

akiyama+0001

Akiyama S.A.

Slap Fingerprint Segmentation Evaluation III

Last Updated: 05 October 2026

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1 Participation Information

1.1 Names and Dates

- **Organization Name:** Akiyama S.A.
- **SlapSeg III Identifier:** akiyama+0001
- **SlapSeg III API Version:** 1.2.0
- **Provided Marketing Name:** “Akiyama SlapSeg”
- **Application Date:** 30 September 2026
- **First Submission Date:** 30 September 2026 (as version 0001)
- **Validation Date:** 02 October 2026
- **Completion Date:** 05 October 2026

1.2 Libraries

Filename	MD5 Checksum	Size
libopencv_imgcodecs.so	3e5ab9a7d2e7d3d35de5de90356e09ea	3 MB
libopencv_imgproc.so.4.12.0	7bd8feac49580e545beb33d080b51810	9 MB
libonnxruntime.so.1.23.1	7a8491aed943ccfb930a64339a7080a4	22 MB
libonnxruntime.so.1	7a8491aed943ccfb930a64339a7080a4	22 MB
libopencv_imgcodecs.so.4.12.0	3e5ab9a7d2e7d3d35de5de90356e09ea	3 MB
libopencv_core.so	e5023fc30a057ea6d899f015ed4ce370	6 MB
libopencv_core.so.412	e5023fc30a057ea6d899f015ed4ce370	6 MB
libopencv_imgproc.so	7bd8feac49580e545beb33d080b51810	9 MB
libslapsegiii_akiyama_0001.so	9404a32f16f9ce48131e74335e367d28	101 MB
libopencv_core.so.4.12.0	e5023fc30a057ea6d899f015ed4ce370	6 MB
libopencv_imgcodecs.so.412	3e5ab9a7d2e7d3d35de5de90356e09ea	3 MB
libopencv_imgproc.so.412	7bd8feac49580e545beb33d080b51810	9 MB

2 Tenprint Cards (“TwoInch” Data)

2.1 Segmentation Timing

All algorithms are run over a small fixed corpus of TwoInch images to estimate the total runtime of the evaluation. To be evaluated under SlapSeg III, algorithms **must** segment the timing corpus, on average, in under 1 500 milliseconds. This maximum reference time is documented in the SlapSeg III test plan, and is subject to change. Times are measured by running a single process on an isolated compute node equipped with an Intel Gold 6254 CPU (submissions received prior to February 2022 were timed with a Intel Xeon E5-4650 CPU).

Box plots of segmentation times are separated by slap orientation and capture technology in Figure 1. Tabular representations are enumerated in Table 1. Results are reported in milliseconds.

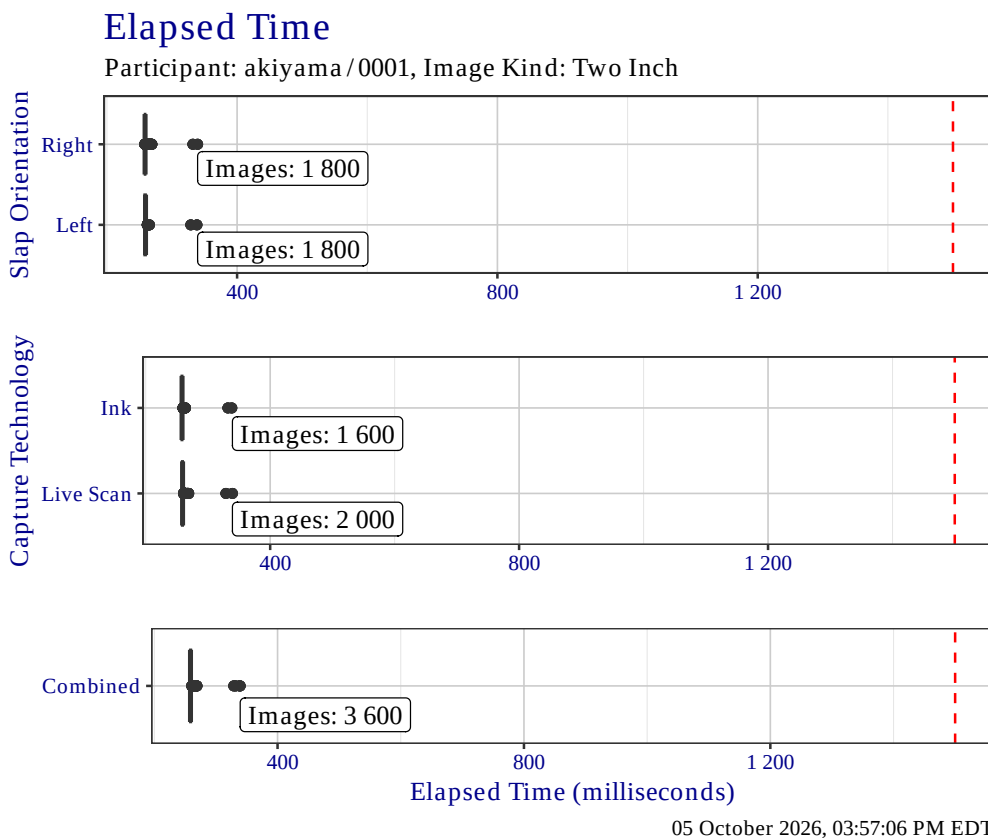


Figure 1: Box plots of elapsed time in milliseconds when segmenting the TwoInch timing test corpus, separated by slap orientation and capture technology.

Table 1: Elapsed time in milliseconds when segmenting the TwoInch timing test corpus, separated by slap orientation and capture technology.

	Right	Left	Live Scan	Ink	Combined
Minimum	258	257	258	257	257
25%	259	258	259	258	258
Median	259	259	259	258	259
75%	259	259	259	259	259
Maximum	339	338	339	338	339

2.2 Segmentation Centers and Dimensions

2.2.1 Segmentation Centers

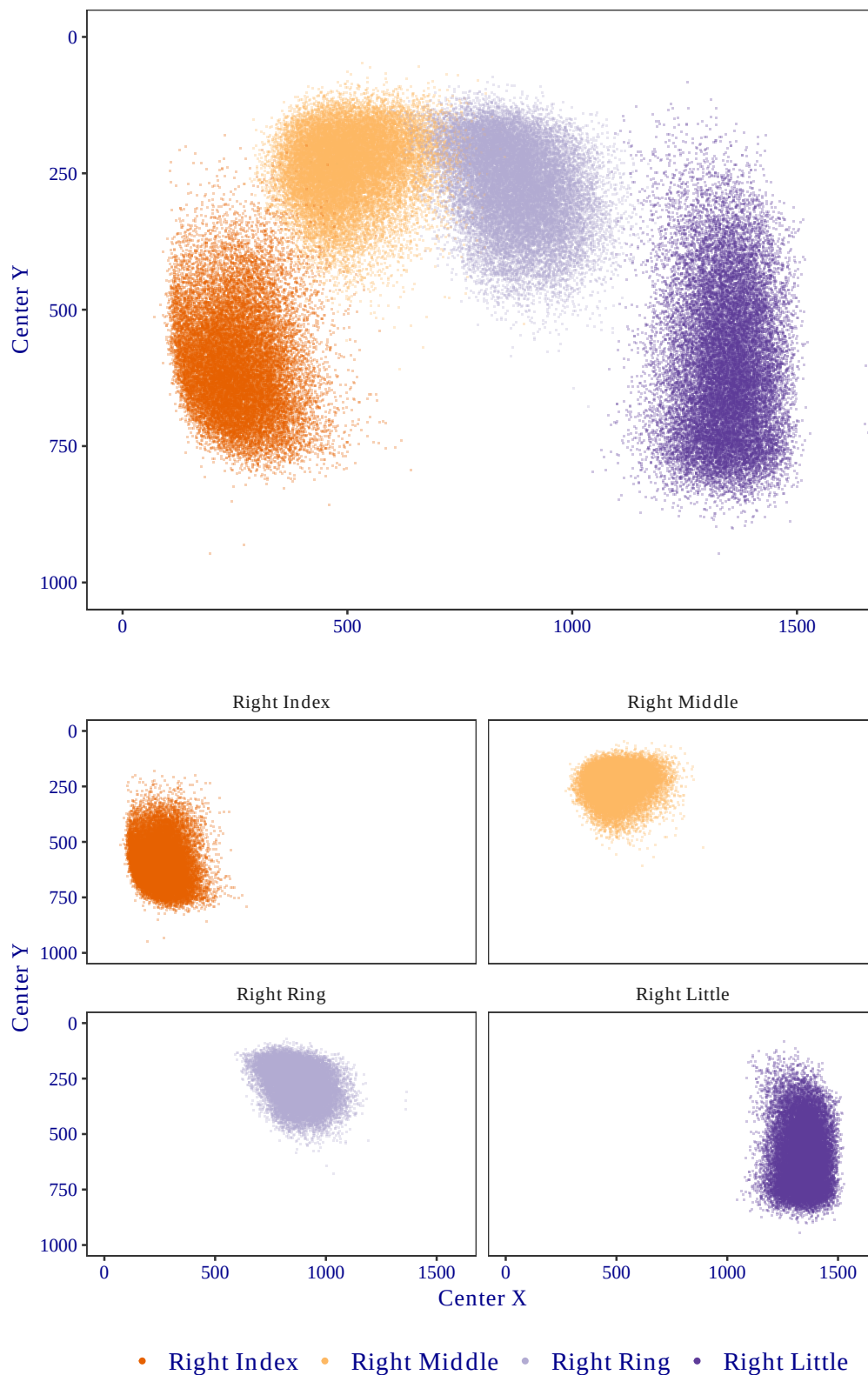
The plots in this section show the distribution of segmentation position centers (x, y) for TwoInch data. At the top of each figure is a combined plot for all finger positions of a given slap orientation. These figures are isolated in plots faceted at the bottom of the figure.

