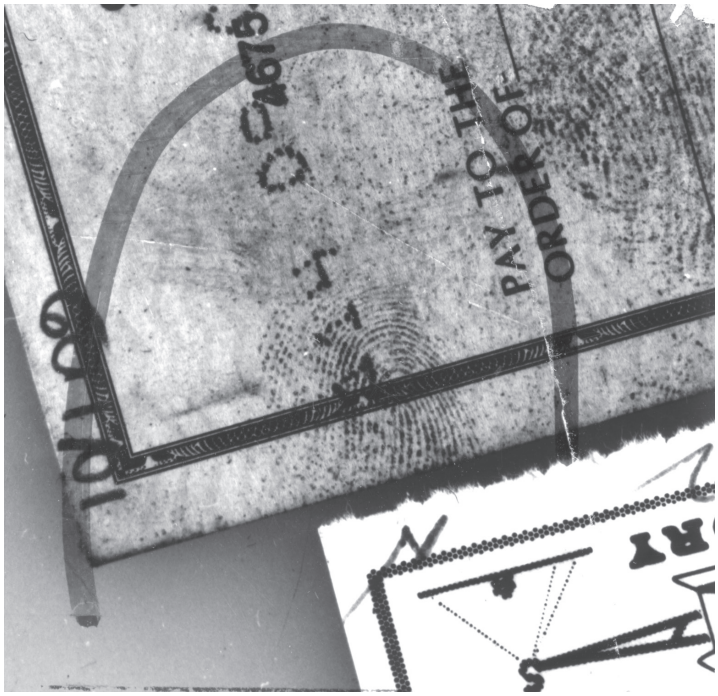


Figure 1: Left slant loop, latent print

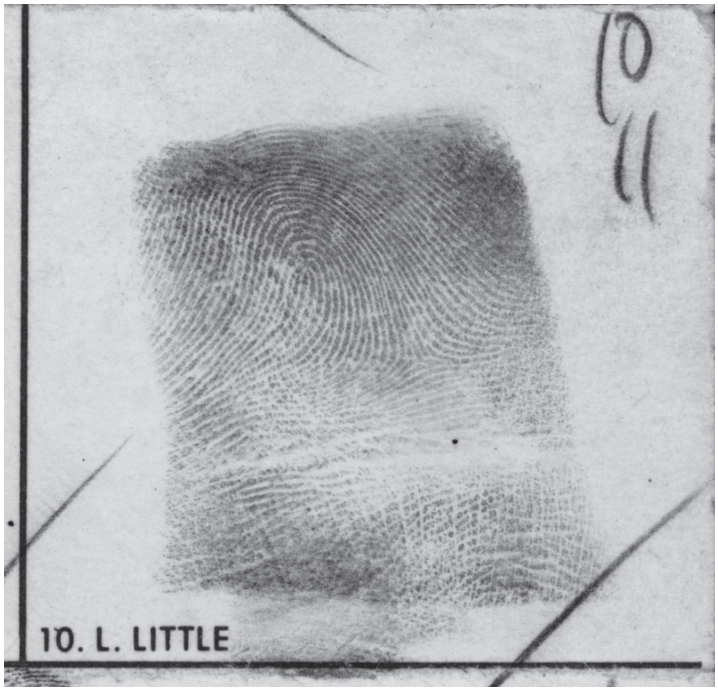


Figure 2: Exemplar image of left slant loop from previous latent

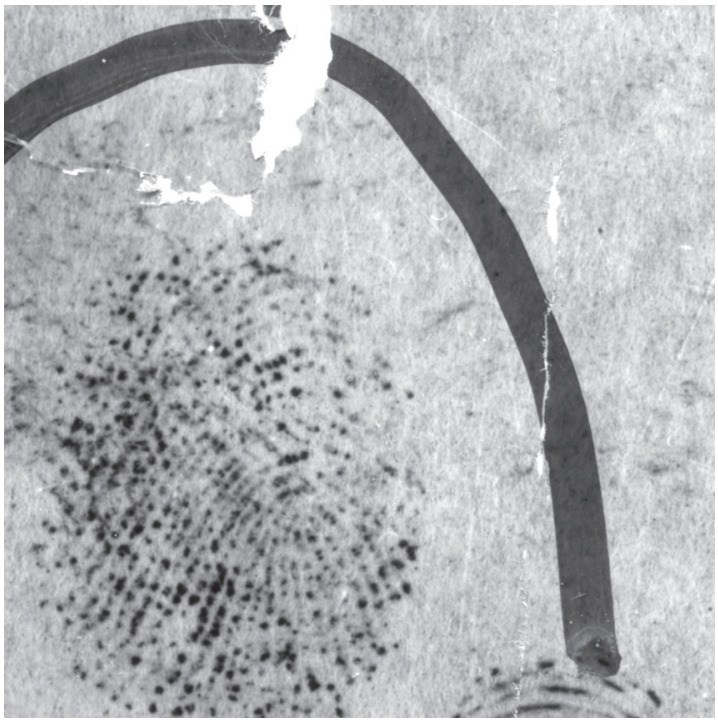


Figure 3: Right slant loop, latent print

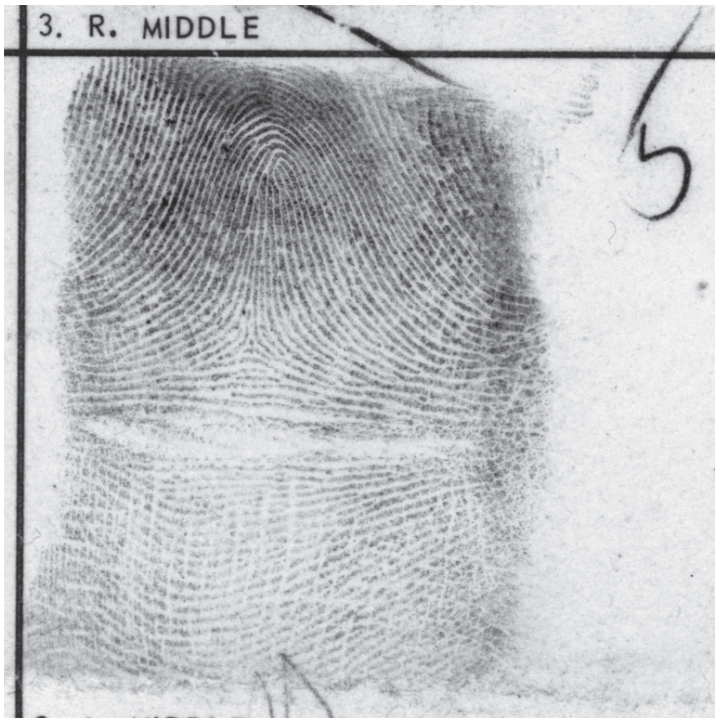


Figure 4: Exemplar image of right slant loop from previous latent

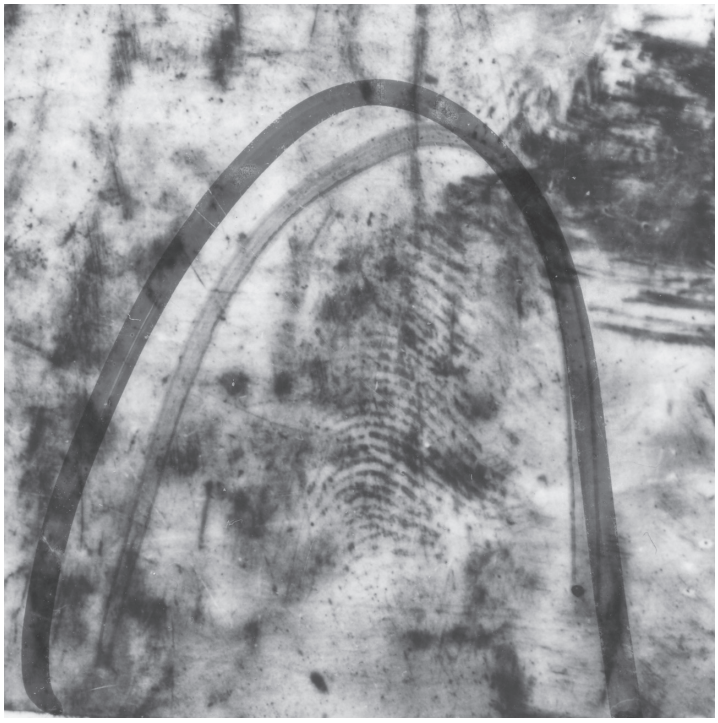


Figure 5: Plain arch, latent print

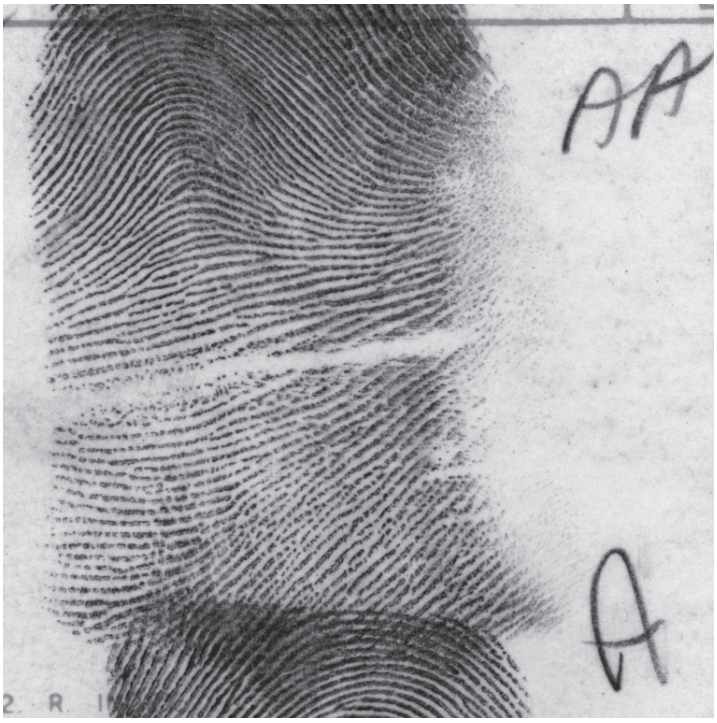


Figure 6: Exemplar image of plain arch from previous latent

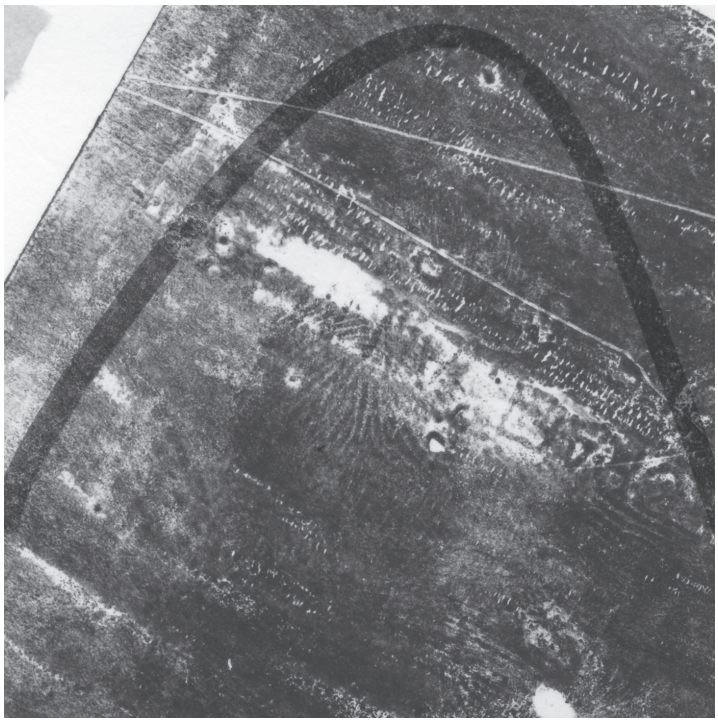


Figure 7: Tented arch, latent print

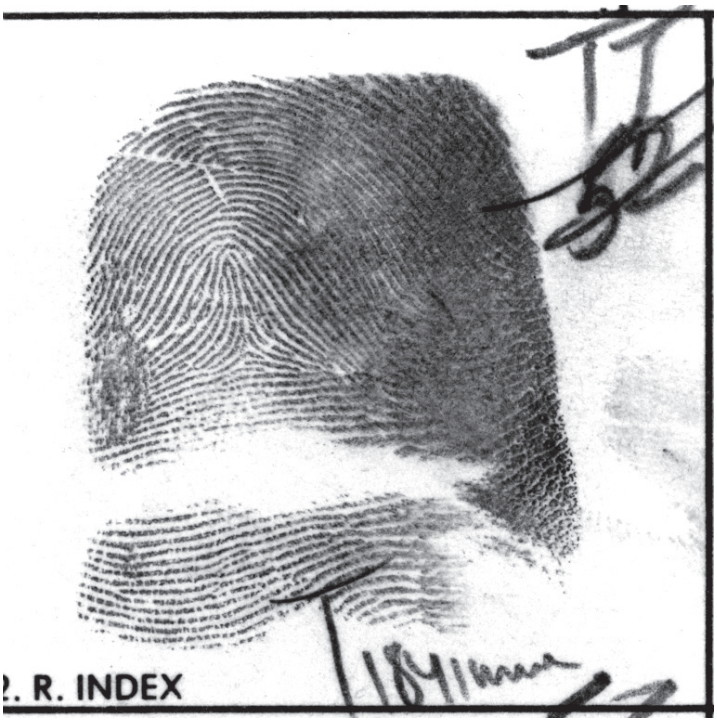


Figure 8: Exemplar image of tented arch from previous latent

Figure 9: Plain whorl, latent print

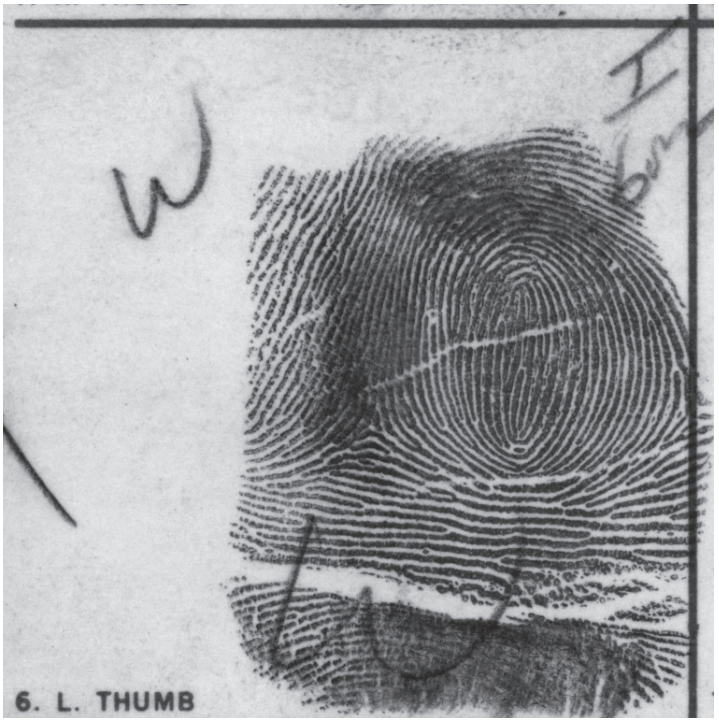


Figure 10: Exemplar image of plain whorl from previous latent

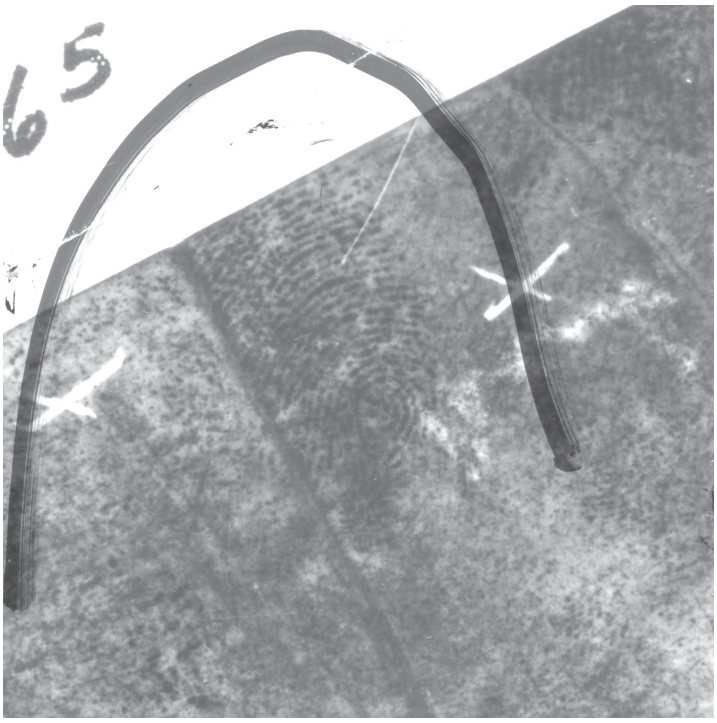


Figure 11: Central pocket loop whorl, latent print

Figure 12: Exemplar image of central pocket loop whorl from previous latent

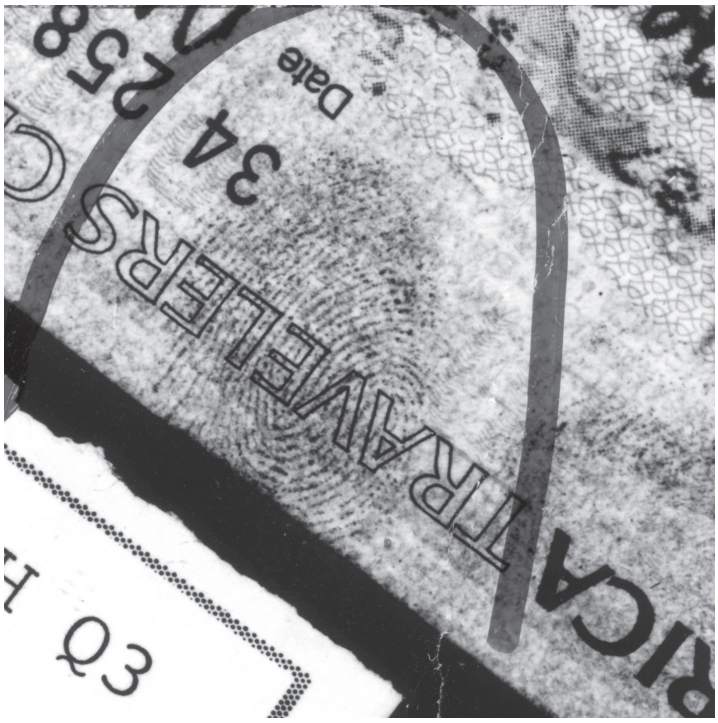


Figure 13: Double loop whorl, latent print

Figure 14: Exemplar image of double loop whorl from previous latent

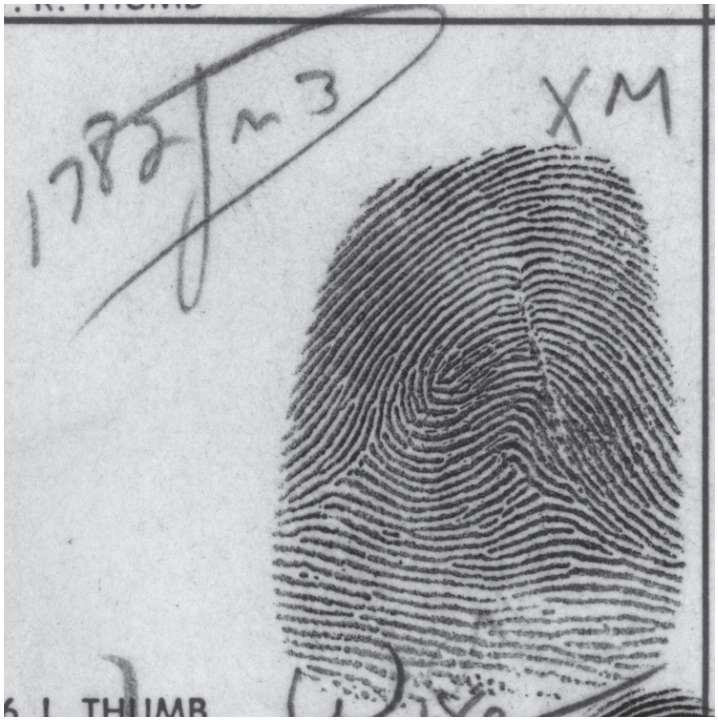


Figure 15: Exemplar image of an accidental whorl

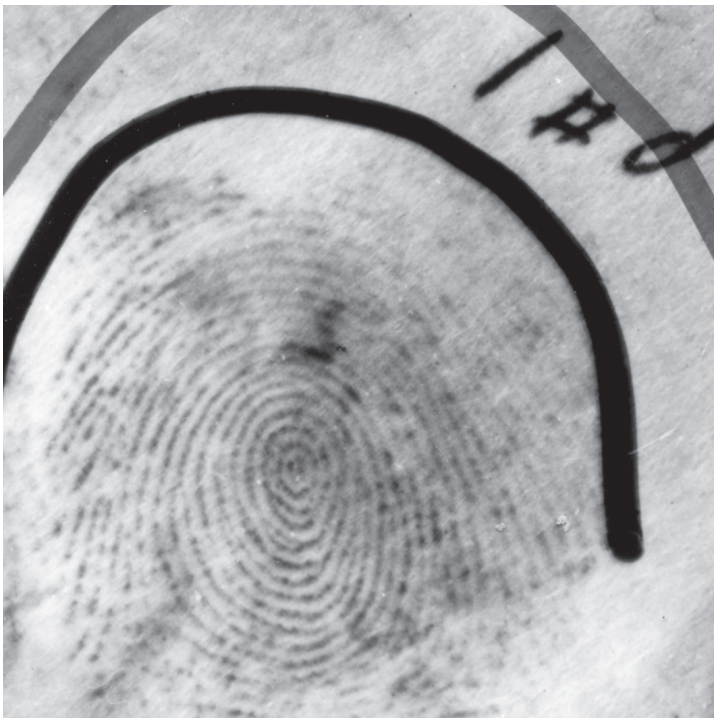


Figure 16: Another plain whorl from a latent print

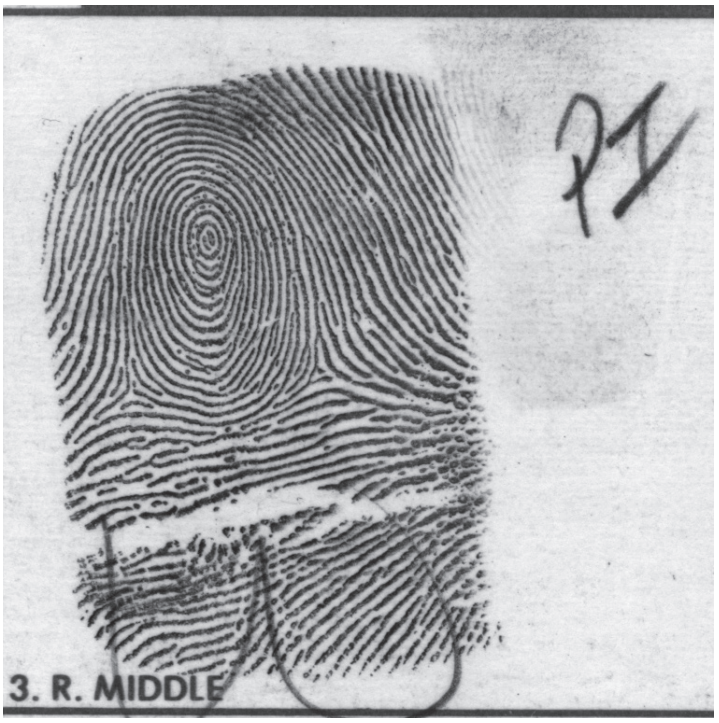


Figure 17: Exemplar image of the preceding plain whorl latent. Whorl-delta relationship: M (Meeting).

Cores

Markup

The core or cores of a fingerprint are defined for all pattern types except for plain arches. When they are present, cores appear in highly curved areas of a ridge impression and are identified by the innermost recurving ridge, sometimes called the innermost recurve. A recurving ridge curves back on itself, making an elongated horseshoe shape; the innermost recurving ridge is the one that does not surround any other recurving ridges. If you imagine the most curved part of the innermost recurving ridge as a circle segment, the core location is the center of that circle.

When an innermost recurving ridge is present on a tented arch, the core is defined and can be marked. Plain or central pocket loop whorls will have only one core if the innermost recurving ridge is circular, or two cores if the ridge is elliptical. The table below details the possible numbers of cores for each ridge pattern type. EFS differs from the Science of Fingerprints (SoF) in its specification of location for cores: the EFS location of cores for loops is at the focus of the innermost recurving ridge, rather than on the ridge itself. Unlike the NCIC method, EFS also defines core locations for whorls and some tented arches using the focus of a recurving ridge. The EFS core locations were developed based on input from AFIS vendors and SWGFAST, specifically because these locations are not as sensitive to the presence or absence of appendages, and are therefore more reliably detected by automated systems.

Pattern Classification		Cores	Deltas
Arches	Plain Arch	0	1
	Tented Arch	0 or 1	0 or 1
Whorl	Plain Whorl	1 or 2	2
	Central Pocket Loop	1 or 2	2
	Double Loop	2	2
	Accidental Whorl	Any Number	Any Number
Loops		1	1

If one or more cores are present and the feature set is from a fingerprint, the Pattern classification/PAT should be defined. This does not mean that the classification has to be known definitively, but it must at least exclude plain arches. For plain arches, a Center point of reference/CPR may be marked instead of marking a core.

The core's direction moves along the ridge flow at the core, pointing away from the innermost recurving ridge. If the core is the center of a complete circle made by a whorl pattern, its direction is not defined. If the direction of ridge flow is not clear at the core, a range of direction uncertainty can be used to include the range of possible directions of ridge flow.

Core-like patterns can also appear in palmprints, lower joints, or plantar impressions, and should be marked in the same way as fingerprint cores.

Special Cases

When marking the location of a core, you may also indicate a radius of uncertainty. If it's relatively clear where the core is, this radius should be small. If the image is unclear or ambiguous, make the radius of uncertainty large enough to include all possible locations of the core.