Plots of segmentation centers for the right hand TwoInch data are shown in Figure 2 and plots of segmentation centers for the left hand are shown in Figure 3. Blank lines that may appear in the plots are **not** rendering artifacts. Rather, they are indicative of image downsampling. Centers have been normalized to 500 pixels per inch.

Points in each plot are plotted with a semi-transparent opacity. This results in points of particular color appearing “darker” to indicate a higher frequency of the observed value, while “lighter” points indicate a lower observed frequency.

Segmentation Position Centers

Participant: akiyama / 0001, FRGPs: 2, 3, 4, 5, Image Kind: Two Inch

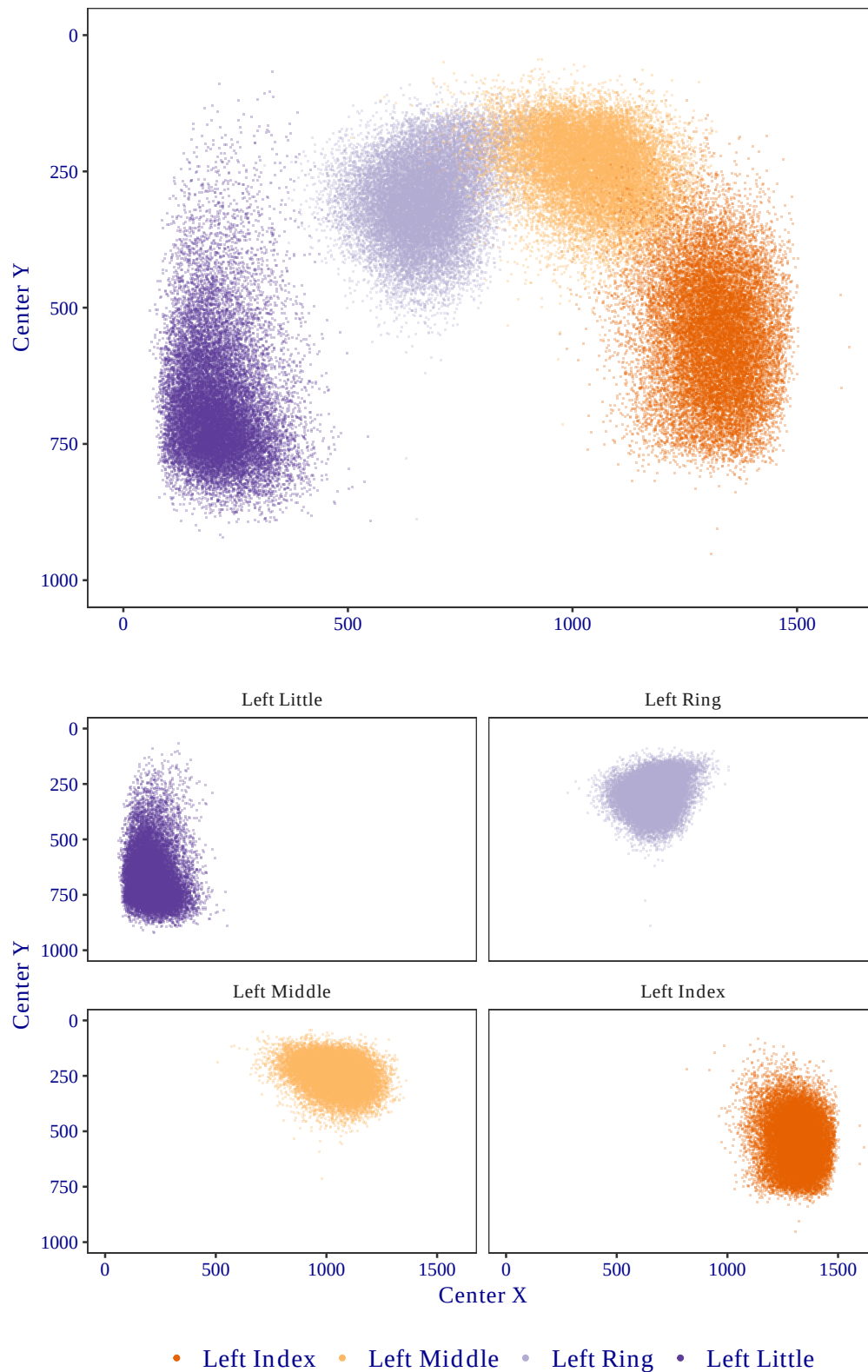


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Figure 2: Segmentation centers for right hand TwoInch data.

Segmentation Position Centers

Participant: akiyama / 0001, FRGPs: 7, 8, 9, 10, Image Kind: Two Inch



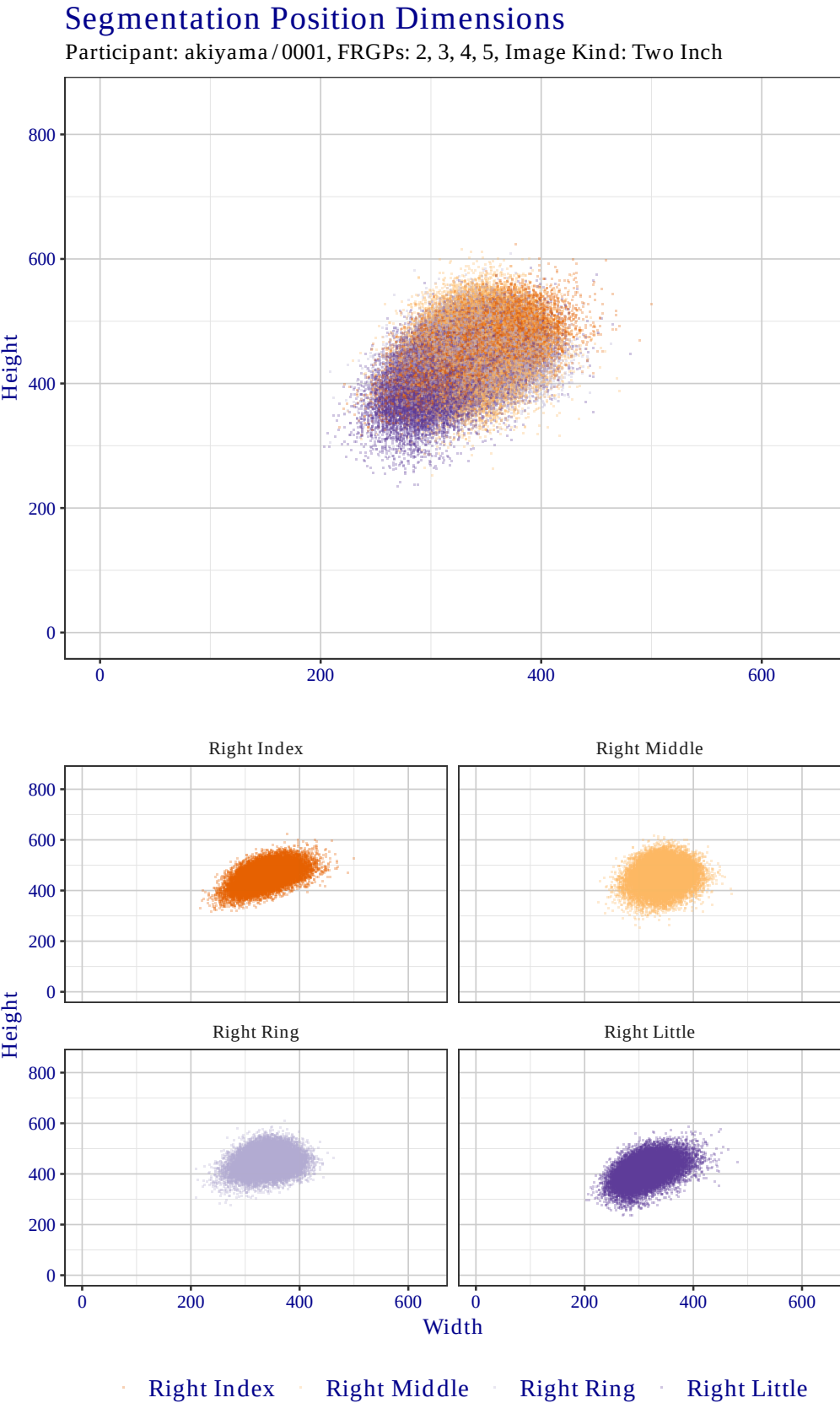
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Figure 3: Segmentation centers for left hand TwoInch data.

2.2.2 Segmentation Dimensions

The plots in this section show the distribution of segmentation position widths and heights for TwoInch data. At the top of each figure is a combined plot for all finger positions of a given slap orientation. These figures are isolated in plots faceted at the bottom of the figure.

Plots of segmentation position dimensions for the right hand TwoInch data are shown in Figure 4 and the left hand in Figure 5. Blank lines that may appear in the plots are **not** rendering artifacts. Rather, they are indicative of image downsampling. Dimensions have been normalized to 500 pixels per inch.

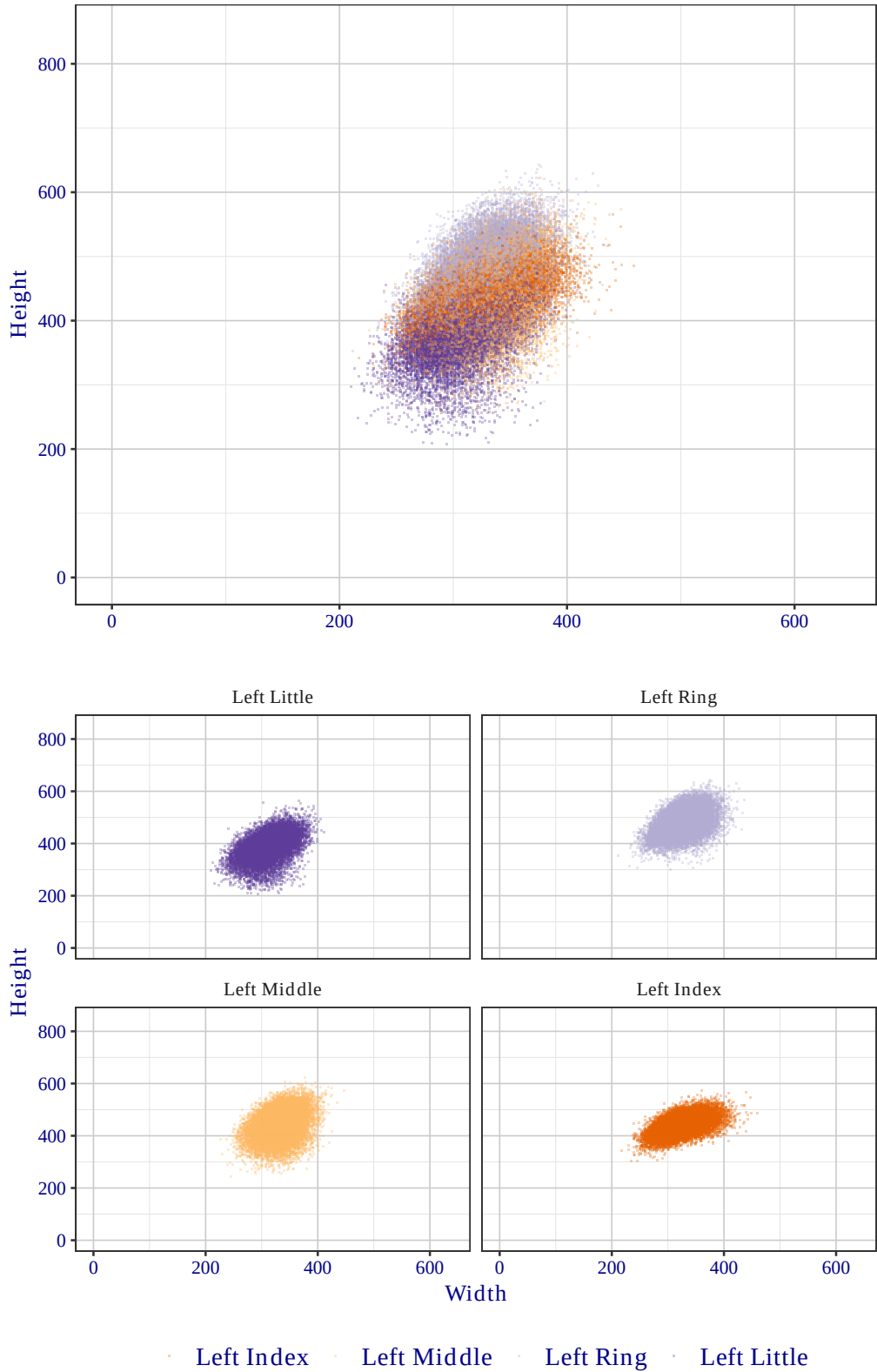


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Figure 4: Segmentation position dimensions for right hand TwoInch data.

Segmentation Position Dimensions

Participant: akiyama/0001, FRGPs: 7, 8, 9, 10, Image Kind: Two Inch



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Figure 5: Segmentation position dimensions for left hand TwoInch data.

2.3 Detailed Segmentation Statistics

This section shows detailed results of segmentation of TwoInch data. Values in each table are the percentage that the variable in the left-most column was correctly segmented.

Each table has three columns of percentages. The *Standard Scoring* column shows the percentage of correctly-segmented positions based on the scoring metrics defined in the SlapSeg III scoring document. The *Ignoring Bottom Y* column shows how the percentage would change if the threshold for the *bottom Y* coordinate of the segmentation position was ignored. Similarly, the *Ignoring Bottom X and Y* columns shows how the percentage would change if only the top, left, and right sides of the segmentation position were considered. These two supplemental columns are included because it has traditionally been difficult to determine the exact location of the distal interphalangeal joint.

Table 2 shows how successful akiyama+0001 segmented fingers for each subject in the test corpus. Table 3 shows success for specific finger positions over the entire test corpus. Similarly, Table 4 shows success for segmenting the same finger position from both hands.

The remainder of the tables show success per subject when considering combinations of subsets of the fingers on each slap image. Table 5 shows success for combinations of all fingers, Table 6 for just the index and middle fingers, and Table 7 for all except the little finger.

Table 2: For each subject, the percentage that at least *Number of Fingers* fingers were correctly segmented, regardless of hand, for a maximum of eight correctly-segmented fingers. In *Standard Scoring*, scoring rules are followed exactly. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Number of Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
1	87.3	90.3	97.6
2	79.5	83.3	92.9
3	71.8	76.4	86.3
4	61.9	67.8	78.2
5	46.2	51.7	65.2
6	37.0	42.2	52.2
7	27.2	32.1	39.5
8	15.2	19.7	24.9

Table 3: For all subjects, percentage that a particular friction ridge generalized position was correctly segmented. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Finger	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Index	55.4	59.4	65.6
Middle	46.3	48.1	49.6
Ring	52.4	54.9	58.0
Little	57.3	62.1	85.9
Left			
Index	56.6	65.0	78.0
Middle	53.4	55.1	63.2
Ring	61.3	64.2	72.4
Little	55.7	68.4	78.4

Table 4: Percentage that a particular type of fingerprint was correctly segmented on *Either* or *Both* hands. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Index			
Either	73.9	79.7	87.6
Both	34.9	41.0	51.4
Middle			
Either	68.3	70.0	75.2
Both	29.2	30.8	34.9
Ring			
Either	74.3	76.8	82.5
Both	36.0	39.0	44.8
Little			
Either	74.7	82.8	94.7
Both	34.8	43.5	65.8

Table 5: Percentage of segmentation success by hand for combinations of all eight fingers of a TwoInch slap. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Any	70.4	72.9	89.0
At Least Two	59.4	62.6	71.6
At Least Three	48.6	51.8	57.0
All Four	33.0	37.3	41.5
Left			
Any	76.2	81.2	91.0
At Least Two	64.6	70.3	81.1
At Least Three	52.2	58.9	69.0
All Four	34.0	42.4	51.1

Table 6: Percentage of segmentation success by hand when only considering combinations of index and middle fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Either Index or Middle	60.9	63.7	69.1
Both Index and Middle	40.8	43.7	46.1
Left			
Either Index or Middle	66.0	70.6	83.0
Both Index and Middle	44.0	49.5	58.2

Table 7: Percentage of segmentation success by hand when only considering combinations of index, middle, and ring fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Any	65.6	67.9	73.4
At Least Two	52.0	54.7	57.6
All Three	36.5	39.7	42.2
Left			
Any	72.4	75.7	86.7
At Least Two	58.7	62.6	72.7
All Three	40.2	46.0	54.3

2.4 Handling Troublesome Images

2.4.1 Capture Failures

Segmentation algorithms may refuse to process an image. This may happen for a technical reason (e.g., the algorithm cannot parse the image data), or for a practical reason (e.g., the hand in the image is placed incorrectly). These failure scenarios are the result of capturing improper image data. In these types of scenarios, it is important to examine the cause of the failure. With many live scan capture setups, segmentation is performed immediately after capture. If an algorithm can detect that it won't be able to segment an image due to a technical or practical issue, it can alert the operator to perform a recapture before the subject leaves.