In the special case that the core cannot be seen in the impression but you can make a reasonable estimate of its location, you may if desired mark the core in the approximate location. Include an appropriately large radius of uncertainty.

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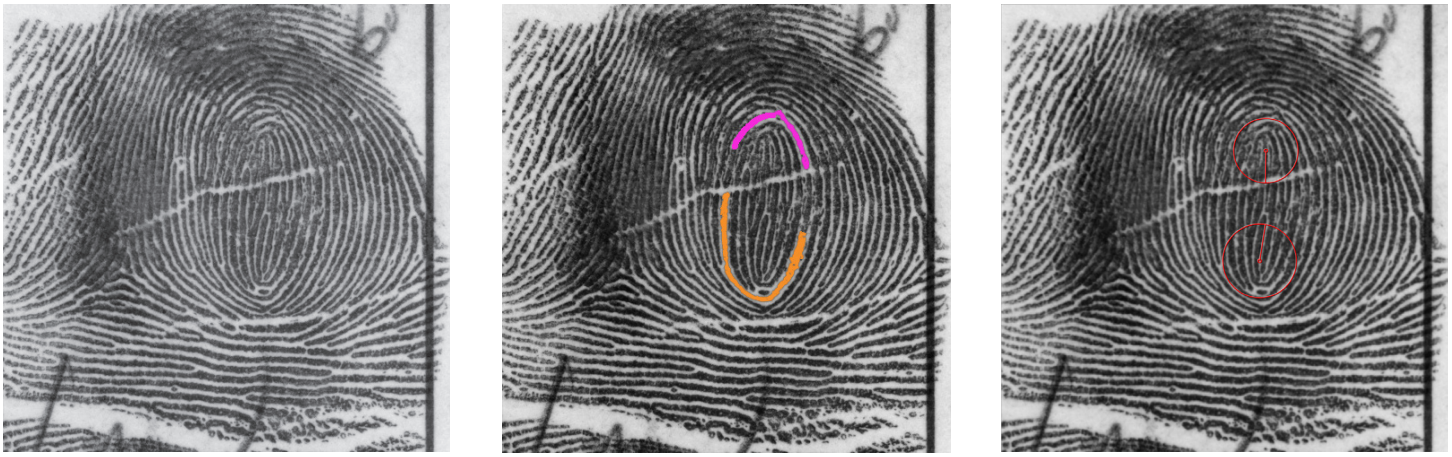
Exercise Instructions

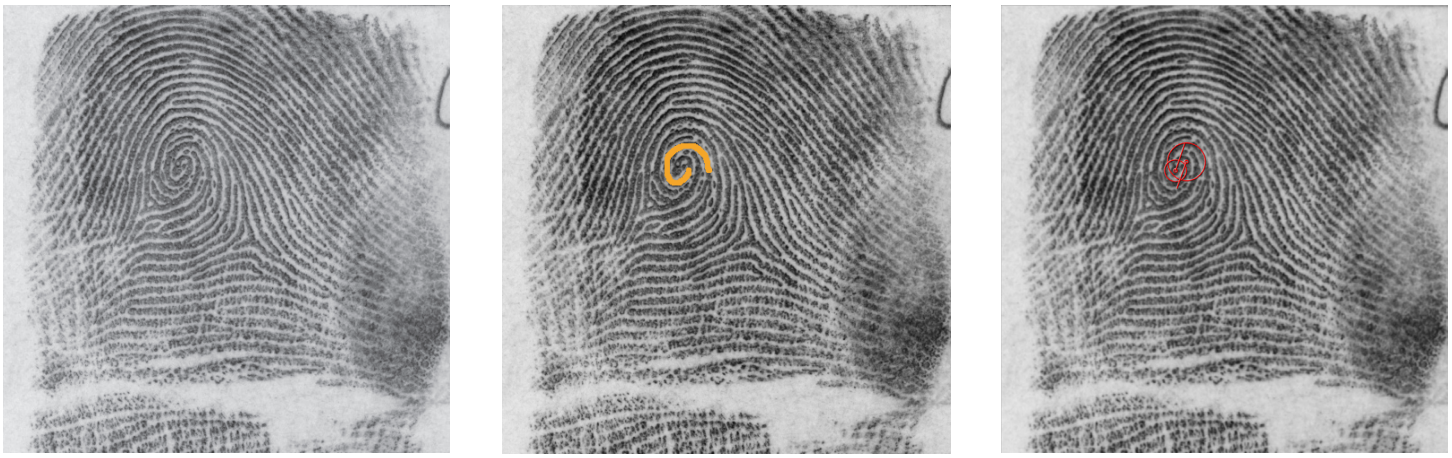
Find the most curved section of an innermost recurving ridge and visualize the circle it is a part of. Identify the circle's center point and click to mark the core location, then drag along the ridge flow for the core's direction direction. Click a second time to indicate a radius of uncertainty: the distance you click from the core's center point will be the radius.

If the print has a second core, mark it in the same way. Use the erase tool to remove any mistakes, then click Check My Answer.

Cores Example Images



The location of the core(s) is determined by identifying the impression's innermost recurving ridge(s), then determining each one's focus.



The location of the core(s) is determined by identifying the impression's innermost recurving ridge(s), then determining each one's focus.

Whorls with a circular innermost recurving ridge will have one core, while those with elliptical innermost recurves have two.

A plain arch does not have an innermost recurving ridge, and hence has no core

Deltas

Description

In a delta structure, three directions of ridge flow converge at one point. This may happen on intersecting ridges, in a valley, or on some combination of the two. The location of the delta is that center point. Use a radius of uncertainty if you cannot precisely determine the location, whether because of poor image quality or an ambiguous delta structure.

Mark the directions of the delta in the three directions of ridge flow. When orientation is known, mark the direction closest to upright first, and mark the next direction counterclockwise (i.e. to the left) second. If necessary, add a range of direction uncertainty for each direction.

Fingerprints with a loop or whorl pattern will always have a delta or deltas. Tented arches sometimes have a delta that needs to be marked. Accidental whorls may have any number of deltas. On palm impressions, carpal and interdigital deltas should be marked. On other friction ridge skin impressions, delta-like patterns may be marked as deltas.

In the special case that the delta cannot be seen in the impression but you can make a reasonable estimate of its location, you may mark the delta in the approximate location. Include an appropriately large radius of uncertainty.

Type

Indicate the type of delta when known, as defined in the table below.

Code	Applied to	Name	Description
L	Finger	Left fingerprint delta	The delta to the left of the image for whorls or right loops. For accidental whorls with more than two deltas, this indicates the leftmost delta.
R	Finger	Right fingerprint delta	The delta to the right of the image for whorls or left loops. For accidental whorls with more than two deltas, this indicates the rightmost delta.
100 102, 105 107, 110	Palm	Interdigital delta (with finger number)	The deltas at the base of the fingers in the interdigital areas - note the finger number if known; otherwise, set the number to “00.” Thumbs do not have interdigital deltas.
C	Palm	Carpal delta	The delta at the base of the palm where the thenar and hypothenar meet.
	Finger, Palm or Foot	Other delta	Any other details or delta-like structure in a friction ridge impression.

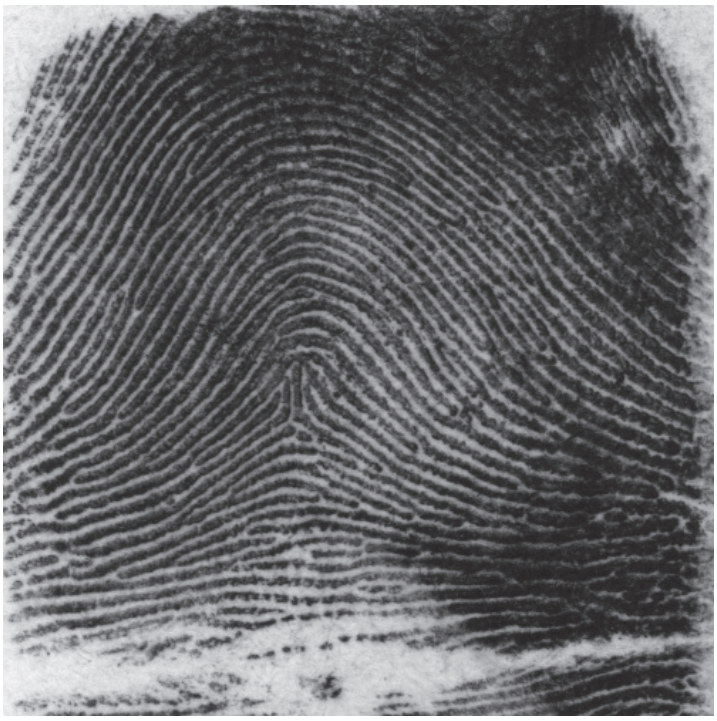
If one or more deltas are present and the feature set is from a fingerprint, the Pattern classification/PAT field should be filled in. This does not mean that the classification has to be known definitively, but it must at least exclude plain arches.

Exercise Instructions

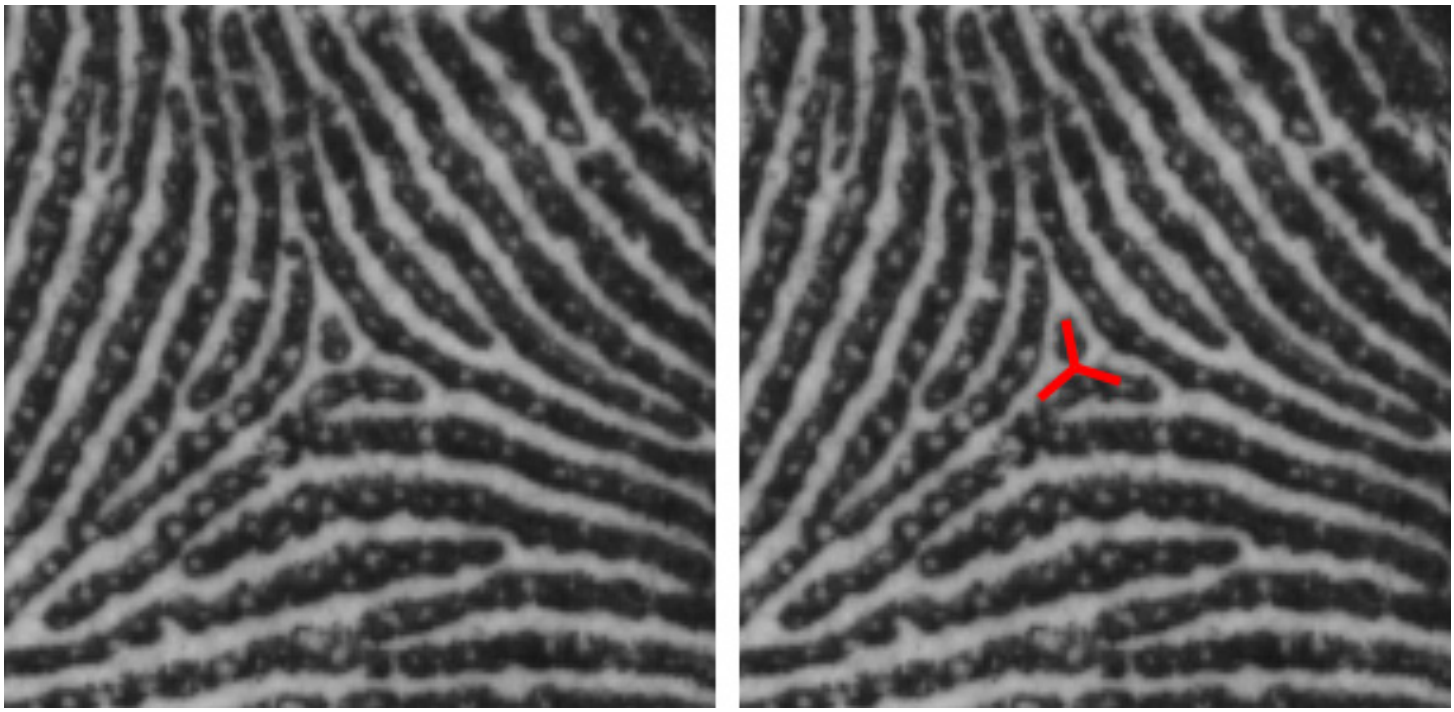
To mark a delta, first identify the location of the delta, where three directions of ridge flow converge. Click there and drag toward the most upward of the three directions. Click again to place the leftward direction of flow, then again for the rightward. Use the delete tool to remove any mistakes, then click Check My Answer.