The SlapSeg III API encourages algorithms to identify these failure reasons by specifying pre-defined *deficiencies* in the image. Algorithms should attempt segmentation even if an image deficiency is encountered if at all possible. Note that SlapSeg III *guarantees* well-formed image data, so failures to parse are **not** an indicator of the data provided.

Reasons for capture-type failures reported by akiyama+0001 are enumerated in Table 8. Note that for TwoInch data, images are expected to be rotated, so a capture failure of *Rotation Detected* is unacceptable.

Table 8: Count of self-reported capture-type failure reasoning.

Failure Reason	Images
Request Recapture (No Attempt)	60

In situations where the algorithm feels that the presented image should be recaptured (Table 8), one or more image deficiencies must be identified. These deficiencies are enumerated in Table 9. At this point, NIST does not have a groundtruth of image deficiencies, but plans to update this table with the accuracy of deficiency observations in the future.

Table 9: Count of image deficiencies reported when requesting a recapture.

Deficiency	Count
Incomplete	60

2.4.1.1 Recovery When encountering a segmentation failure, SlapSeg III algorithms are encouraged to provide a *best-effort* segmentation when possible. In some cases, that best-effort may be correct, which reduces the amount of images that need to be manually adjudicated by an operator.

akiyama+0001 did not attempt any recovery segmentations.

2.4.2 Segmentation Failures

Even if an algorithm accepts an image for processing, it can still fail to process one or more fingers from the image, regardless of if the algorithm requested a recapture and provided best-effort segmentation.

The SlapSeg III API allows algorithms to communicate reasons for failure to process these fingers. In some cases, the distal phalanx in question might not be present in the image due to amputation or being placed outside the platen's capture area. It is imperative that the segmentation algorithm correctly report this as failing to segment the correct friction ridge generalized position without disrupting the sequence of valid positions present in the image. This can help prompt an operator to recapture or record additional information about the subject.

In SlapSeg III, a number of images are missing fingers or otherwise have fingers that will not be able to be segmented. Reasons for segmentation failures reported by akiyama+0001 are enumerated in Table 10.

Table 10: Count of self-reported segmentation failure reasoning.

Failure Reason	Fingers
Finger Not Found	94
Finger Found, but Can't Segment	0
Vendor Defined	0

2.4.3 Identifying Missing Fingers

A small portion of the test corpus in SlapSeg III are missing fingers. Table 11 shows how successful akiyama+0001 was in correctly determining if a finger was missing. The *Missed* row shows when a segmentation position was returned for a missing finger. All possible failure reasons are enumerated, but are not considered *Correctly Identified* because the algorithm specified failure for a reason other than the finger not being found.

Table 11: Performance of akiyama+0001 at detecting fingers missing from an image.

Result	Percentage
Missed	15.6
Correctly Identified	0.0
Other Failure: Finger Found, but Can't Segment	0.0
Other Failure: Vendor Defined	0.0
Other Failure: Segmentation Not Attempted	84.4

2.4.4 Sequence Error

Sequence error occurs when a fingerprint is segmented from an image but assigned an incorrect finger position (e.g., segmenting a right middle finger but labeling it a right index finger). Table 12 shows cases in which a segmentation position was returned that matched a ground truth segmentation position for a different finger in the same image.

Table 12: Percentage of images in the dataset where one or more segmentation positions correctly matched an incorrect finger position within the same image, indicating sequence error.

Hand	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Left	0.00	0.00	0.01
Right	0.00	0.00	0.00
Combined	0.00	0.00	0.00

2.5 Determining Orientation

An *optional* portion of the SlapSeg III API asked participants to determine the hand orientation of an image. Participants were provided the kind (e.g., Tenprint card) and capture technology (e.g., ink), and needed to determine whether the image was of the left or right hand.

Overall Two Inch accuracy: 99.9%

Table 13: Percentage of accuracy when determining hand orientation of a two inch image. The first column indicates the true hand orientation. Subsequent columns indicate the percentage of the time in which the indicated hand orientation was hypothesized.

	Left	Right	Skip
Left	99.9	0.1	0
Right	0.1	99.9	0

3 Identification Flats (“ThreeInch” Data)

3.1 Segmentation Timing

All algorithms are run over a small fixed corpus of ThreeInch images to estimate the total runtime of the evaluation. To be evaluated under SlapSeg III, algorithms **must** segment the timing corpus, on average, in under 1 500 milliseconds. This maximum reference time is documented in the SlapSeg III test plan, and is subject to change. Times are measured by running a single process on an isolated compute node equipped with an Intel Gold 6254 CPU (submissions received prior to February 2022 were timed with a Intel Xeon E5-4650 CPU).

Box plots of segmentation times are separated by hand in Figure 6, with tabular representations are enumerated in Table 14. Results are reported in milliseconds

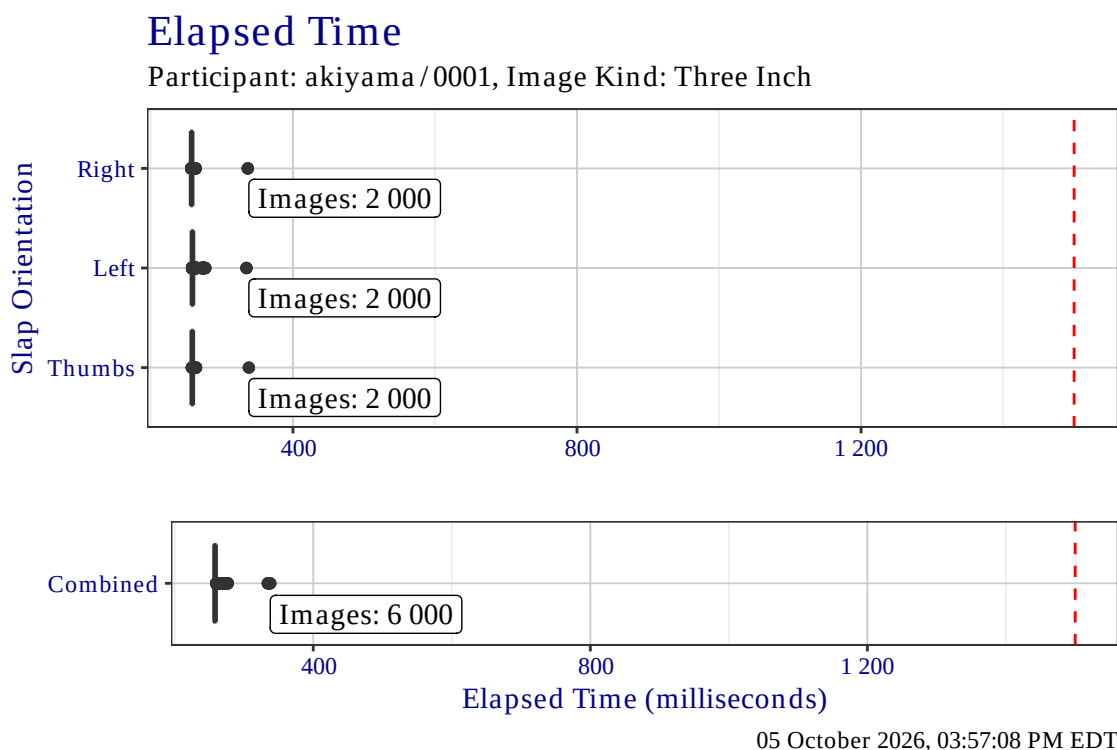


Figure 6: Box plots of elapsed time in milliseconds when segmenting the ThreeInch timing test corpus, separated by slap orientation.

Table 14: Elapsed time in milliseconds when segmenting the ThreeInch timing test corpus, separated by slap orientation.

	Right	Left	Thumbs	Combined
Minimum	257	258	258	257
25%	257	258	258	257
Median	257	258	258	258
75%	257	259	258	258
Maximum	336	335	338	338

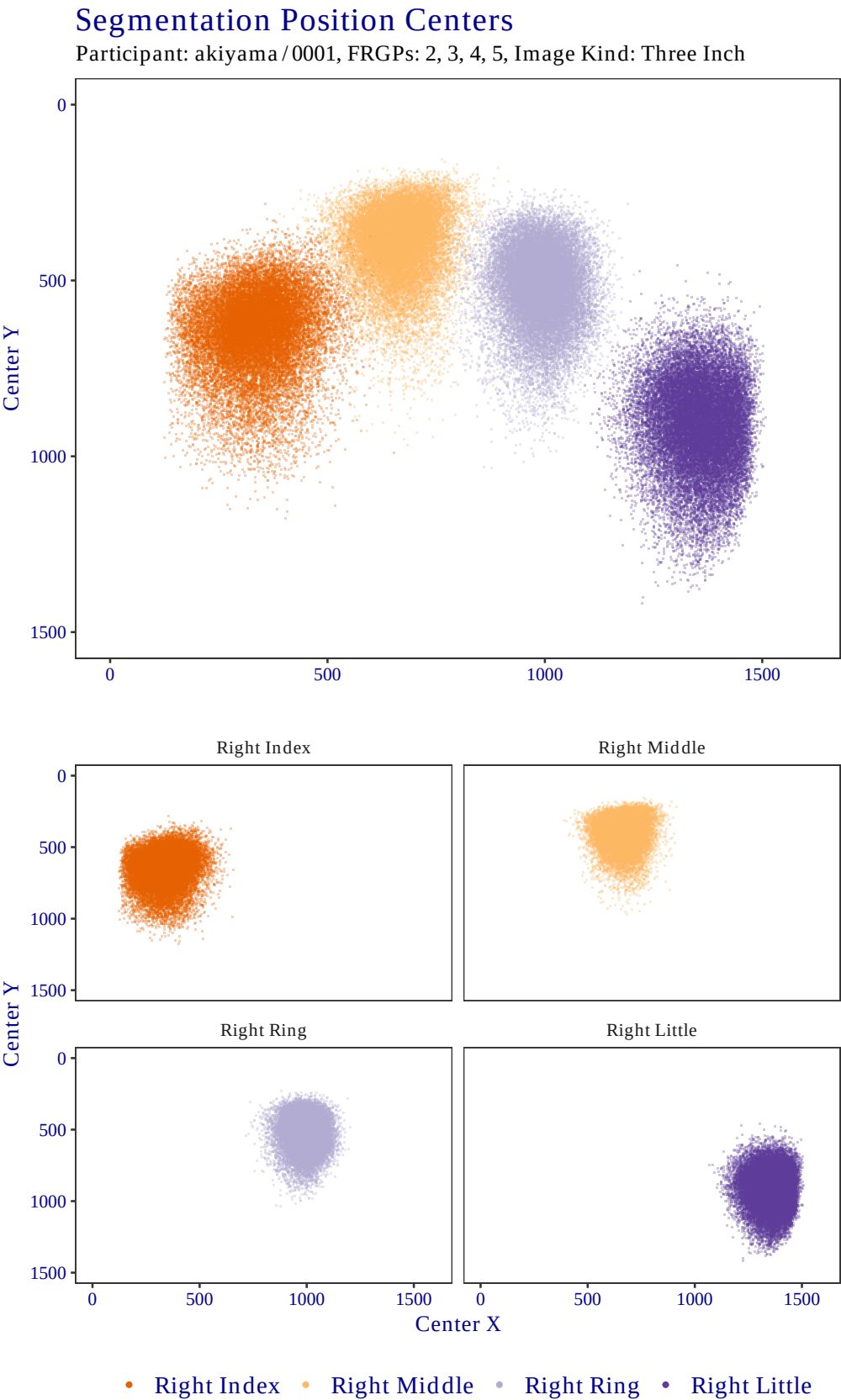
3.2 Segmentation Centers and Dimensions

3.2.1 Segmentation Centers

The plots in this section show the distribution of segmentation position centers (x, y) for ThreeInch data. At the top of each figure is a combined plot for all finger positions of a given hand orientation. These figures are isolated in plots faceted at the bottom of the figure.

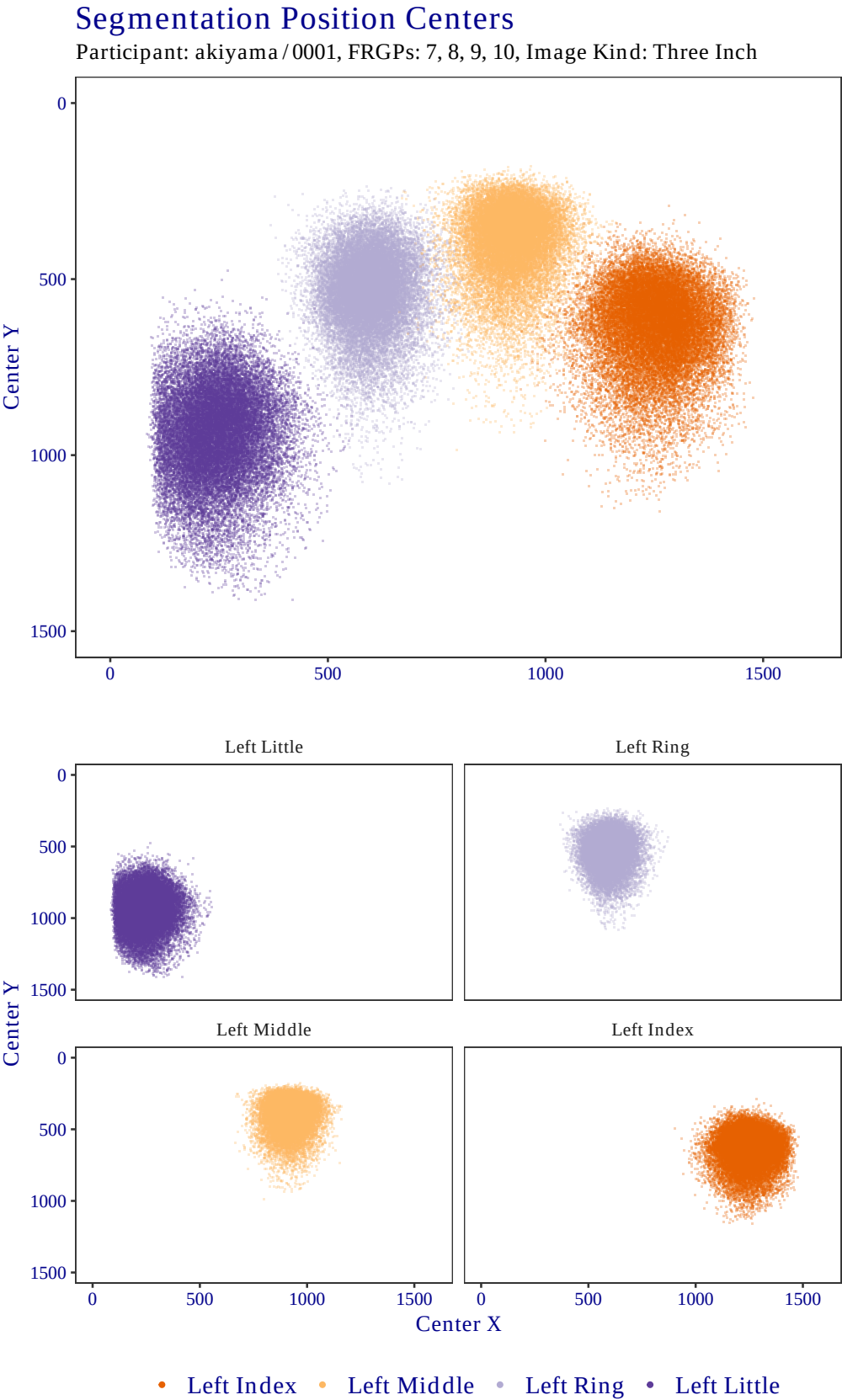
Plots of segmentation centers for the right hand ThreeInch data are shown in Figure 7, for the left hand in Figure 8, and for thumbs in Figure 9. Blank lines that may appear in the plots are **not** rendering artifacts. Rather, they are indicative of image downsampling. Centers have been normalized to 500 pixels per inch.

Points in each plot are plotted with a semi-transparent opacity. This results in points of particular color appearing “darker” to indicate a higher frequency of the observed value, while “lighter” points indicate a lower observed frequency.



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Figure 7: Segmentation centers for right hand ThreeInch data.