Deltas Example Images

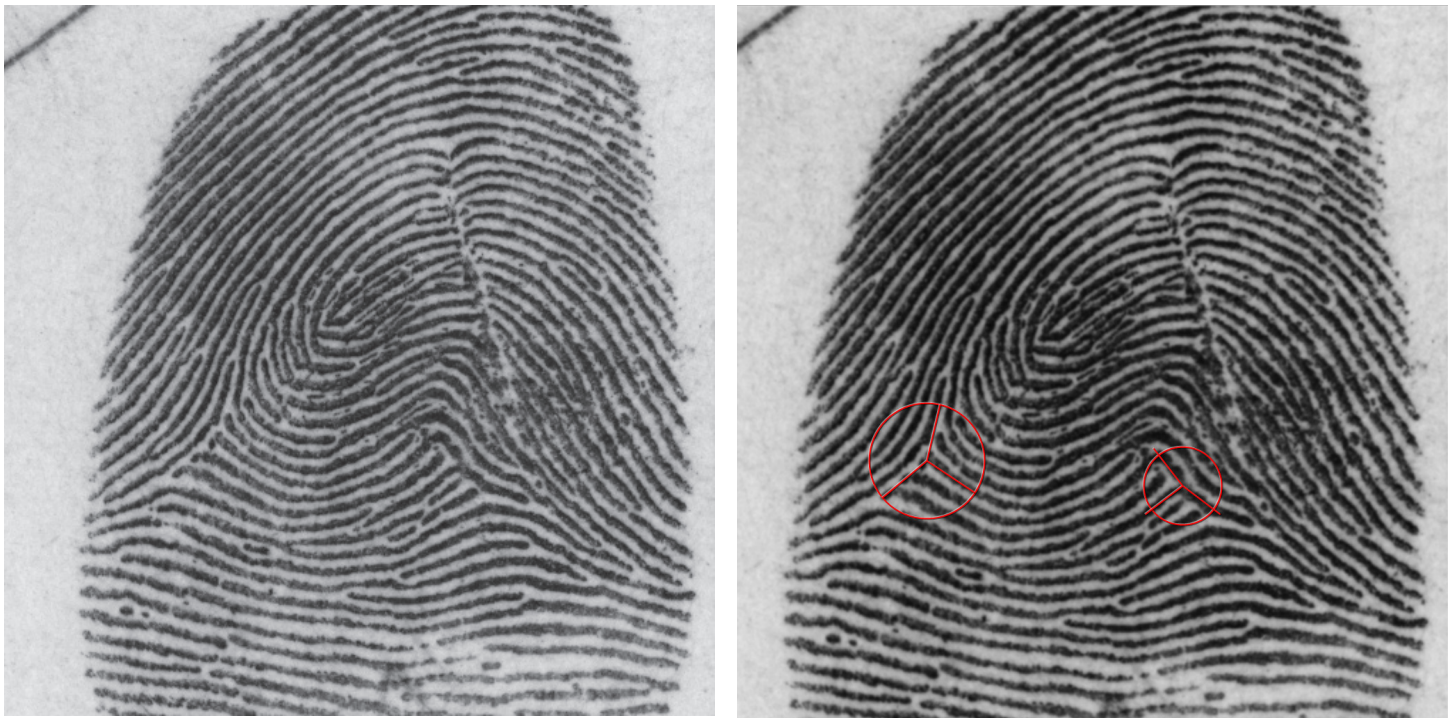
A delta's directions follow the patterns of local ridge flow



Unlike plain arches, tented arches sometimes have deltas



Close-up of a precise delta location and direction



Even with a clear impression, a radius of uncertainty around a delta's location may be necessary

Minutiae

Basics

Minutiae are major features of a friction ridge structure, and consist of ridge endings and bifurcations. Their location and direction marking is defined by EFS in a manner that is interoperable across different AFIS systems. Minutiae are a critical part of the Quick Minutiae Search and Detailed Markup profiles; accurate marking of all identifiable minutiae is a major factor in obtaining optimal search performance.

Mark all minutiae in an impression, including short ridges or minutiae near cores and deltas (this is a departure from traditional markup methods). If a receiving AFIS does not differentiate such minutiae, it will make the appropriate adjustments. Ridges less than twice as long as their width should be marked as dots rather than minutiae.

Corresponding ridge endings and bifurcations provide strong supporting evidence for a match between impressions. Because minutiae frequently appear to be ridge endings in one impression and bifurcation in another, even in clear images, it is not recommended that minutia type be used as a basis for exclusion.

Location and Direction

When identifying minutiae, the markup locations for bifurcations and ridge endings are equivalent: the location always goes in the center of a point where a ridge or valley splits to form a “Y” shape. The minutia direction, or theta angle, then points along the gap between the two ridge or vally branches of the “Y”. Thus, for a bifurcation, the minutia’s location is where the ridge starts to split into two, and the minutia’s direction moves along the valley between the two branching ridges.

If an image were tonally reversed (light and dark areas switched), every minutia would be marked in the same way.

The ridge ending location corresponds with that used for the FBI’s Integrated Automated Fingerprint Identification System (IAFIS) and Next Generation Identification (NGI), as well as the INCITS 378, (ANSI/INCITS 2004) definition, but differs from some legacy vendor-specific approaches.

The EFS data specification differentiates between ridge endings and bifurcations; however, some AFIS vendors make no such distinction.

Handling Uncertainty

If you identify the general location of a minutia but cannot distinguish which type it is, mark the feature type as “unknown”. In most unknown cases, the precise location will be unclear and a radius of uncertainty should be indicated. In these cases, the radius of uncertainty outlines an area that includes the location of the minutiae if it were a bifurcation, and the location of the minutiae if it were a ridge ending.

Special Cases

The angle of a minutia may be more difficult to determine when the direction of ridge flow is ambiguous, when the ridges are near the minutiae curve, or when the ridges come together at obtuse angles. In such cases, the angle of a bifurcation is determined by following each of the three ridges forming the bifurcation for a distance of about three ridge widths (1.93mm or 0.064”); the smallest of the three angles formed by the rays is bisected to indicate the minutiae direction. The angle of a ridge ending is determined equivalently, based on following the three valleys that form the ridge ending.

Mark all complex minutiae types as combinations of bifurcation/endings; for example, mark a crossover or trifurcation as two bifurcations located closely together. The figure to the right shows a trifurcation and a crossover, and their correct markup.

Minutiae should be marked even if there is some doubt about its presence; most vendor software will perform better if the feature is marked.

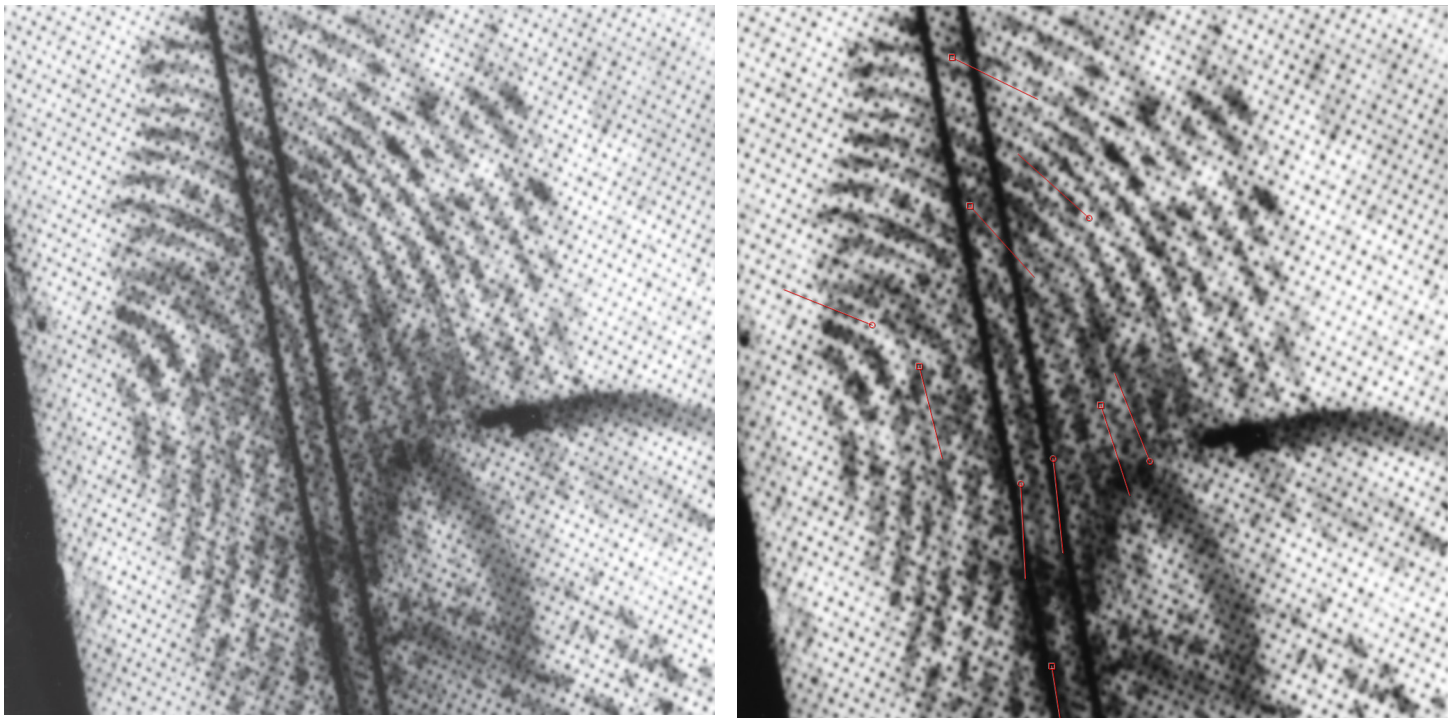
Exercise Instructions

Click on the center of the “Y” of a ridge ending or bifurcation, then drag to indicate the minutia’s direction. Repeat for every minutia you see in the image. To remove a particular minutia mark, select the Delete tool and then click on that mark.

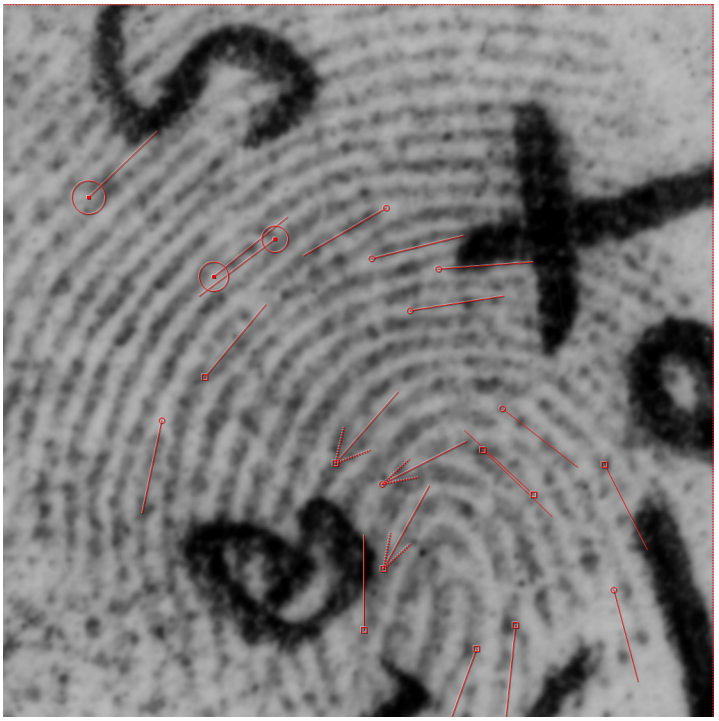
This tool does not allow you to mark radius of uncertainty for a minutia, but an EFS-compliant workstation will.

Click the arrows to the image’s left and right to navigate to different minutiae exercises, and click Check My Answer to get feedback on your responses.

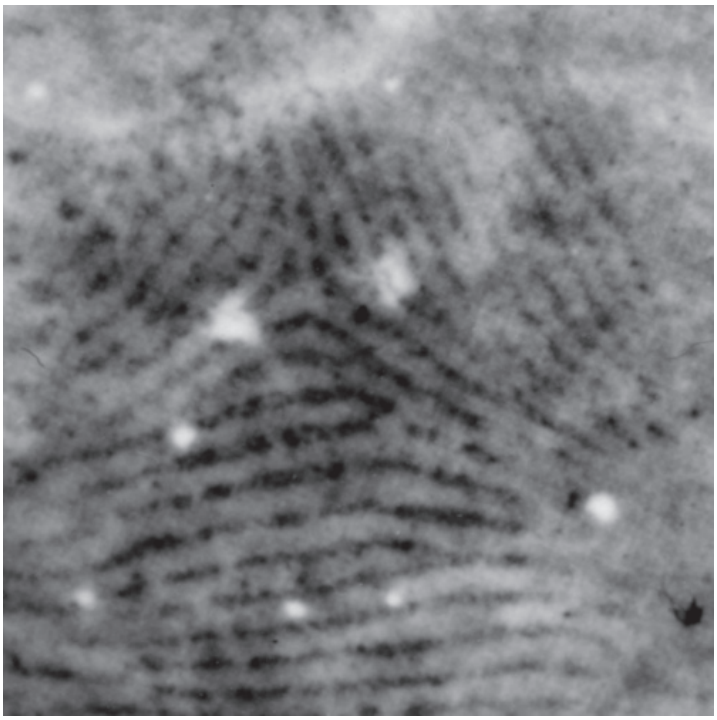
Minutiae Example Images

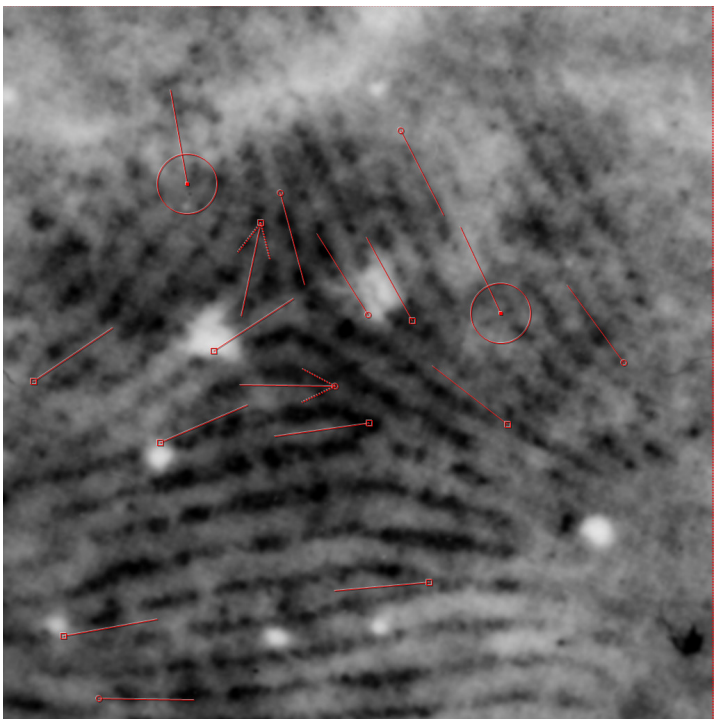


Disruptions in ridge flow are often artifacts of the image’s quality. When they are, they should not be marked as ridge endings

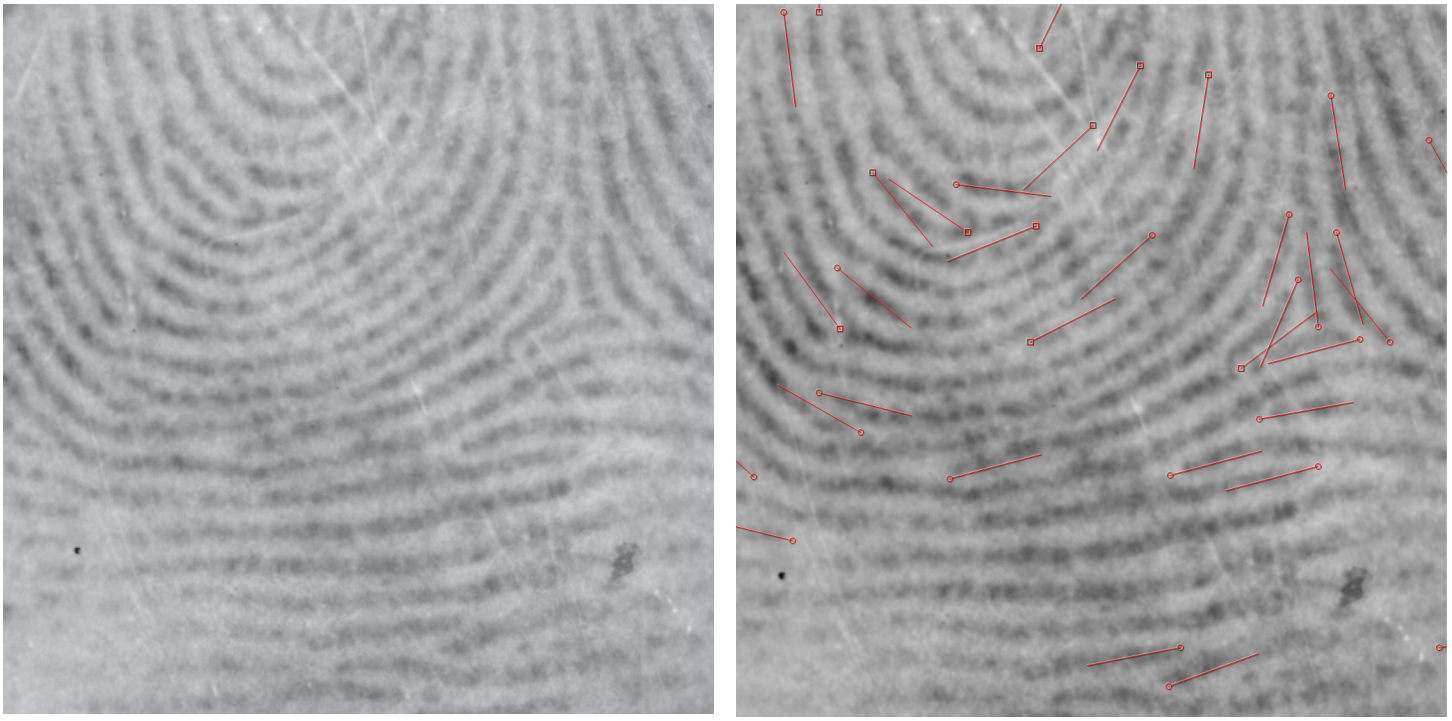


Note several minutiae of unknown type in the upper left area of the image. Because their location is less precise, a radius of uncertainty is used

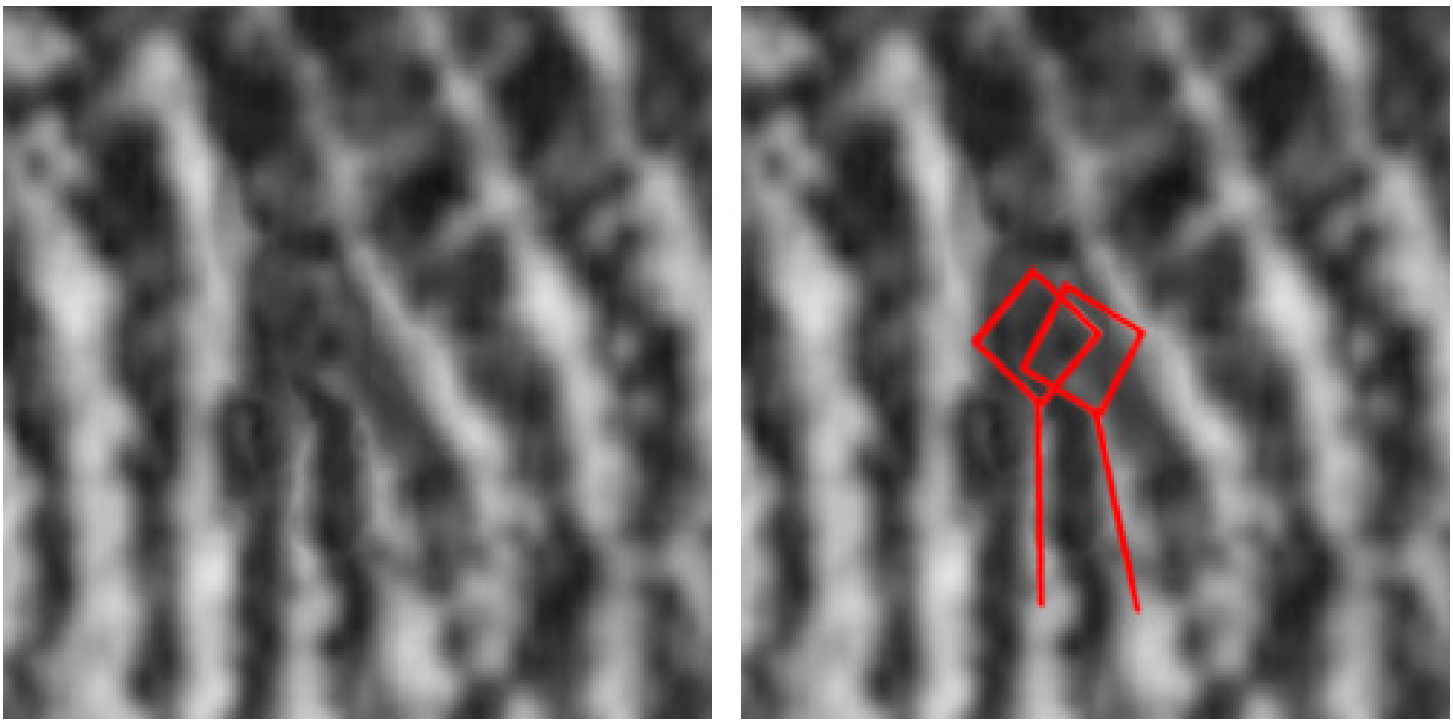




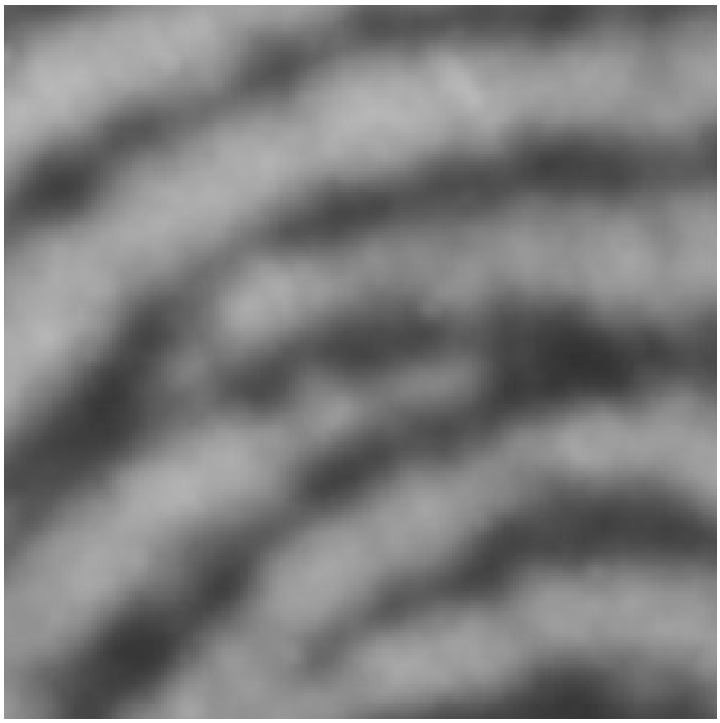
In an image with poorer clarity, some minutiae may require a radius of uncertainty