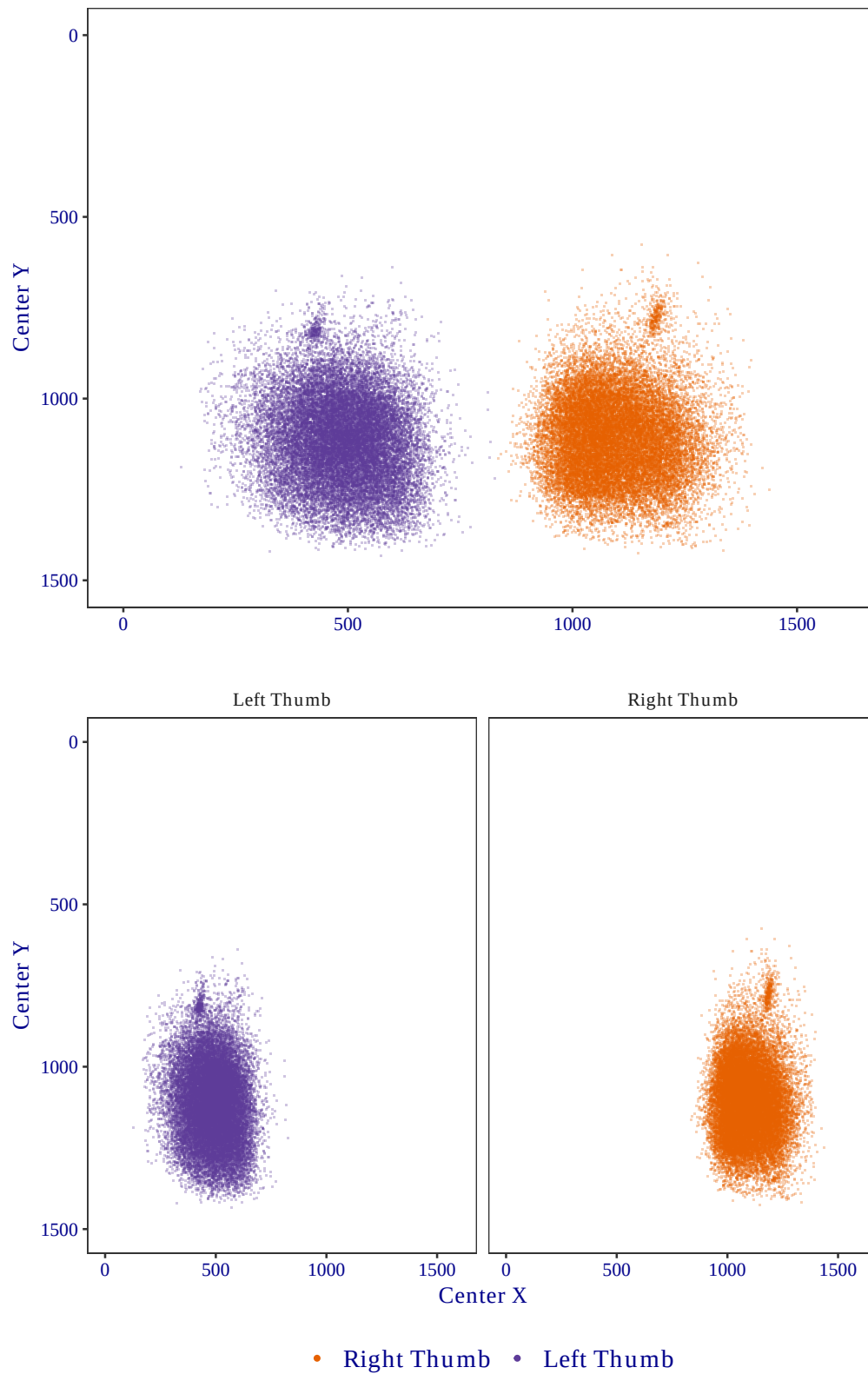


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Figure 8: Segmentation centers for left hand ThreeInch data.

Segmentation Position Centers

Participant: akiyama / 0001, FRGPs: 1, 6, Image Kind: Three Inch



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Figure 9: Segmentation centers for thumb ThreeInch data.

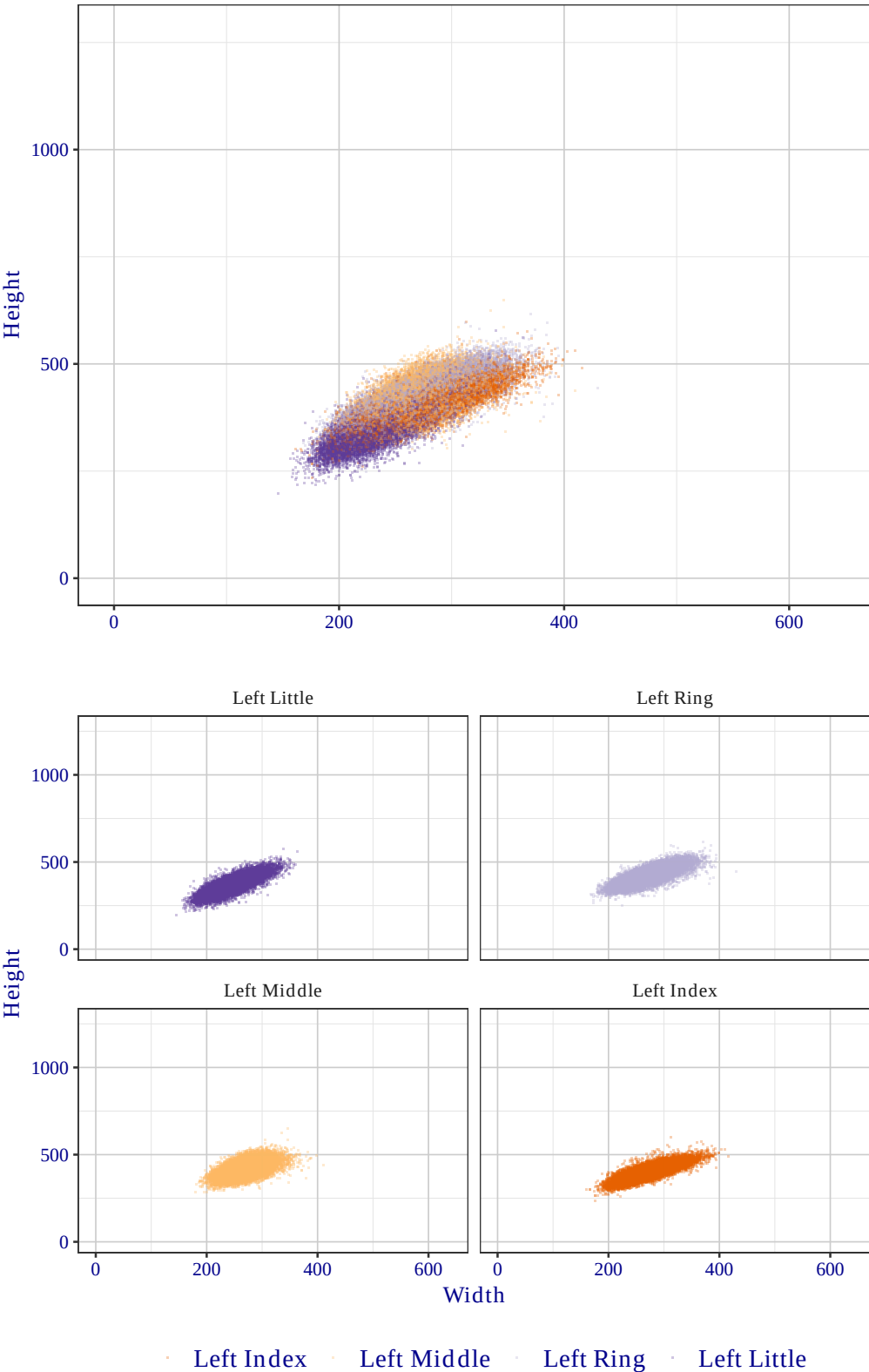
3.2.2 Segmentation Dimensions

The plots in this section show the distribution of segmentation position widths and heights for ThreeInch data. At the top of each figure is a combined plot for all finger positions of a given hand orientation. These figures are isolated in plots faceted at the bottom of the figure.

Plots of segmentation position dimensions for the right hand ThreeInch data are shown in Figure 11, for the left hand in Figure 10, and for thumbs in Figure 12. Blank lines that may appear in the plots are **not** rendering artifacts. Rather, they are indicative of image downsampling. Dimensions have been normalized to 500 pixels per inch.

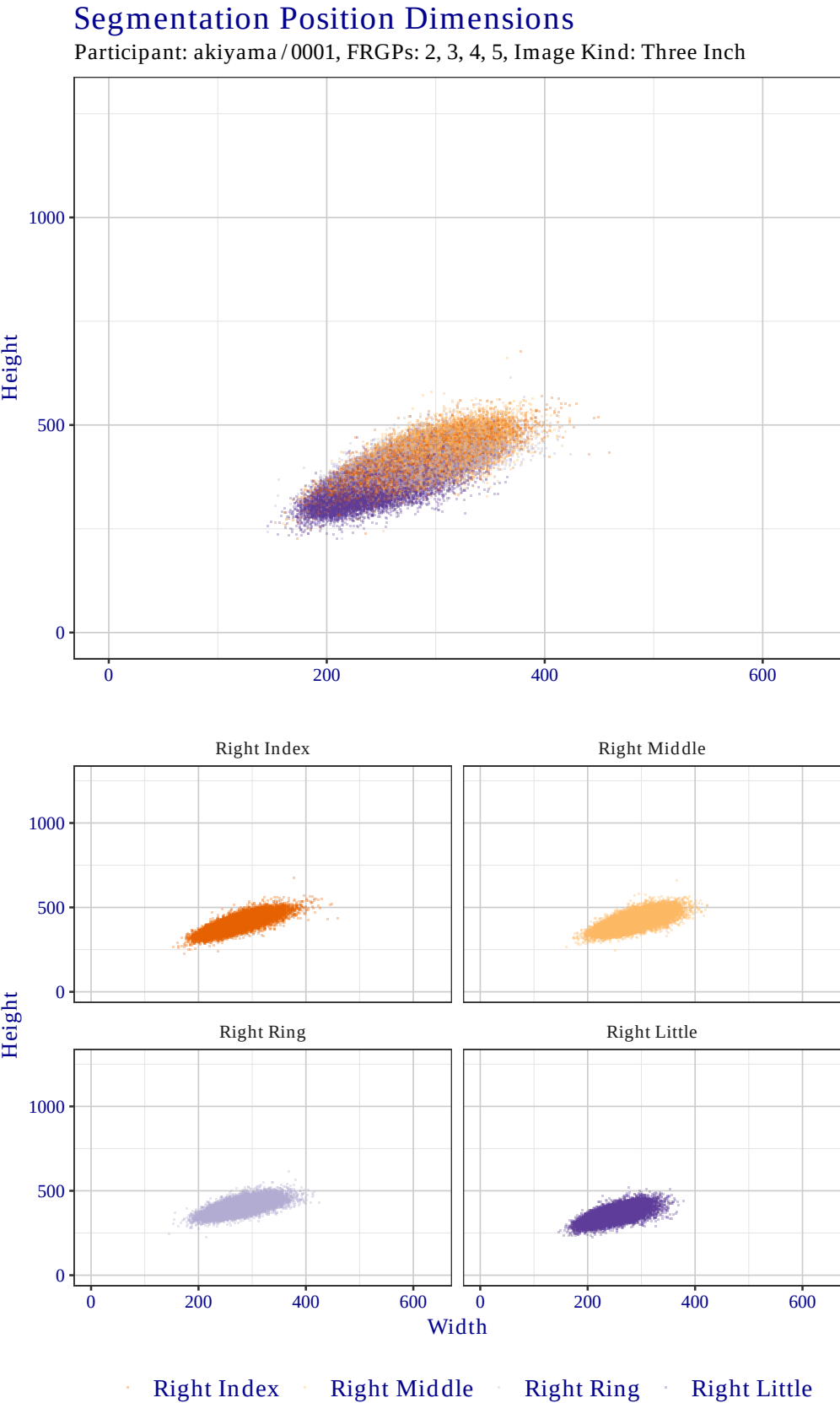
Segmentation Position Dimensions

Participant: akiyama / 0001, FRGPs: 7, 8, 9, 10, Image Kind: Three Inch



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Figure 10: Segmentation position dimensions for left hand ThreeInch data.

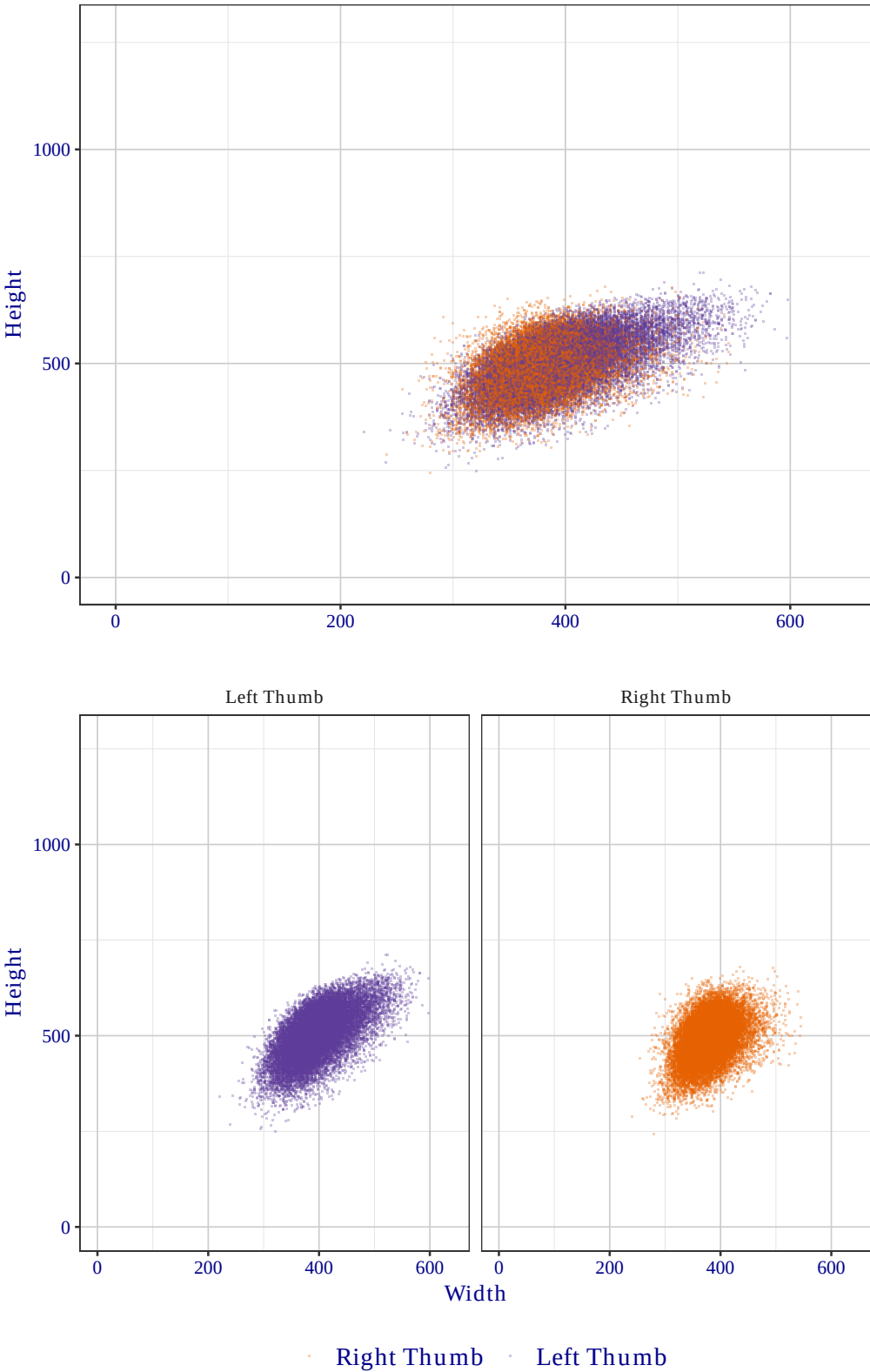


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Figure 11: Segmentation position dimensions for right hand ThreeInch data.

Segmentation Position Dimensions

Participant: akiyama / 0001, FRGPs: 1, 6, Image Kind: Three Inch



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Figure 12: Segmentation position dimensions for thumb ThreeInch data.

3.3 Detailed Segmentation Statistics

This section shows detailed results of segmentation of ThreeInch data. Values in each table are the percentage that the variable in the left-most column was correctly segmented.

Each table has three columns of percentages. The *Standard Scoring* column shows the percentage of correctly-segmented positions based on the scoring metrics defined in the SlapSeg III scoring document. The *Ignoring Bottom Y* column shows how the percentage would change if the threshold for the *bottom Y* coordinate of the segmentation position was ignored. Similarly, the *Ignoring Bottom X and Y* columns shows how the percentage would change if only the top, left, and right sides of the segmentation position were considered. These two supplemental columns are included because it has traditionally been difficult to determine the exact location of the distal interphalangeal joint.

Table 15 shows how successful akiyama+0001 segmented fingers for each subject in the test corpus. Table 16 shows success for specific finger positions over the entire test corpus. Similarly, Table 17 shows success for segmenting the same finger position from both hands.