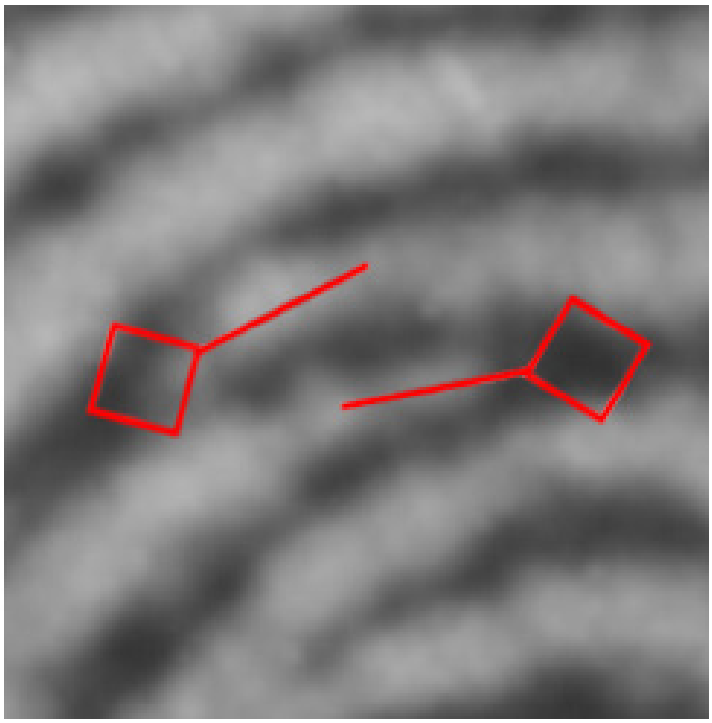


Only areas where ridge flow can be clearly discerned should have minutiae marked

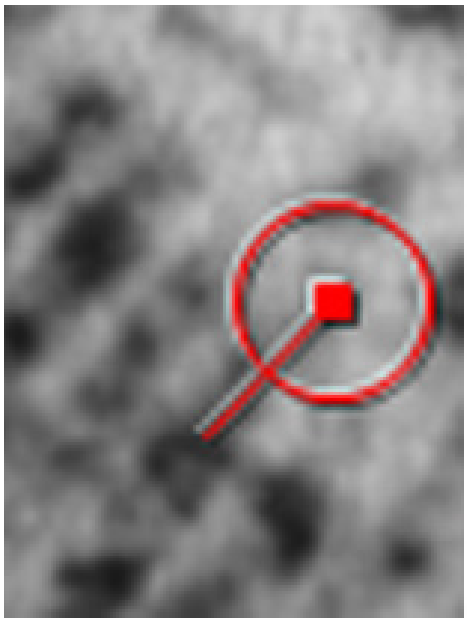


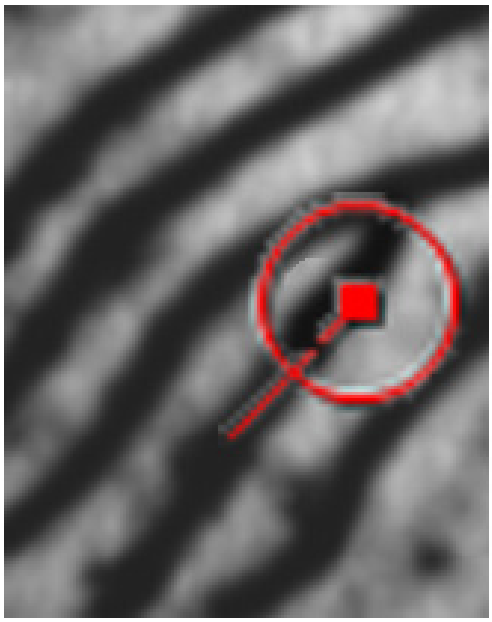
A trifurcation is marked as two bifurcations

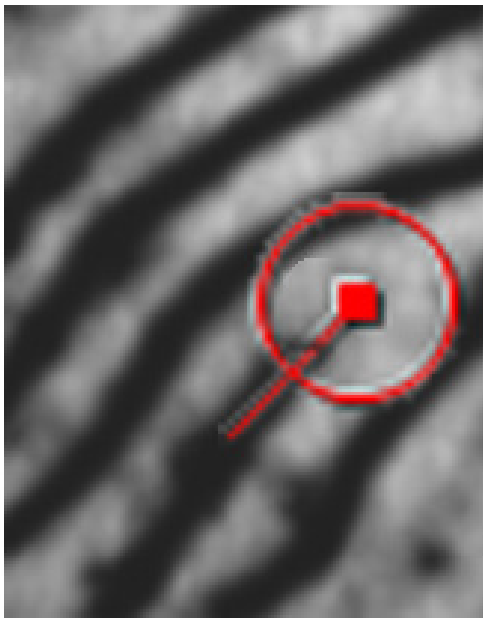




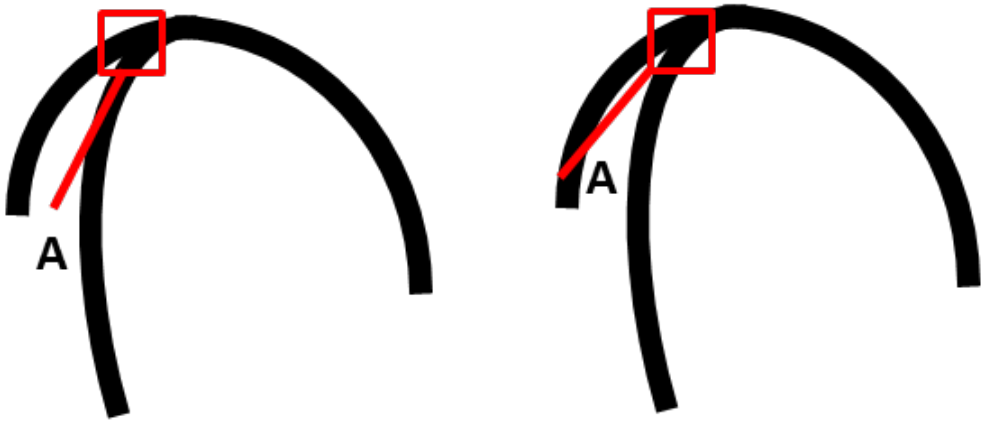
A crossover is marked as two bifurcations







Minutia placement when type is unknown. The minutia is placed as for a ridge ending, type is set to unknown, and the radius of uncertainty is defined to include possible points of intersection with neighboring ridges, as illustrated in the right two images



Correct Direction Placement **Wrong Direction Placement**

End of the minutiae's tail (point A) must bisect the valley if the minutiae is a bifurcation, or bisect the ridge if the minutiae is a ridge ending

Quck Minutiae Search Profile

Ridge Quality Map

Basics

Local friction ridge quality is an assessment of the clarity of each area within an image. This is the means by which the recipient can determine whether the features marked at a given location are definitive or debatable. The colors and categories are defined in the tables below. Because accurate and consistent markup of ridge quality is essential, follow the guidelines in this section as closely as possible. In each case, if there is doubt as to which level of ridge quality to assign, use the lower quality.

- Black - Background
- Red - Debatable ridge flow
- Yellow - Definitive ridge flow, debatable minutiae
- Green - Definitive minutiae, debatable ridge edges
- Blue - Definitive ridge edges, debatable pores
- Aqua - All features definitive

Ridge quality can be generated by an automated process with human review, or it can be painted manually by an examiner. While automated systems and all examiners should ideally concur on ridge quality markup, in practice individual examiners are likely to disagree at times.

To examine the decision process in detail, please see the flowchart in Figure 17 of the Markup Instructions for Extended Friction Ridge Features.

Figure 1 shows examples of ridge quality markup. The images of ridge quality markup allow an examiner (or software program) reviewing the image a straightforward means of assessing the value and data content of the image: large Blue areas are excellent, Green areas are satisfactory, Yellow areas may potentially contain false or missed features, and Red areas are not of value.

Details

The ridge quality map is used to define the confidence in all other friction ridge features. In addition, when the quality map indicates a high-quality region in which features are not marked (such as an open field of ridges), that information can be used as “negative features” or definitive absence of features, which may be used as support for exclusion.

	Incipients	Ridge Edge Features	Pores
Black	✗	✗	✗
Red	✗	✗	✗
Yellow	✗	✗	✗
Green	?	?	✗
Blue	✔	✔	?
Aqua	✔	✔	✔

Key:

✔ - Definitive and unambiguous - Presence, absence, and location are definitive. Contradictory presence or absence of definitive features in a comparison is caise for exclusion

? - Debatable or ambiguous - Features may be marked, but presence, ansence, and location are debatable. Corresponding/contradictory features on a comparison are supporting evidence for individualization.

✗ - Not discernible or unreliable - Features should not be marked and are ignored if present. No evidence for individualization or exclusion in a comparison exists.

Note particularly two critical distinctions:

- If the presence or absence of minutiae is definitive enough to be used for exclusion in future comparisons, mark the area Green or better; otherwise, mark the area Yellow.
- If the area was left as a single impression with continuity of ridge flow, mark the area Yellow or better; however, if a double tap, movement, or second impression resulted in discontinuous ridge flow, mark the separation between continuous areas with a region of Red.

Careful marking of ridge quality is most important for images with extensive discontinuities. In an image such as the one shown in Figure 9, limit the analysis of the image to the contiguous areas of Yellow or better. The small separations of Red are critical because they may mask overlap or transition between distinct impressions.

For further detail on each color’s criteria and how to handle other complex situations, refer to the Markup Instructions document.

Exercise Instructions

Select a paintbrush color, then click and drag on the canvas to paint an area that color. Adjust the paintbrush size by clicking the paintbrush icon and using the slider that appears. Click on the eraser to switch your cursor to an erase tool.

Ridge Quality Map Example Images

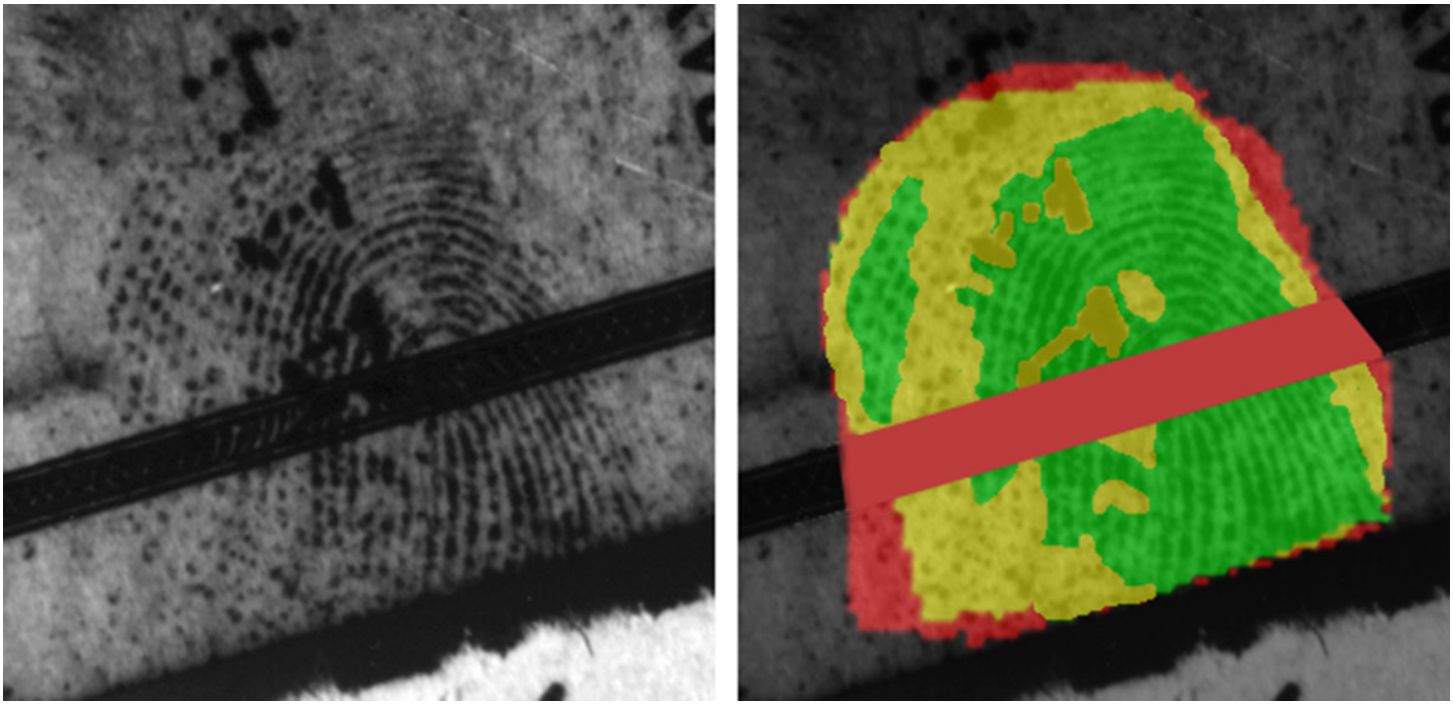


Figure 1: Ridge quality map on a latent print.

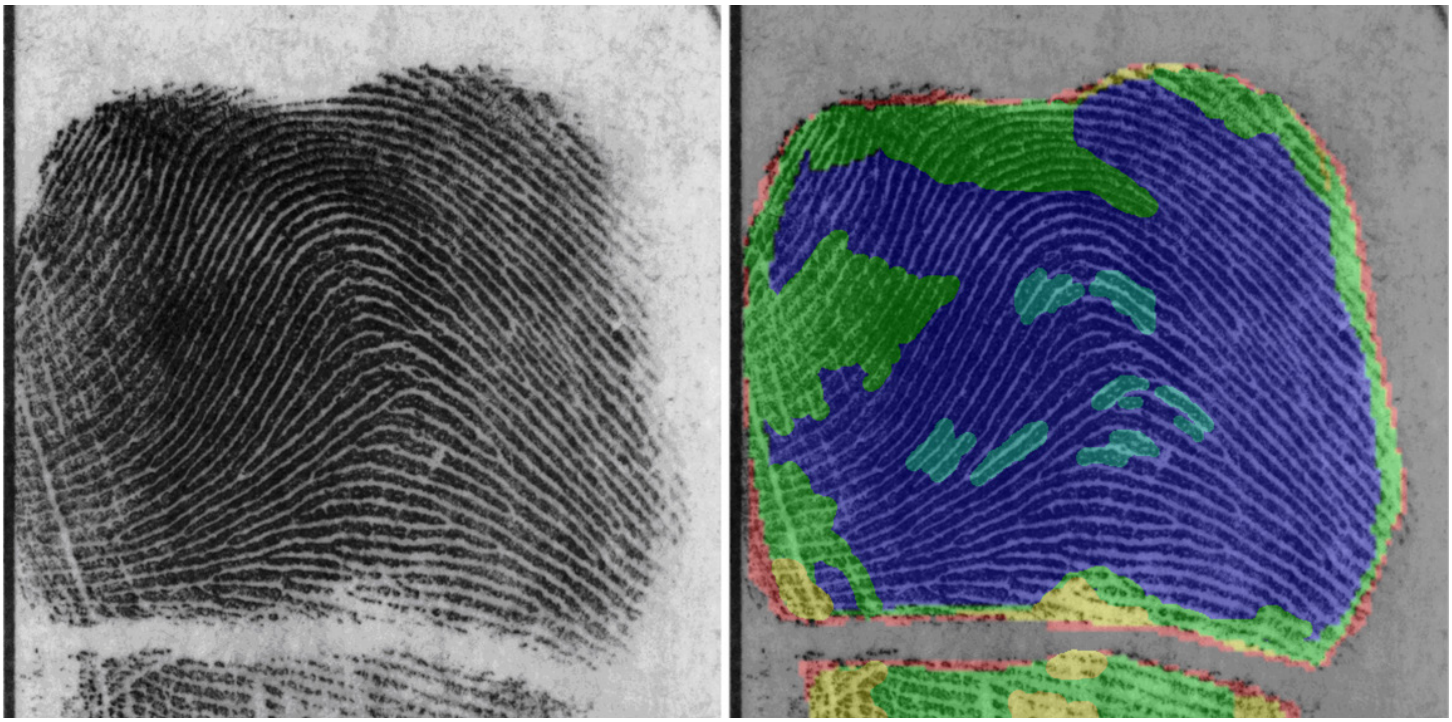


Figure 2: Ridge clarity at the aqua (definitive pores) level occurs more often in exemplars than latents.

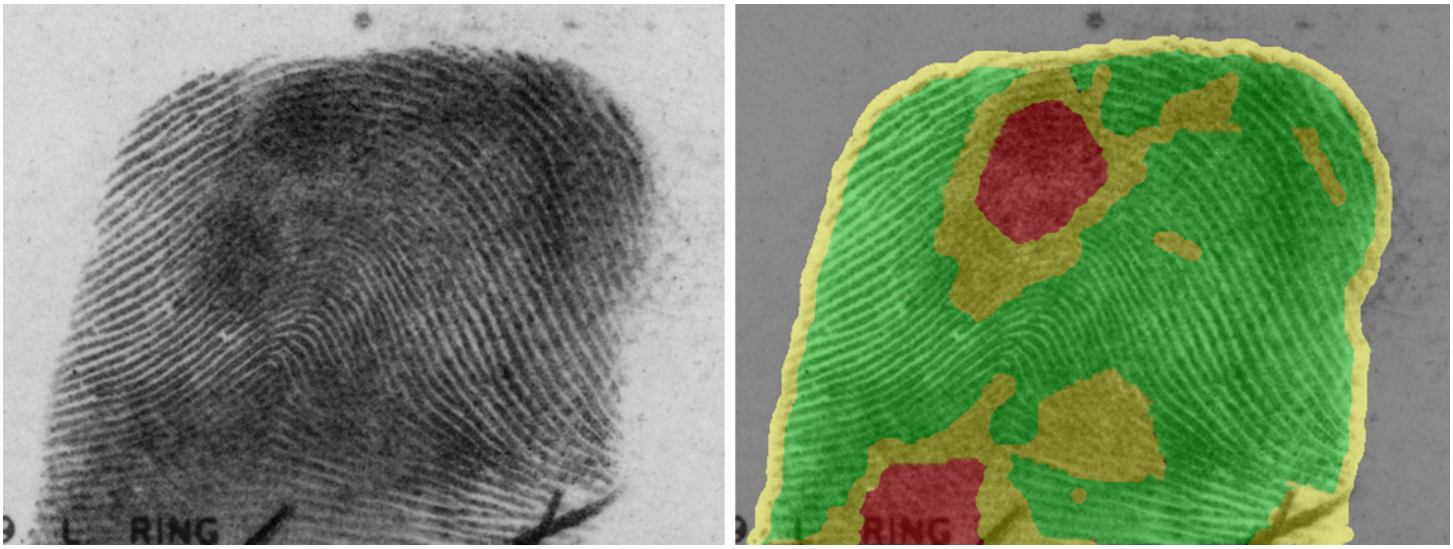


Figure 3: This exemplar has less clarity than the last.

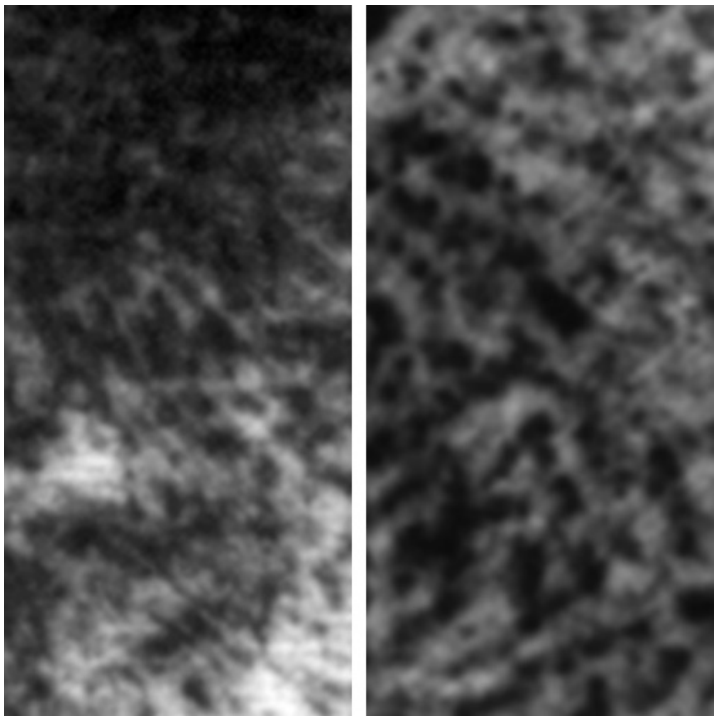


Figure 4: Examples of Red areas (Debatable ridge flow)

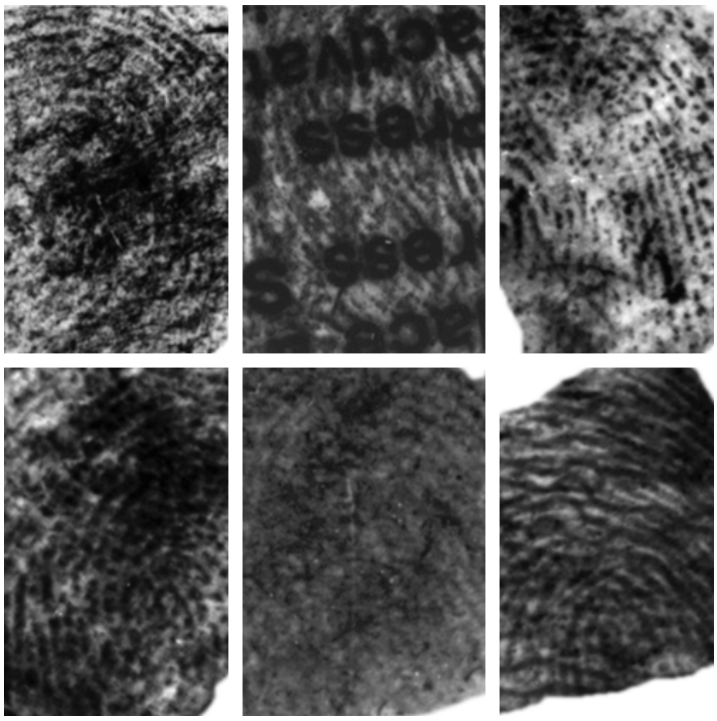


Figure 5: Examples of Yellow areas (Clear ridge flow but debatable minutiae)

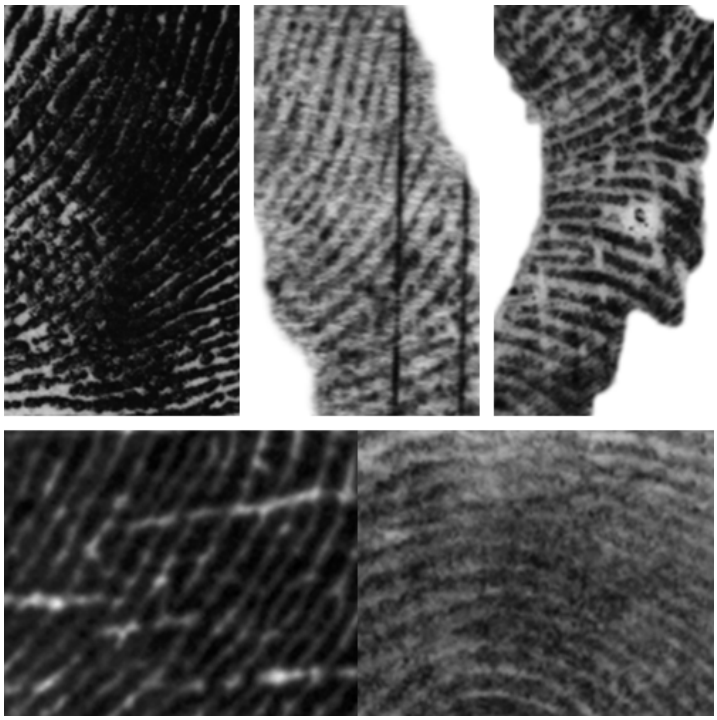


Figure 6: Examples of Green areas (Definitive minutiae)

Figure 7: Examples of Blue areas (Clear ridge edge, debatable pores). Portions of the leftmost image are Aqua quality.

Figure 8: Example print with Aqua quality (All features definitive)

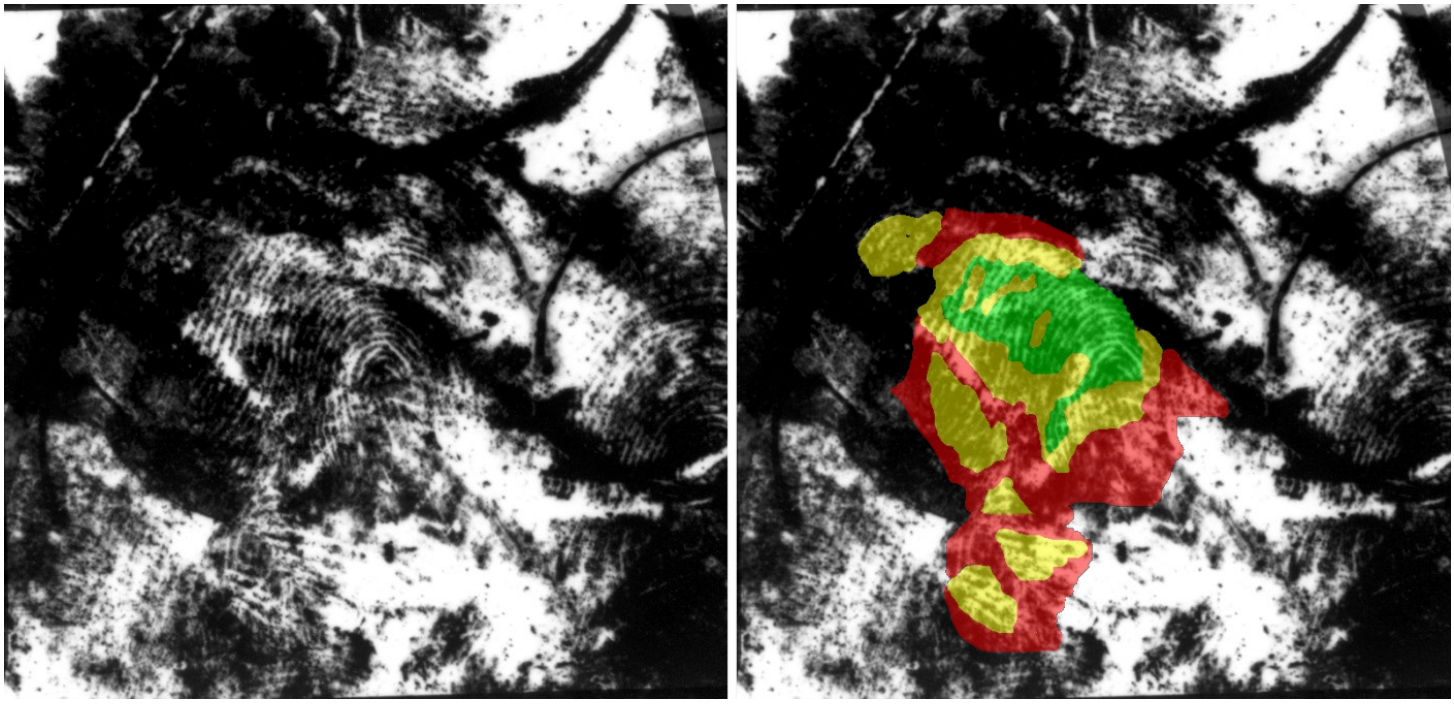


Figure 9: This image contains at least five impressions. All but the impression of interest should be considered background.

Dots and Incipients

Distinction

A **dot** is an isolated single ridge unit (ridge that contains a single pore). Generally, the width of a dot is similar to the width of neighboring ridges, and the length of a dot approximates its width. If a ridge is significantly longer than it is wide and contains multiple ridge units, it is a short ridge rather than a dot.

An **incipient ridge** is a thin ridge, substantially thinner than nearby ridges. Incipient ridges generally do not contain pores. Incipients frequently appear as a series of separate segments.

Often the distinction between a dot, an incipient ridge, and a short ridge is unclear.

If the feature is similar in width to the local ridge width and at least twice as long as it is wide, consider it a standard ridge and mark both ridge endings. If pores are visible, a standard ridge should have at least two pores.

If the feature is similar in width to the local ridge width, but about as long as it is wide, mark it as a dot.

If the feature is substantially thinner than local ridge width, mark it as an incipient ridge.
Dots and incipients are marked for case work and if EFS Profile 3: Detailed Markup Profile is to be used.

Markup

An incipient ridge is marked with a line segment along its longest dimension. If an incipient ridge is composed of a series of segments, do the following:

- Mark the series as a single line if the segments of the incipient are close together or the separations between segments are indistinct.

- Mark the series as separate incipient ridges if the segments are clearly separate (with distinct lines drawn for each).
- If an unbroken incipient ridge curves, mark it as a series of adjoining line segments. In many cases, distinguishing among dots, incipients, and ridge edge protrusions (spurs) is a judgment call.

Exercise Instructions

Select Dot or Incipient to change your cursor to that tool. For a dot, click and release on the center of the feature. For an incipient ridge, click down at one end of the ridge, then drag to the other end and release. To erase a mark, click on the Erase tool, then on that spot on the canvas.

Dots and Incipients Example Images

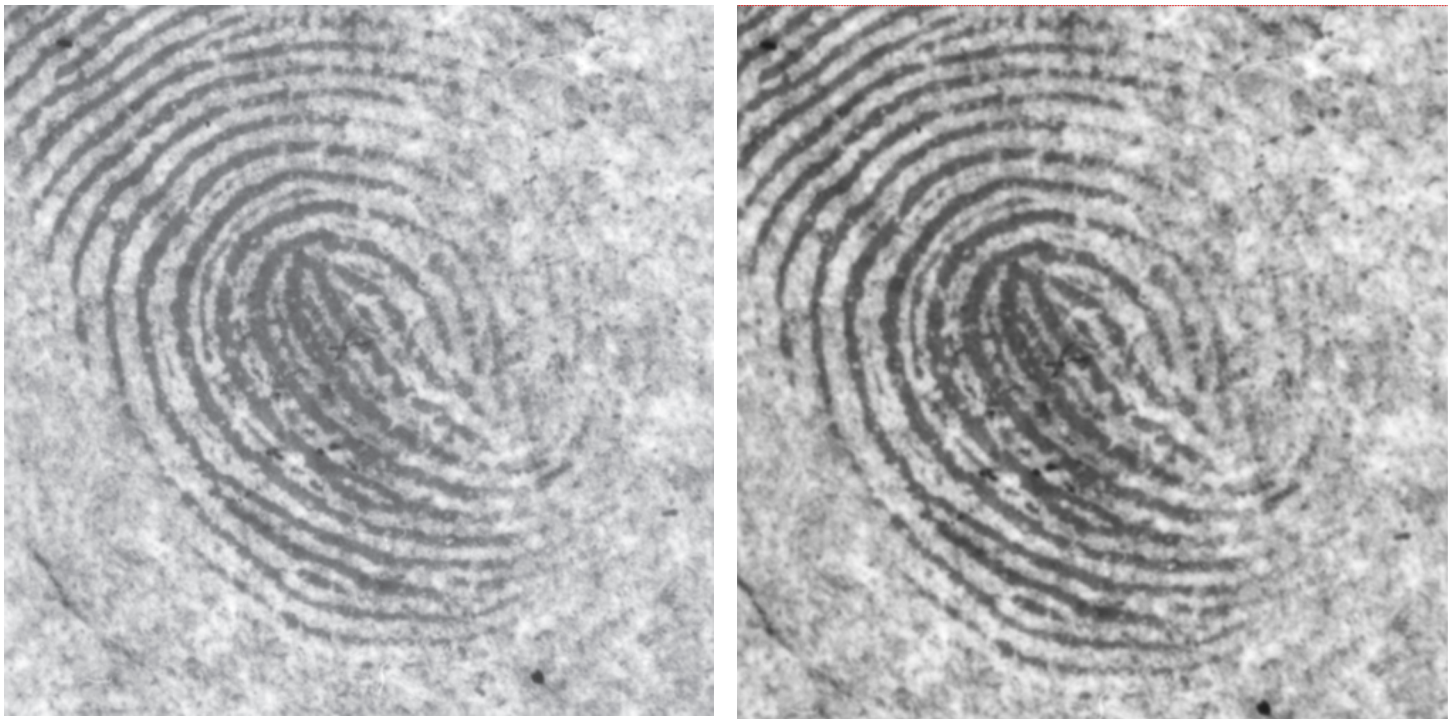


Figure 1: Distinguishing between dots and incipients can be difficult. The three “dots” in the middle of the print are very debatable and could be considered incipients.

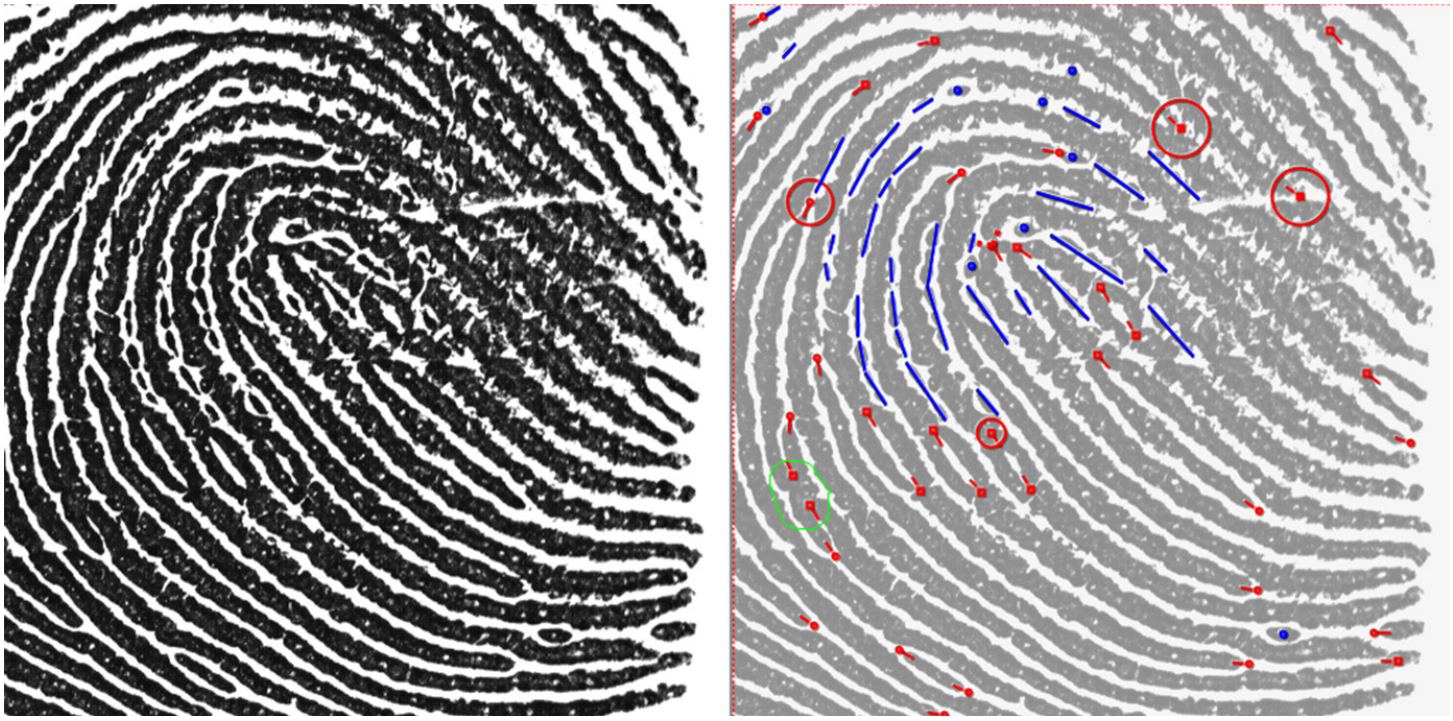


Figure 2: Dots (blue circles) and incipients (blue lines) marked along with minutiae (in red). In many cases, the distinction between dots, incipients, and ridge edge protrusions is a judgment call.

Distinctive Features

Basics

Some friction ridge patterns have distinctive features which can be especially valuable in identifications. Scars, dysplasia/dissociated ridges, warts, blisters, or other abnormalities that interfere with normal ridge flow should be marked as distinctive features. These features are physical aspects of the friction skin itself, not issues specific to the impression (such as smudging). Minor cuts (white lines) that do not affect ridge flow are not considered scars.

Enclose the relevant area with a polygon, with the appropriate code from the table. Physical abnormalities must be marked when performing a search under the Detailed Markup Search Profile.

Advanced

Other unusual features such as feature clusters or a large area with no minutia, may be marked as Distinctive Features for casework annotation; marking of these unusual features is optional.

	Code	Description
Physical abnormalities	SCAR	Scar
	WART	Wart or Blister
	DYSPLASIA	Disassociated ridges/dysplasia
	MINGROUP	Unusual group or cluster of minutiae
Unusual features	CORE	Unusually distinctive core area
	DELTA	Unusually distinctive delta area
	MINUTIAE	Unusually shaped minutiae
	CREASE	Unusually distinctive crease
	CLEAR	Large clear field of ridges; large clear area with no minutiae
	OTHERFEAT	Other unusual features not characterized elsewhere; details should be noted in comments

Exercise Instructions

First, use the dropdown to select the type of feature to be outlined. Then click and drag around that feature to create an outline. Use the trash can tool to erase a marking.

Distinctive Features Example Images

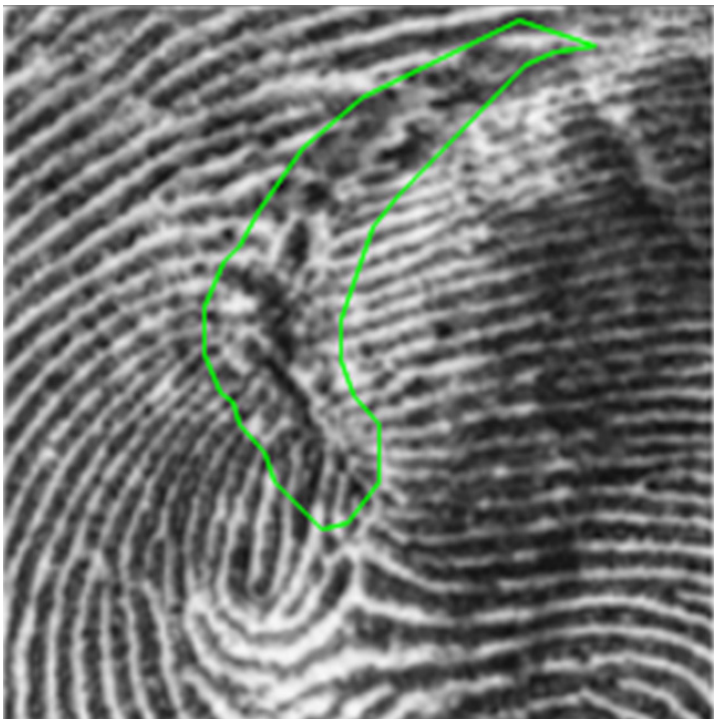


Figure 1: An outlined scar.

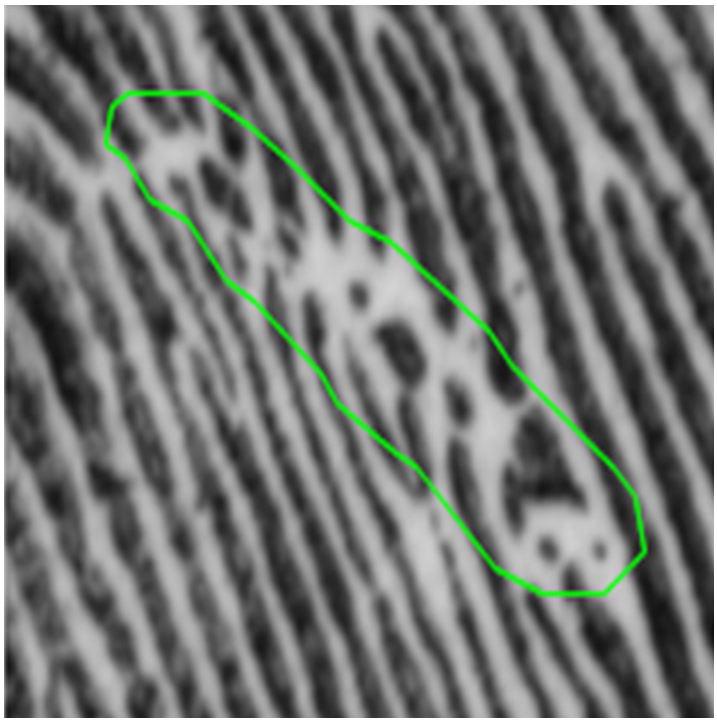


Figure 2: An outlined scar.

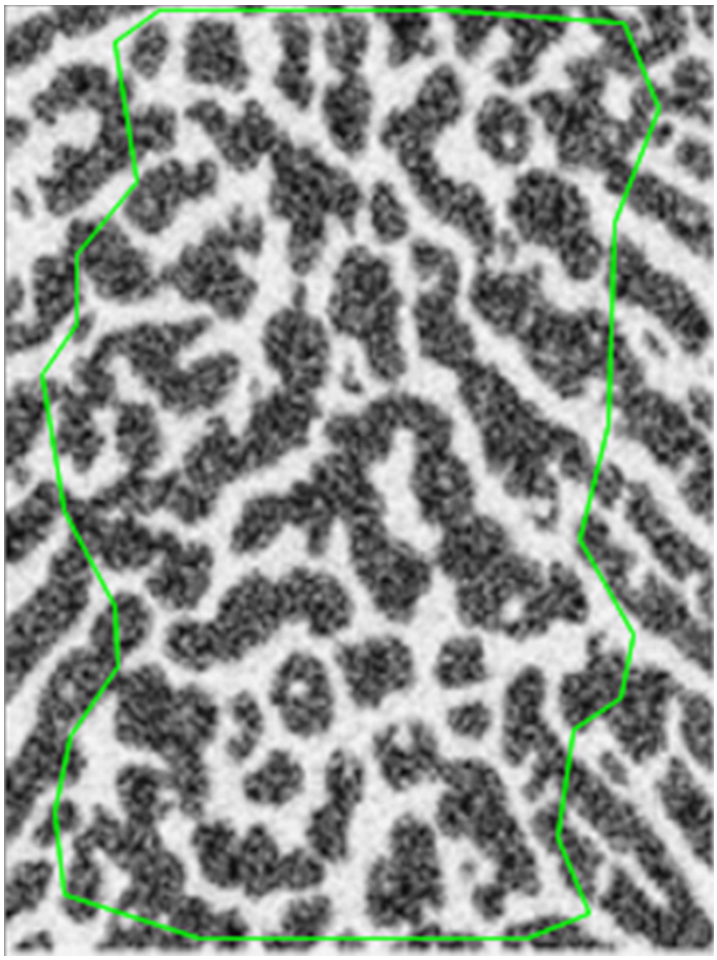


Figure 8: Example print with Aqua quality (All features definitive)

Ridge Flow Map

Ridge flow refers to the directional arrangement of friction ridges and is most often used for pattern-level screening of fingerprints. Ridge flow provides more specific detail than pattern classification and can be used more effectively on partial fingerprints. It can be used by AFIS algorithms as an end matcher to refine the list of candidates produced by the feature matchers.

Ridge flow map markup, as shown in Figure 1, is typically started using automated tools to extract the flow directions from the image. This automated markup is then modified by the examiner (if necessary) to correct inaccuracies in the automated flow map. A latent corresponding to the right half of this print would appear to be a left slant loop rather than a double loop whorl; unlike traditional pattern classification, ridge flow maps permit rapid automatic comparison of such partial prints.

Ridge flow is marked if EFS Profile 3: Detailed Markup Search Profile is to be used. No exercises are provided for Ridge Flow Map markup.

Ridge Flow Map Example Images

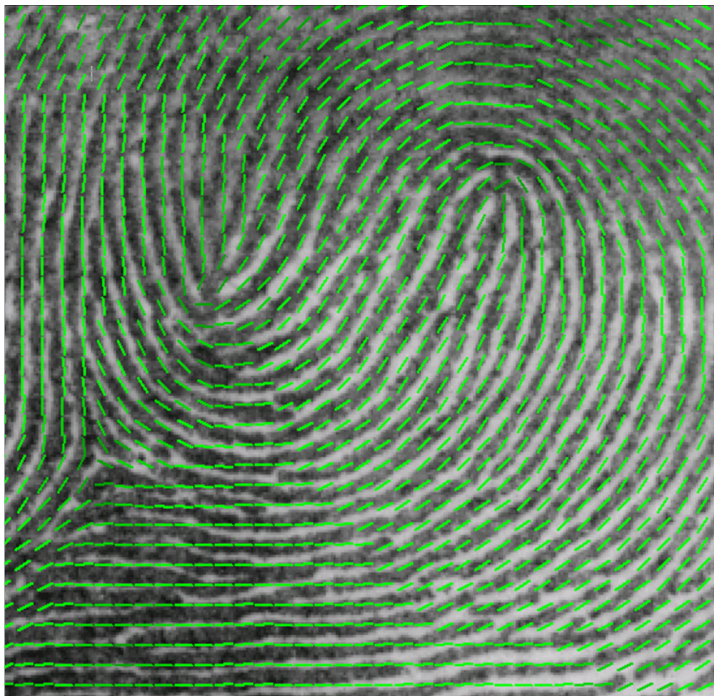


Figure 1: Ridge flow map. A latent corresponding to the right half of this print would deceptively appear to be a left slant loop. Ridge flow maps permit rapid automatic comparison of such partial prints, unlike traditional pattern classification.

Center Point of Reference

Basics

This location of a center point of reference of a fingerprint is used to indicate how centered a fingerprint is for registration or orientation by the AFIS algorithms, as a feature in annotation, and for quality measurements. Although the core may serve some of the same purposes, a center point of reference is defined for arches and also provides a single center location for complex whorls. The center point of reference does not apply to palmprints or plantar impressions.

The center point of reference is the sole EFS feature that can be located outside of the Region of Interest; as such, it allows the estimated center of the finger to be marked even for an extreme side or tip. The center point of reference must be within the bounds of the overall image itself.

The location of a center point of reference can be determined using different approaches. When practical, use the uppermost point of the ridge with greatest curvature approach. Otherwise, use an estimate of the approximate center of the distal fingerprint pad, with a radius of uncertainty. For extreme tips, lower joints, or any cases where the center of the distal fingerprint pad cannot be estimated, indicate the lateral centerline of the finger.

The center point of reference is marked if EFS Profile 3: Detailed Markup Profile is to be used.

Approaches

Uppermost point of the ridge with greatest curvature

For a fingerprint with a known or estimated orientation, determine the center point using the following process.

1) Find the highest point of each ridge that is convex and pointing upward.
2) From that point, trace the ridge about 3 ridge widths in both directions. Create a line from the high point to the end of each trace, then measure the angle between the two lines to find the peak angle.
3) Compare the curvatures of the ridges. The point with the minimum angle (greatest curvature) is the center point of reference. (See 1.)

Estimate of approximate center of the distal fingerprint pad

When the ridge structure is not clear, estimate the center of the distal pad of the finger. Measure halfway vertically between the crease and the tip, and halfway horizontally across the finger. (See figure 2 for examples.) This is the center of the physical finger, not the center of the print as seen in the image.

Lateral centerline of the finger

For arches, tips, and lower joints, if the vertical center can not be determined but the approximate horizontal centerline of the finger can, mark the lateral centerline. The lateral center is only meaningful if the orientation is known or can be estimated (See 3.)

Exercise Instructions

Determine whether you want to mark a center point of reference or a lateral centerline, then select that tool. For the center point of reference, click on the center point, then click again to set a radius of uncertainty. For a lateral centerline, the mouse's vertical position doesn't matter. Click anywhere along that vertical line to set the lateral centerline.

Setting another center point of reference or lateral centerline will erase any existing markings. You can also use the trash can tool to erase your marking.

Center Point of Reference Example Images

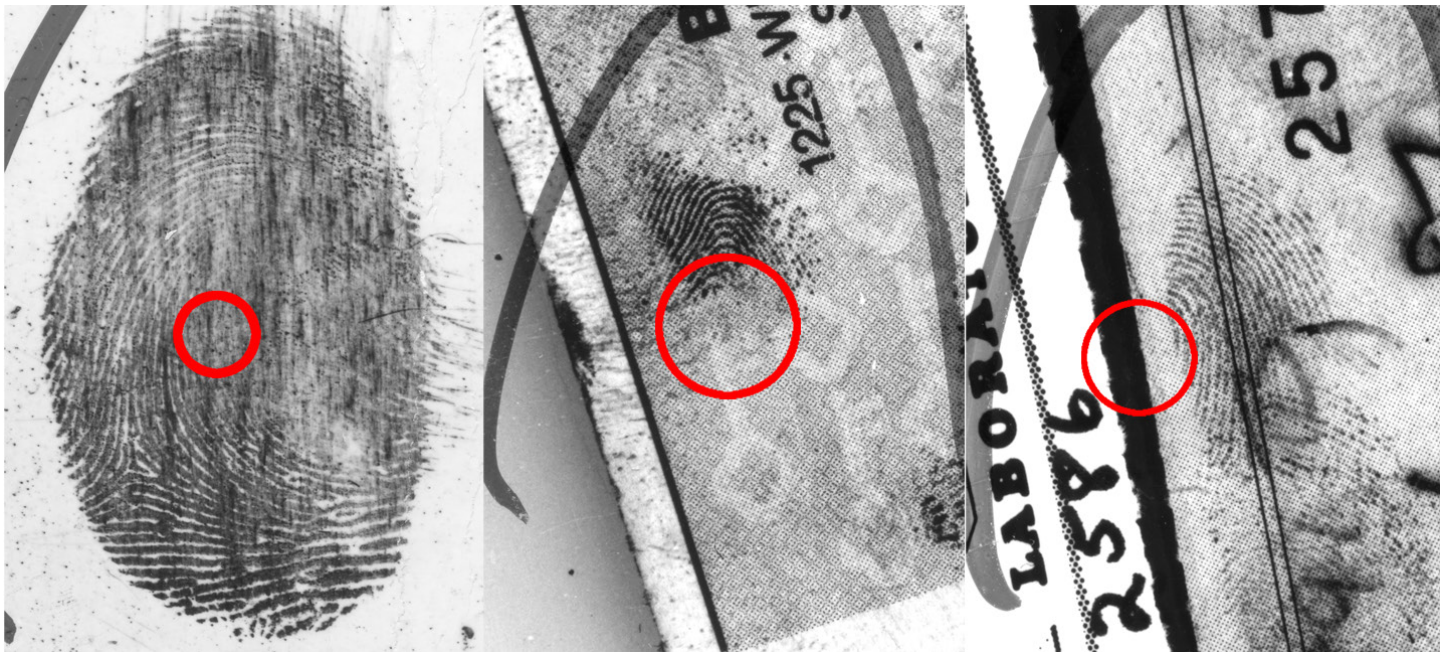


Figure 1 of 1: Examples of center point of reference based on an estimate of the approximate center of the finger.

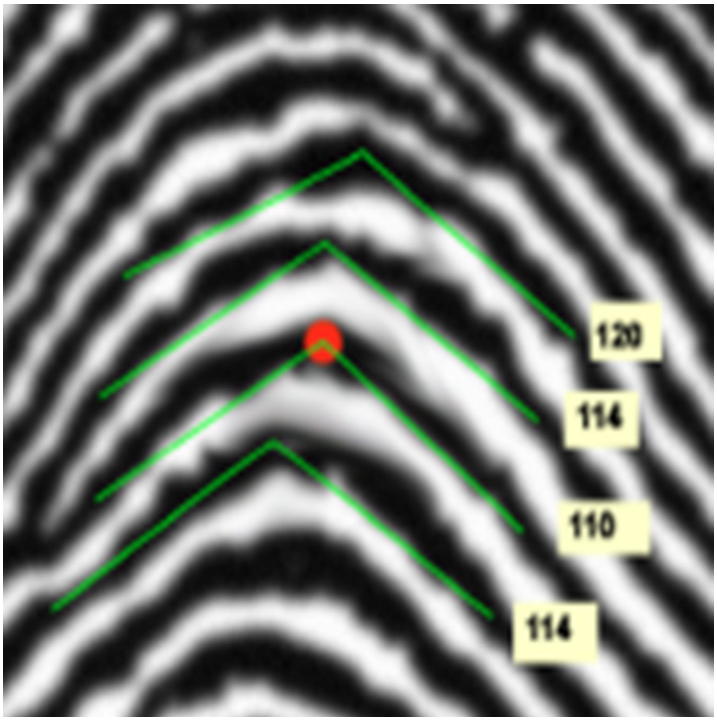


Figure 2: Uppermost point of the ridge with greatest curvature. Measurements are angles, in degrees.

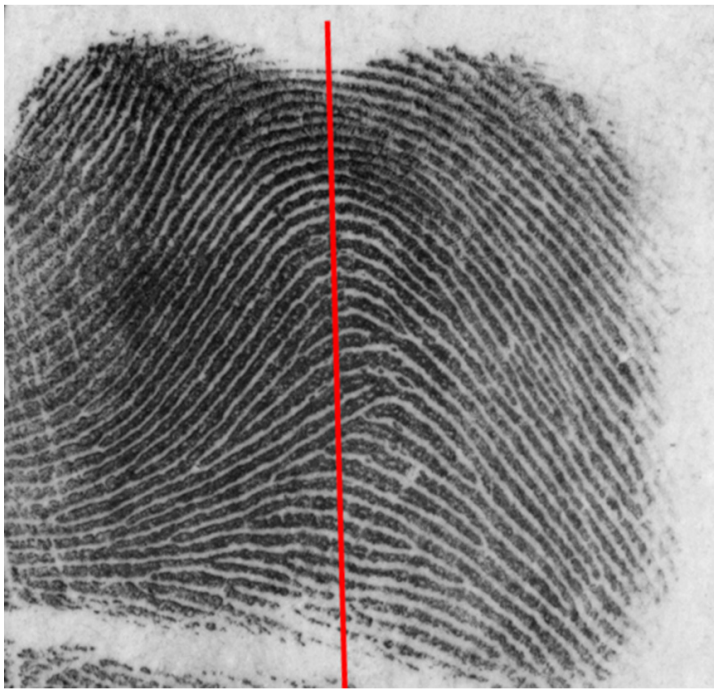


Figure 3: Lateral centerline of an arch

Core-Delta Ridge Counts

Basics

Ridge count is the number of intervening ridges between a core and a delta on the impression of a loop or a whorl. If the exact count cannot be determined, minimum and maximum values can be specified; if it can, the count should be put in both the minimum and maximum fields. (See figure 1.)

The count begins at zero at the core and increases by one for each ridge crossed along a straight connecting line to the delta, not including ridges that form part of the core and the delta. If there are two cores or deltas, provide ridge counts between all cores and deltas, unless there are more than two cores or two deltas. In that case, only the leftmost and rightmost cores and deltas need to be used for ridge counts.

For whorls only, the following marking conventions shall be used:

- Because of the curving of ridges, the straight line between a core and a delta might cross a ridge twice (or more).
- Do not count the additional crossing unless the straight line first passes through at least the center of an adjacent valley.
- Do not count a ridge unless the straight line passes at least to the center of the ridge.

Core-delta ridge count is marked if EFS Profile 3: Detailed Markup Search Profile is to be used.

Exercise Instructions

Count or estimate the number of ridges between the core and the delta. If you can determine the exact number, enter that number as the minimum and the maximum. If not, enter the range of possibilities.

Core-Delta Ridge Count Example Images

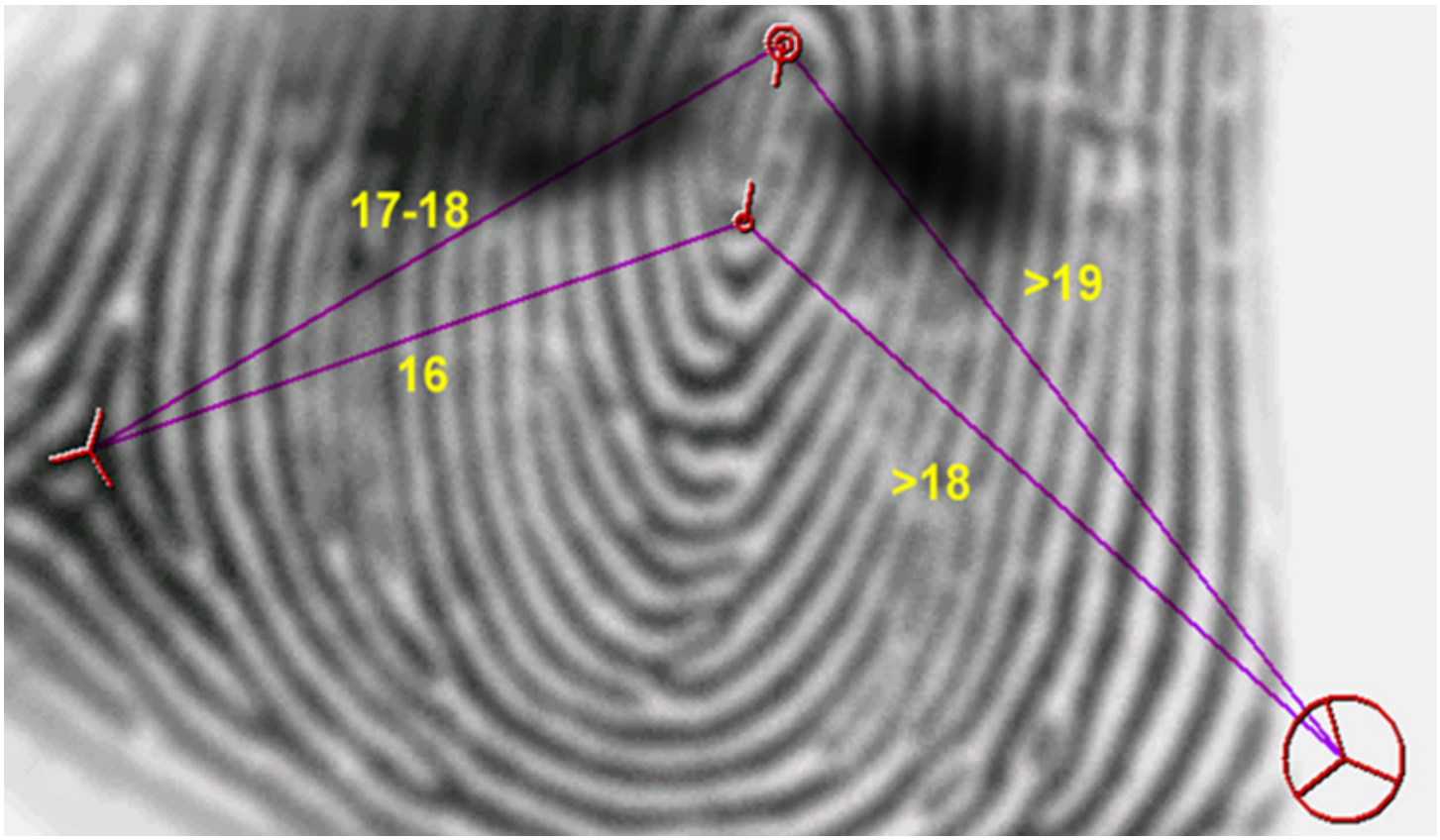


Figure 1 of 1: Core/delta ridge count example (note approximate location of right delta).

Special Cases

Lateral Reversal

This section of the Training Tool is a tutorial on common friction ridge issues that require examiner action. There are no exercises provided. During examination, you would normally indicate the existence of a special case in its specific field and then proceed to process the print using Quick Minutiae or Detailed Search markup profiles.

If the impression is or may be laterally reversed (i.e., flipped left for right, such as in some prints on transparent tape), note the possible lateral reversal when the image is marked up. The workstation software will create two search transactions reflecting the mirrored image and/or feature data.

Because both possible images are sent as search transactions, the lateral reversal field is not included in the actual search transactions sent to an AFIS.

Lateral Reversal Example Images

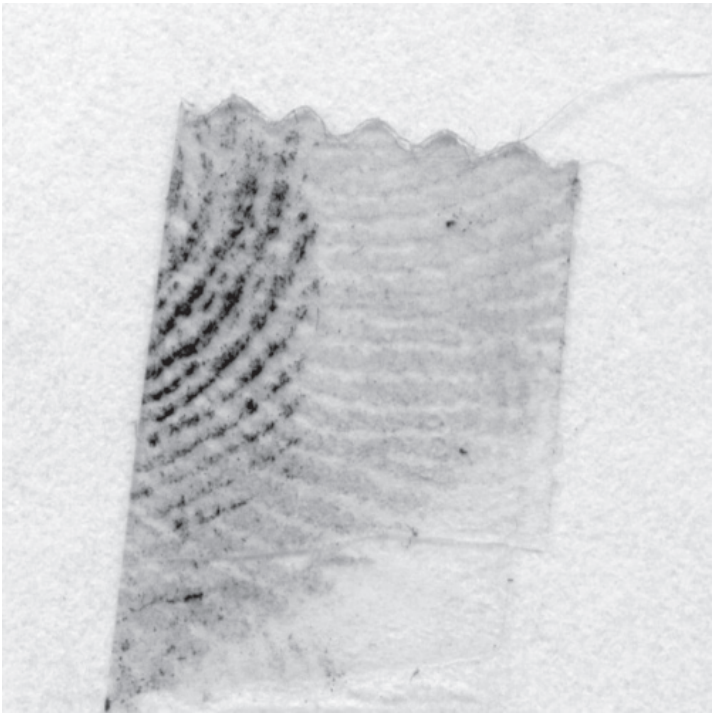


Figure 1: In some cases it is difficult to know if the image is flipped laterally, such as for tape folded on itself.

Tonal Reversal

Ridges in friction ridge images are generally represented as dark areas, with valleys as light areas. The entire image may be reversed tonally (black-for-white) or it may be that only a part of the image is reversed tonally. Indicate this using ‘full’ or ‘partial’ reversal. If definable portions of the image are negative, the examiner may use the local quality issues / LQI field to define the specific tonally reversed areas. Note that in some cases, the tonal reversal is so mixed that only portions of individual ridges are reversed, making it impractical or impossible to define the tonally reversed areas.

When this field is set, the image in the transaction record shall be left as it was originally received (i.e., tonally reversed). A software interface may display the tonally corrected image, but save the image as originally received.

Tonal Reversal Example Images

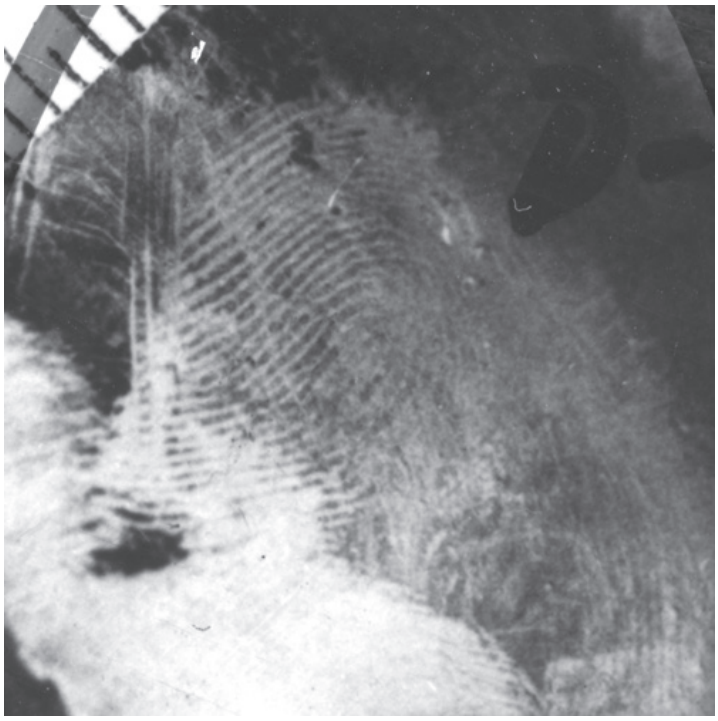


Figure 2: A friction ridge impression that may be tonally reversed.

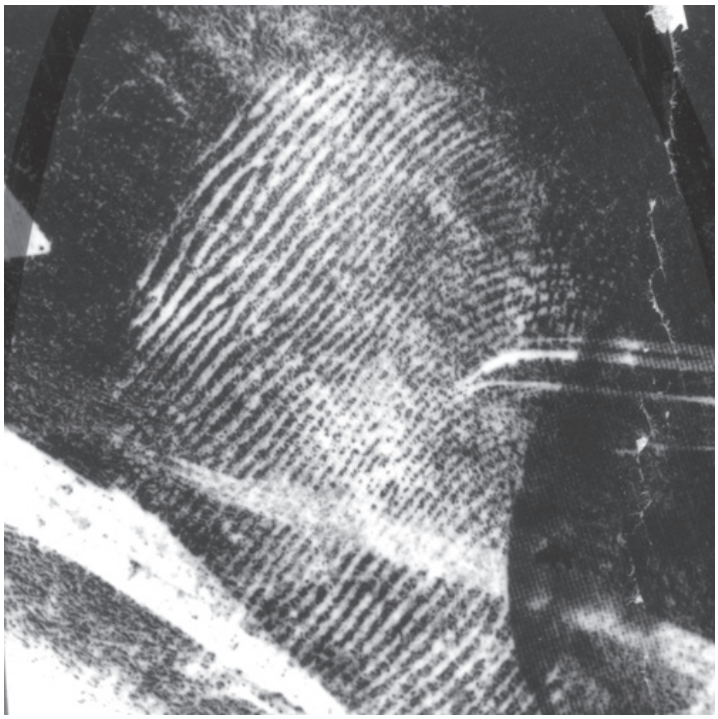


Figure 3: A friction ridge impression that may be tonally reversed.

Fraud

Always indicate when there is evidence that the image may be fraudulent, regardless of the EFS profile used. A comment must be included to explain what indications of fraud are present.

There are four types of fraud: evasion, spoofing, forged evidence, and fabricated evidence:

- Evasion includes actions that prevent/lessen the likelihood of matching, such as by degrading or obscuring physical characteristics or mutilating fingers. Examples are acid balding of fingers or use of a knife or laser to alter the fingerprints.
- Spoofing includes purposefully attempting to be identified as a different person in a biometric system by modifying biological characteristics or using fabricated characteristics. Examples are using a rubber finger, gelatin fingerprint attached to a real finger, or an image of a fingerprint to fool a biometric reader.
- Forged evidence is forensic evidence that was fraudulently placed on the surface from which it was collected, using another mechanism or device than the natural contact with friction ridge skin. An example is using a rubber lifter to move a fingerprint from its actual source to another source.
- Fabricated evidence is forensic evidence that never existed on the surface from which it was supposedly collected. An example is a crime scene examiner deceitfully mislabeling the source of images or lift cards.

Fraud Example Images

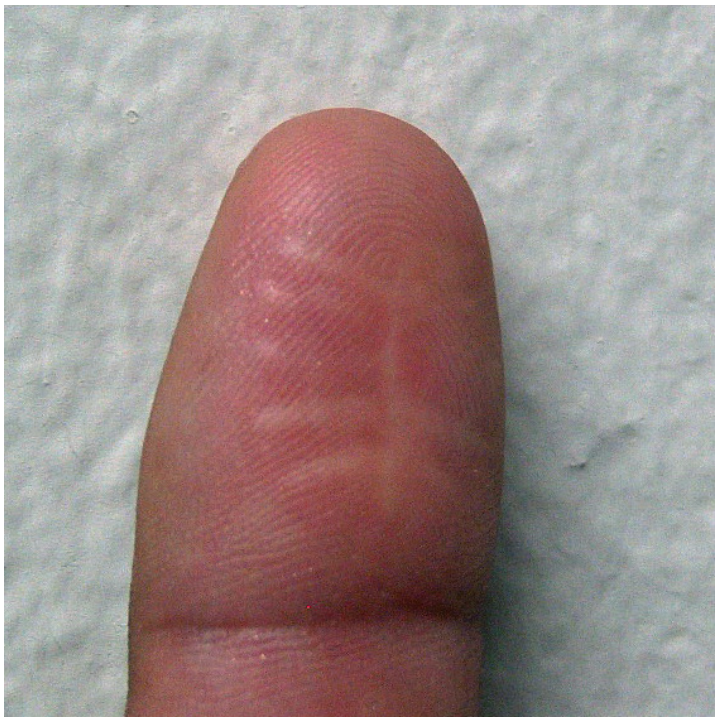


Figure 4: This laser-altered fingerprint is an example of evasion.

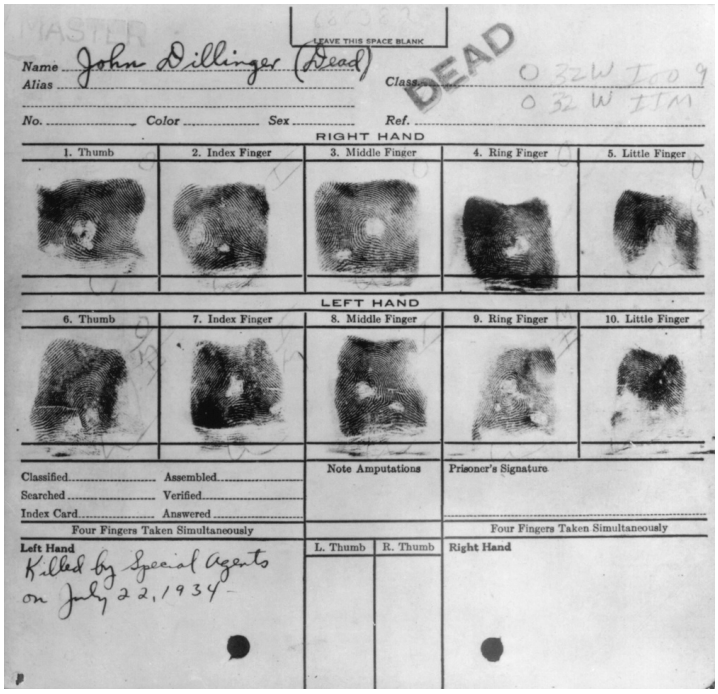


Figure 5: Another instance of evasion. Acid was used to remove fingerprint cores.

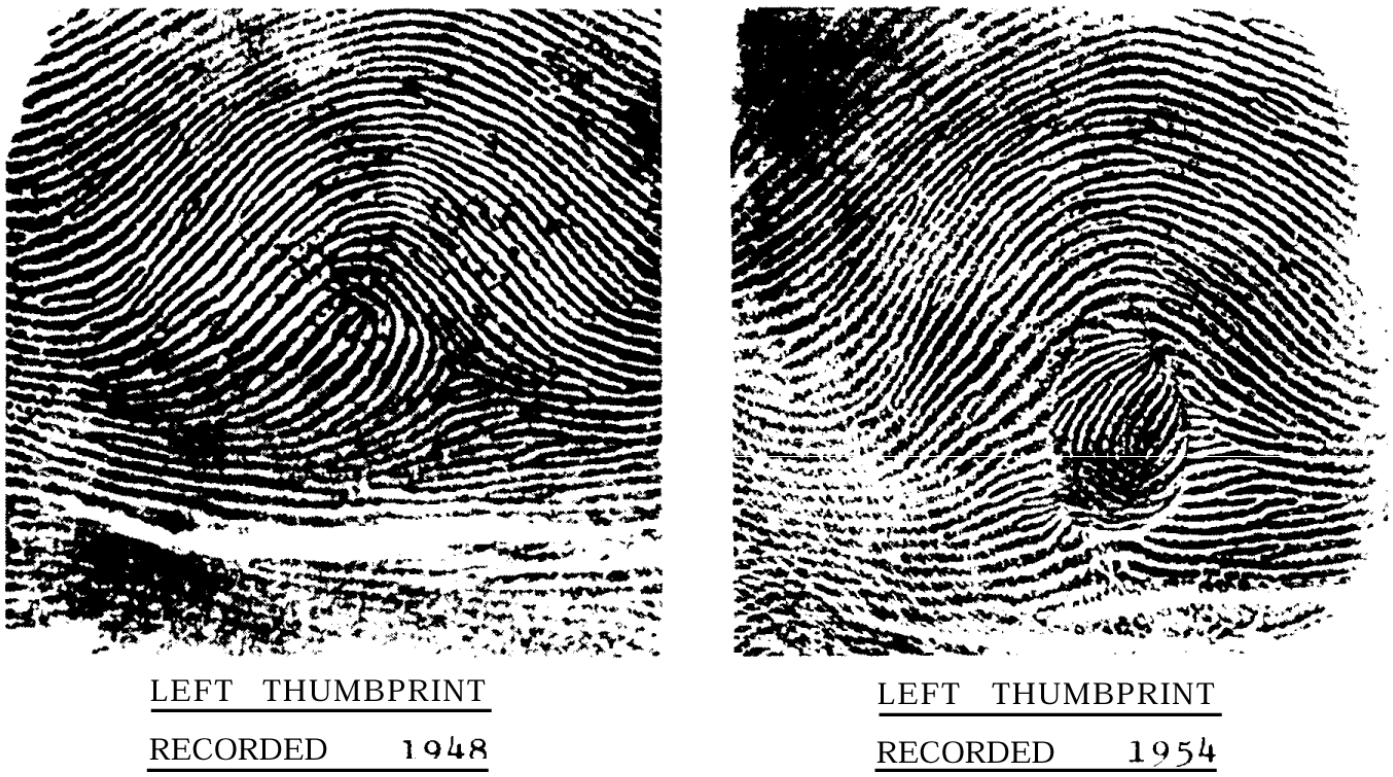


Figure 6: Evasion -- Pieces of friction ridge skin switched between two fingers (see Figure 7 for right thumbprint). Retrieved from April 1974 issue of Identification News.

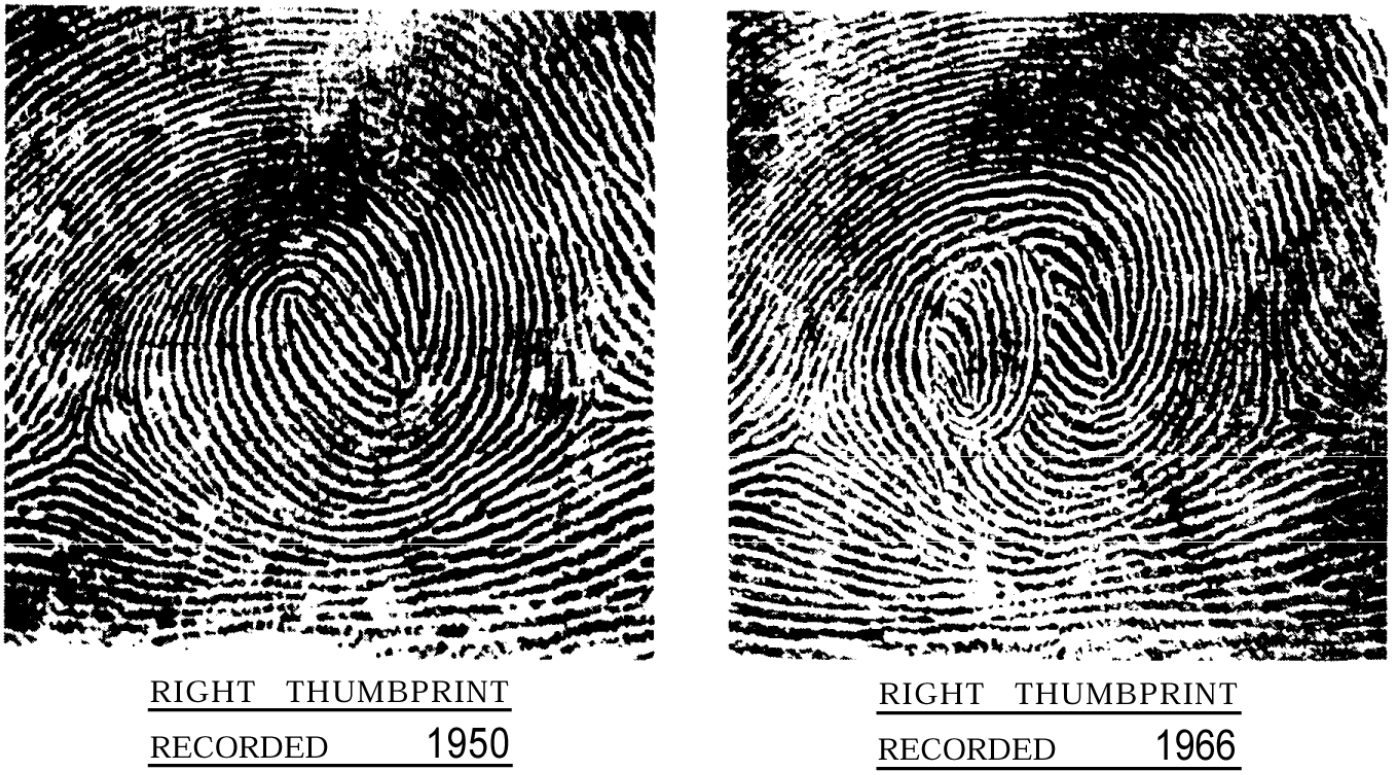


Figure 7: Evasion -- Pieces of friction ridge skin switched between two fingers (see Figure 6 for left thumbprint). Retrieved from April 1974 issue of Identification News.

Resources

Glossary

A

AFIS

Automated Friction-ridge Identification System, formerly defined as Automated Fingerprint Identification System, but modified because of the introduction of palm and plantar identification capabilities.

ANSI-NIST/ITL 1-2011

NIST Special Publication 500-290 Data Format for the Interchange of Fingerprint, Facial & Other Biometric Information. It is the base standard that defines mandatory field requirements, optional fields, and rules for configuring options. It is used as a basis for defining specifications for transactions between interconnected systems, e.g., FBI EBTS v9.3.

Arch

A fingerprint pattern in which the ridges enter on one side of the impression, and flow, or tend to flow, out the other with a rise or wave in the center.

B

Bifurcation

A type of minutia defined by the division of one friction ridge into two friction ridges.
ANSI-NIST/ITL 1-2011

C

Clarity

The fidelity with which anatomical details are represented in a friction ridge impression. Clarity corresponds to an examiner's confidence that the presence, absence, and details of the anatomical friction ridge features in that area can be correctly discerned in that impression.

Core

In EFS, a core is the focus of the innermost recurving ridge in a fingerprint. Cores are found in loops, whorls, and some tented arches. In the past, other definitions have noted different locations for cores, includingAFIS-specific definitions. The Science of Fingerprints defines core as the topmost point on the innermost upwardly curving friction ridgeline, which differs from the EFS definition; this definition was not used in EFS because the EFS location is more reliably determined in AFIS.

Core-Delta Ridge Counts

A count of intervening ridges between a core and a delta; only applies to loops and whorls. It is used to obtain greater granularity in fingerprint classification and is a feature used for comparison of a latent with the exemplar.

Crease

Flexion creases are found between movable parts of the hand (and foot). Those creases are embedded in the skin and mostly fit naturally in the ridge flow. The flexion creases are permanent and may show particular skin shapes such as crow feet. A line or linear depression; grooves at the joints of the phalanges, at the junction of the digits and across the palmar and plantar surfaces that accommodate flexion.
Other creases are skin folds; their presence increases as the skin ages. The friction ridges are lower for the path of the crease causing the ridges not to print and leaving a white line without information. They are also called white lines.

D

Delta

A delta is a meeting point of three (3) individual ridge flows. Deltas are found in fingerprint loop and whorl patterns and may occur in tented arches. They are common in the interdigital palmprint area.

Direction Uncertainty

A range that may be defined if a feature's direction cannot be accurately determined.

Distal Segment

The segment of a finger or thumb farthest from the palm.

Distinctive feature

An unusually discriminating/unique feature such as scars that cannot be defined adequately using other features.

Dot

A dot is an isolated single ridge unit (ridge that contains a single pore). Generally, the width of a dot is similar to the width of neighboring ridges, and the length of a dot approximates its width.

E

EBTS

The FBI's Electronic Biometric Transmission Specification (EBTS v9.3) (which supports NGI Increment 3, and supports certain elements of ANSI/NIST-ITL 1-2011) defines the specifications to which agencies must adhere when electronically communicating with the FBI's NGI (formerly IAFIS). The specification provides descriptions of all requests and responses associated with electronic fingerprint identification services, including 10-print, latent, and fingerprint image services.

EFS Differences with NCIC Classification Methodology

EFS differs from the NCIC Classification methodology in its locations for cores: the EFS location of cores for loops is at the focus of the innermost recurving ridge, rather than on the ridge itself; EFS also defines core locations for whorls and some tented arches. The EFS core locations were developed based on input from AFIS vendors and SWGFAST, specifically because these locations are not as sensitive to the presence or absence of ridge appendages or crossing ridges, and are therefore more reliably detected by automated systems.

Exclusion

The determination by an examiner that there is sufficient quality and quantity of detail in disagreement to conclude that two areas of friction ridge impressions did not originate from the same source.

Exemplar

An impression or image of friction ridge skin purposely collected with the knowledge of the subject; a non-latent friction ridge image.

Extended Feature Sets (EFS)

A set of friction ridge features defined in the ANSI-NIST-ITL 1-2011 standard, and used in the FBI's EBTS. The EFS fields are designed to be interoperable among AFIS systems, as well as to document latent friction ridge features for archiving or exchange between latent examiners.

F

Finger/Palm/Plantar position

The specific finger, thumb, or palm or plantar area that created an impression.

Fingerprint

An impression of the friction ridges of a finger or thumb. While this may be used to refer to impressions from any part of a finger or thumb, it is most frequently used to refer to impressions from distal segments.

Fingerprint Examination

Fingerprint or palmprint examination is the process of analysis, comparison, evaluation, and verification of friction ridge impressions.

Fingerprint Pattern

See Pattern Classification.

Friction Ridge

A raised portion of the epidermis on the palms of the hand or the soles of the feet, consisting of one or more connected ridge units of friction ridge skin. Synonymous to ridge.

Friction Ridge Skin

The skin found on the palms of the hands and soles of the feet.

Friction Ridge Unit

Single section of a friction ridge containing one pore.

H

Henry Classification

A system of fingerprint pattern classification named for Sir Edward Richard Henry (1850 - 1931).

I

Identification

See individualization.

Impression

Friction ridge detail deposited on a surface. Synonymous to print.

Incipient Ridge

An incipient is a thin ridge, substantially thinner than a normal ridge width. Incipient ridges generally do not contain pores. Incipient ridges frequently appear as a series of separate segments.

Inconclusive

The determination by an examiner that there is neither sufficient agreement to individualize, nor sufficient disagreement to exclude.

Individualization

The determination by an examiner that there is sufficient quality and quantity of detail in agreement to conclude that two friction ridge impressions originated from the same source. Synonymous with identification.

Innermost Recurving Ridges

A recurving ridge path that does not enclose any other recurving ridges.

Intervening Ridges

The number of friction ridges between two characteristics.

IAFIS

Integrated Automated Fingerprint Identification System. A national fingerprint and criminal history system operated by the FBI. It is being replaced by NGI.

L

Latent Print (Latent)

An impression, often not visible to the naked eye, left on crime scene evidence; generic term used for unintentionally deposited friction ridge detail. Also known as “mark” or “trace”(generally outside of North America).

Lateral Center

The left-to-right center of a fingerprint.

Left Slant Loop

A loop in which the pattern flows to the left in the impression. Also known as a left loop. A left slant loop from a right finger is a radial loop; a left slant loop from a left finger is an ulnar loop.

Level 1 Detail

The general ridge flow and pattern type in an impression. The details are not sufficient for individualizationbut can be used for exclusion. They may include information enabling orientation, core and delta location and distinction of finger versus palm.

Level 2 Detail

Individual friction ridge paths and associated events, including minutiae.

Level 3 Detail

Attributes related to dimensions and shapes of individual friction ridges, such as width, edge shapes, and pores.

Linear Discontinuity

Minor crease, crack, cut, thin or non-permanent scar. They are often called “white lines.”

Loop

A fingerprint pattern in which one or more friction ridges enter upon one side, recurve, touch or pass an imaginary line between delta and core and flow out on the same side the friction ridges entered. If the hand (left or right) is known, the types of loops are ulnar and radial loops; if the hand is unknown, the types are leftand right loops.

Local Quality Issues

One or more areas within an impression containing quality or transfer issues that indicate that the anatomical friction ridge features may not have been accurately represented in the image.

M

Medial Segment

The middle segment of a finger. The thumb does not have a medial segment.

Minutia (pl. minutiae)

Events along a ridge path, including bifurcations and ending ridges; in some uses, dots are considered minutiae.

Minutiae Ridge Counts

Count of intervening ridges between specified minutiae.

N

NGI

FBI's Next Generation Identification system which replaces IAFIS (the latent identification capability is expected to be operational in April 2013).

NCIC Classification

A pattern classification system based on the Henry system with extensions and modifications developed by the FBI and documented in the Science of Fingerprints and the Fingerprint Training Manual.

O

Orientation

The distal direction, towards the tips of the fingers.

P

Pattern Classification

Indicates the general shape or pattern of fingerprint impression (see Henry classification).

Plain Arch

A fingerprint pattern in which the ridges enter on one side of the impression and flow out the other with a rise or wave in the center. A plain arch does not have a defined up-thrust in the ridge flow at or near the point of highest curvature.

Plantar

Having to do with the friction ridge skin on the feet (soles and toes).

Pores

Small openings on friction ridges through which perspiration is released.

PPI

Pixels Per Inch: The spatial resolution of a digital image. Often referred to incorrectly as DPI (dots per inch).

Print

See impression.

Profile (EFS Profile)

Sets of EFS features to be used in latent friction ridge (fingerprint, palmprint, or plantar) searches of AFIS systems from different vendors. Different EFS Profiles are defined to allow for tradeoffs between examiner time and search accuracy.

Protrusion

An abrupt increase in ridge width that is not long enough to be called a bifurcation. Also known as a spur.

Proximal Segment

The segment of the finger or thumb closest to the palm.

R

Radial Loop

A loop in which the pattern flows in the direction of the radius bone of the forearm (toward the thumb).

Radius of Uncertainty

A circle with a selected radius of uncertainty is marked to include the area of possible locations if the precise location for a ridge ending cannot be ascertained.

Recurving Ridge

A ridge path that turns back on itself i.e. turns around in the same direction that it came from.

Region of Interest (ROI)

A single continuous friction ridge impression that includes all of the impression being evaluated while excluding as much as possible of the background and other impressions. Also used to refer to a polygon used to outline a region of interest.

Ridge

See friction ridge.

Ridge Edge Features

Protrusions and indentations at the edges of ridges.

Ridge Ending

The termination point of a single, continuous ridge.

Ridge Flow

The arrangement and direction of adjacent friction ridges.

Ridge Flow Map

A representation of the direction of ridge flow at sampling points in a grid superimposed over a friction ridge image.

Ridge Path

The course of a single friction ridge, including the starting position of the ridge, the path the ridge takes, the length of the ridge path, and where the ridge path stops.

Ridge Quality

A determination by an examiner of whether the features in the area being examined are definitive or debatable.

Ridge Quality Map (Clarity Map)

An assessment of the clarity in areas within an image. The means by which the recipient can determine whether all other features in a given area of a friction ridge impression are definitive or debatable. The quality/confidence is painted over the image (within the region of interest) using the standard colors of black, red, yellow, green, blue, and aqua; each color corresponding to a level of confidence.

Ridge Segment

A section of a ridge that connects two minutiae, so each ridge segment starts and stops either where the ridge intersects another ridge path segment (a bifurcation), ends (a ridge ending), or leaves the region of interest. (Also known as Ridge path segment).

Right Slant Loop

A loop in which the pattern flows to the right in the impression. Also known as a right loop. A right slant loop from a right finger is an ulnar loop; a right slant loop from a left finger is a radial loop.

S

Scar

A damaged area of the original structure of the skin that results in the unnatural disturbance of the ridge flow.

Skeleton

A thinned representation of the ridge structure of a friction skin image in which all pixels are white except for a thinned black skeleton following the midpoint of each ridge (also known as a ridge tracing or skeletonized image).

Spur

See protrusion.

T

Tented Arch

A type of arch fingerprint pattern that possesses either an angle, an upthrust, or two of the three basic characteristics of a loop (i.e. recurve, delta, and ridges between the core and the delta).

Type Lines

The two innermost ridges that start or go parallel, diverge and surround or tend to surround the pattern area. The pattern area includes the core(s) and delta(s).

U

Ulnar Loop

A loop in which the pattern flows in the direction of the ulna bone of the forearm (toward the little finger).

Universal Latent Workstation (ULW)

Software distributed by the FBI that provides functionality to create, edit, and view latent fingerprint transactions. ULW provides operational access to FBI IAFIS/NGI latent print services, as well as enabling cross-jurisdictional interoperability between vendor-specific AFIS feature formats.

W

Whorl

A pattern classification with two or more deltas (see exception for accidental whorls). The subclasses of whorls are accidental, central pocket loop, double loop, and plain whorls.

Whorl - Accidental

A whorl consisting of two different types of patterns, with the exception of the plain arch, with two or more deltas; or a pattern which possesses some of the requirements for two or more different types; or a pattern which conforms to none of the definitions. Some Accidental Whorls may not have two deltas that are fully defined.

Whorl - Central Pocket Loop

A whorl which has two deltas and at least one ridge which makes, or tends to make, one complete circuit, which may be spiral, oval, circular, or any variant of a circle. An imaginary line drawn between the two deltas must not touch or cross any recurving ridges within the inner pattern area.

Whorl - Double Loop

A whorl that consists of two separate loop formations with two separate and distinct sets of shoulders and two deltas.

Whorl - Plain

A whorl which consists of one or more ridges which make, or tend to make, a complete circuit, with two deltas, between which, when an imaginary line is drawn, at least one recurving ridge within the inner pattern area is cut or touched.

References

On Friction Ridge Markup

- Science of Fingerprints (FBI)
- Fingerprint Training Manual (FBI)
- The Fingerprint Sourcebook (Scientific Working Group on Friction Ridge Analysis, Study and Technology, et al.)
- Extended Friction Ridge Feature Sets (Committee to Define an Extended Fingerprint Feature Set)
- Markup Instructions for Extended Friction Ridge Features (National Institute of Standards and Technology; Noblis, Inc.)

Organizations and Committees

- Federal Bureau of Investigation (FBI)
- NIST Information Technology Laboratory
- Scientific Working Group on Friction Ridge Analysis, Study, and Technology (SWGFAST)
- Committee to Define an Extended Fingerprint Feature Set (CDEFFS)

EFS and Interoperability

- Extended Feature Set Profile Specification
- NIST-OLES Interoperability Project
- Latent Interoperability Transmission Specification
- Latent AFIS Interoperability Project at Noblis

Additional Technical and Standards Information

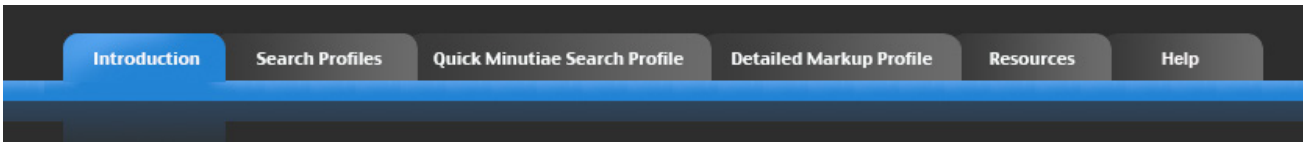
- NIST Evaluation of Latent Fingerprint Technologies
- NIST Information Technology Laboratory: Biometrics Programs/Projects
- Electronic Biometric Transmission Specification
- ANSI/NIST-ITL Standard

Please address questions and comments for the Training Tool team to EFSTT@noblis.org.

Help

Main sections

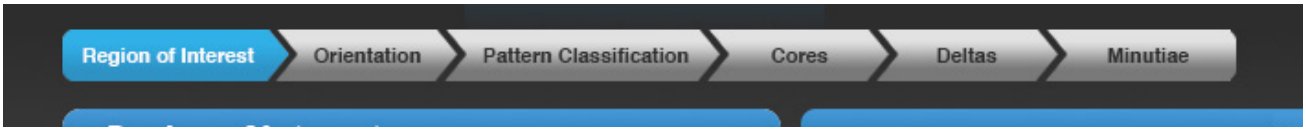
The Extended Feature Set Training Tool is broken up into several main sections. Use the tabs at the top of the website to navigate between these sections:



- The Introduction tab explains the tool's context and goals.
- The Search Profiles tab addresses which images will benefit the most from manual markup.
- The Quick Minutiae Search Profile and Detailed Markup Profile tabs hold the bulk of the tool's content.
- Resources contains a glossary and external references where you can find additional information about EFS markup and the organizations involved.
- The Help tab contains this guide.

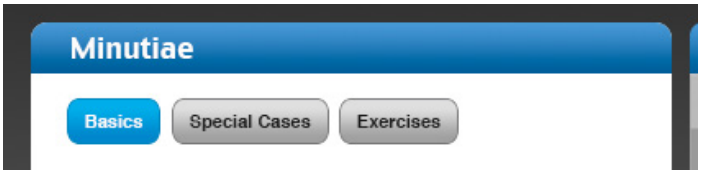
Secondary navigation

To move around inside the Quick Minutiae Search Profile and Detailed Markup Profile tabs, use the chevron buttons near the top of the screen:

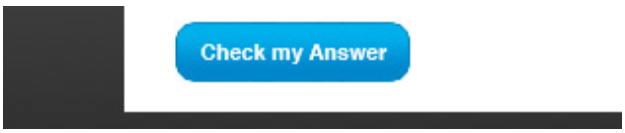


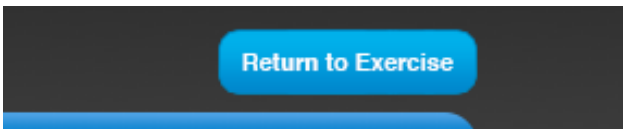
Navigation within features

Some features, like Minutiae, include a second description section. Use the buttons under the feature header to switch between these sections.



- To practice marking up a particular feature, click on the Exercises button.
- Click Check My Answer to see an example of expert markup, then click Return to Exercise in the top right to continue practicing.



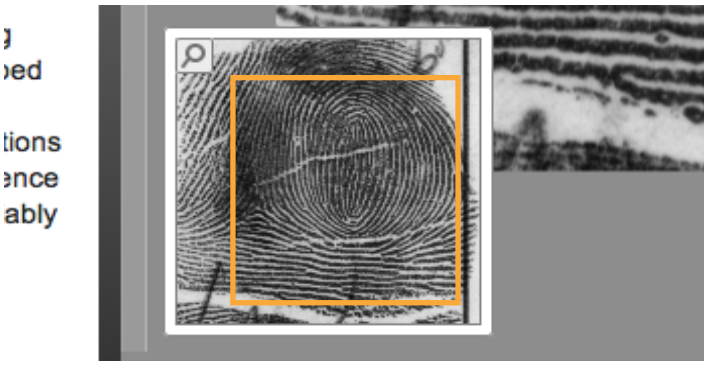


Inside each feature section, you will find a description of that feature on the left and example images on the right.

Zooming in and out

To zoom in or out on any image, use the zoom slider to the top right of the image's canvas area. You may also click on the plus and minus buttons to zoom.

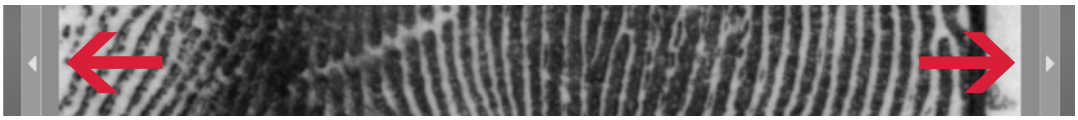
The image navigator is at the bottom left of the image's canvas area. Click and drag inside this box to change where the zoom is focused.



You can turn the image navigator on and off by clicking the magnifying glass icon next to the zoom slider.

Navigating through images and exercises

The left and right arrows on either side of each image let you move between example images and exercises.



Activity tools

Each activity has a set of tools specific to the markup needed. Check the instructions in the exercise text area to learn how to use a particular activity. To create new marks, you will need to click on a specialized tool button. Every activity also has a Delete or Erase button. The Delete and Erase button have different actions depending on what feature you are working in.

Icon	Tool	Feature	Outcome
	Erase	Ridge Quality Map	Clears the specific area you move the cursor over
	Delete	Center Point of Reference Region of Interest	Clears entire canvas
		Dots and Incipients Distinctive Features Cores Deltas Minutiae	Will delete specific mark when that mark is clicked on