The remainder of the tables show success per subject when considering combinations of subsets of the fingers on each slap image. Table 18 shows success for combinations of all fingers, Table 19 for just the index and middle fingers, and Table 20 for all except the little finger.

Table 15: For each subject, the percentage that at least *Number of Fingers* fingers were correctly segmented, regardless of hand, for a maximum of eight correctly-segmented fingers. In *Standard Scoring*, scoring rules are followed exactly. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Number of Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
1	98.8	98.8	98.9
2	98.1	98.1	98.2
3	97.2	97.2	97.6
4	95.3	95.3	96.3
5	91.2	91.3	93.5
6	85.1	85.1	89.9
7	73.0	73.0	82.3
8	53.5	53.5	66.5
9	29.0	29.0	40.5
10	9.6	9.6	15.8

Table 16: For all subjects, percentage that a particular friction ridge generalized position was correctly segmented. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Finger	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Thumb	50.6	50.6	55.1
Index	79.7	79.7	81.3
Middle	89.8	89.8	93.3
Ring	82.3	82.3	85.8
Little	76.4	76.4	87.6
Left			
Thumb	49.1	49.1	52.2
Index	81.0	81.0	85.4
Middle	81.3	81.4	86.0
Ring	86.2	86.3	89.0
Little	73.9	73.9	84.6

Table 17: Percentage that a particular type of fingerprint was correctly segmented on *Either* or *Both* hands. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Thumb			
Either	67.3	67.3	71.4
Both	32.5	32.5	36.0
Index			
Either	94.7	94.7	95.9
Both	64.1	64.1	68.8
Middle			
Either	96.7	96.7	98.0
Both	72.2	72.2	79.0
Ring			
Either	95.8	95.8	97.0
Both	70.6	70.6	75.6
Little			
Either	91.8	91.8	96.8
Both	56.5	56.5	73.3

Table 18: Percentage of segmentation success by hand for combinations of all ten fingers of a ThreeInch slap. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Any	98.1	98.1	98.4
At Least Two	95.3	95.3	96.4
At Least Three	87.3	87.3	91.4
At Least Four	66.0	66.0	75.7
All Five	25.7	25.7	34.3
Left			
Any	97.6	97.7	98.1
At Least Two	94.0	94.0	96.0
At Least Three	84.9	84.9	89.9
At Least Four	63.6	63.7	73.7
All Five	25.0	25.0	32.6

Table 19: Percentage of segmentation success by hand when only considering combinations of index and middle fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Either	95.6	95.6	96.6
Both	74.0	74.0	78.0
Left			
Either	93.2	93.2	95.1
Both	69.1	69.1	76.3

Table 20: Percentage of segmentation success by hand when only considering combinations of index, middle, and ring fingers. In *Ignoring Bottom Y*, the bottom left and right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Any	97.7	97.7	98.2
At Least Two	90.2	90.2	92.6
All Three	63.9	63.9	69.6
Left			
Any	97.3	97.3	98.1
At Least Two	87.8	87.9	91.2
All Three	63.5	63.5	71.0

3.4 Handling Troublesome Images

3.4.1 Capture Failures

Segmentation algorithms may refuse to process an image. This may happen for a technical reason (e.g., the algorithm cannot parse the image data), or for a practical reason (e.g., the hand in the image is placed incorrectly). These failure scenarios are the result of capturing improper image data. In these types of scenarios, it is important to examine the cause of the failure. With many live scan capture setups, segmentation is performed immediately after capture. If an algorithm can detect that it won't be able to segment an image due to a technical or practical issue, it can alert the operator to perform a recapture before the subject leaves.

The SlapSeg III API encourages algorithms to identify these failure reasons by specifying pre-defined *deficiencies* in the image. Algorithms should attempt segmentation even if an image deficiency is encountered if at all possible. Note that SlapSeg III *guarantees* well-formed image data, so failures to parse are **not** an indicator of the data provided.

Reasons for capture-type failures reported by akiyama+0001 are enumerated in Table 21.

Table 21: Count of self-reported capture-type failure reasoning.

Failure Reason	Images
Request Recapture (No Attempt)	1 045

In situations where the algorithm feels that the presented image should be recaptured (Table 21), one or more image deficiencies must be identified. These deficiencies are enumerated in Table 22. At this point, NIST does not have a groundtruth of image deficiencies, but plans to update this table with the accuracy of deficiency observations in the future.

Table 22: Count of image deficiencies reported when requesting a recapture.

Deficiency	Count
Incomplete	1 045

3.4.1.1 Recovery When encountering a segmentation failure, SlapSeg III algorithms are encouraged to provide a *best-effort* segmentation when possible. In some cases, that best-effort may be correct, which reduces the amount of images that need to be manually adjudicated by an operator.

akiyama+0001 did not attempt any recovery segmentations.

3.4.2 Segmentation Failures

Even if an algorithm accepts an image for processing, it can still fail to process one or more fingers from the image, regardless of if the algorithm requested a recapture and provided best-effort segmentation.

The SlapSeg III API allows algorithms to communicate reasons for failure to process these fingers. In some cases, the distal phalanx in question might not be present in the image due to amputation or being placed outside the platen's capture area. It is imperative that the segmentation algorithm correctly report this as failing to segment the correct friction ridge generalized position without disrupting the sequence of valid positions present in the image. This can help prompt an operator to recapture or record additional information about the subject.

In SlapSeg III, a number of images are missing fingers or otherwise have fingers that will not be able to be segmented. Reasons for segmentation failures reported by akiyama+0001 are enumerated in Table 23.

Table 23: Count of self-reported segmentation failure reasoning.

Failure Reason	Fingers
Finger Not Found	184
Finger Found, but Can't Segment	0
Vendor Defined	0

3.4.3 Identifying Missing Fingers

A small portion of the test corpus in SlapSeg III are missing fingers. Table 24 shows how successful akiyama+0001 was in correctly determining if a finger was missing. The *Missed* row shows when a segmentation position was returned for a missing finger. All possible failure reasons are enumerated, but are not considered *Correctly Identified* because the algorithm specified failure for a reason other than the finger not being found.

Table 24: Performance of akiyama+0001 at detecting fingers missing from an image.

Result	Percentage
Missed	51.1
Correctly Identified	16.8
Other Failure: Finger Found, but Can't Segment	0.0
Other Failure: Vendor Defined	0.0
Other Failure: Segmentation Not Attempted	32.1

3.4.4 Sequence Error

Sequence error occurs when a fingerprint is segmented from an image but assigned an incorrect finger position (e.g., segmenting a right middle finger but labeling it a right index finger). Table 25 shows cases in which a segmentation position was returned that matched a ground truth segmentation position for a different finger in the same image.

Table 25: Percentage of images in the dataset where one or more segmentation positions correctly matched an incorrect finger position within the same image, indicating sequence error.

Hand	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Left	0.00	0.00	0.00
Right	0.00	0.00	0.00
Thumbs	0.00	0.00	0.00
Combined	0.00	0.00	0.00

3.5 Determining Orientation

An *optional* portion of the SlapSeg III API asked participants to determine the hand orientation of an image. Participants were provided the kind (e.g., Identification Flat) and needed to determine whether the image was of the left hand, right hand, or thumbs.

Overall Three Inch accuracy: 98.6%

Table 26: Percentage of accuracy when determining hand orientation of a three inch image. The first column indicates the true hand orientation. Subsequent columns indicate the percentage of the time in which the indicated hand orientation was hypothesized.

	Left	Right	Skip	Thumbs
Left	99.8	0.2	0	0
Right	0.3	99.7	0	0
Thumbs	1.2	0.7	2	96.1

A Tenprint Cards (“TwoInch” Data)

A.1 Bootstrap Confidence for Segmentation Statistics

This section shows the same detailed results of segmentation of TwoInch data from Section 2.3, but with an added bootstrap confidence interval. For each observation, a bootstrap routine with 1 000 replicates was run, and a 95 % confidence interval extracted. The lower and upper confidence from that confidence interval are printed in each column within square brackets.

In Table 27, results are shown of how successful akiyama+0001 segmented fingers for each subject in the test corpus. Table 28 shows success for specific finger positions over the entire test corpus. Similarly, Table 29 shows success for segmenting the same finger position from both hands.

The remainder of the tables show success per subject when considering combinations of subsets of the fingers in each slap image. Table 30 shows success for combinations of all fingers, Table 32 for the all except the little finger, and Table 31 for just the index and middle fingers.

Table 27: For each subject, the percentage that at least *Number of Fingers* fingers were correctly segmented, regardless of hand, for a maximum of eight correctly-segmented fingers. In *Standard Scoring*, scoring rules are followed exactly. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Number of Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
1	87.3 [86.7, 87.8]	90.3 [89.8, 90.8]	97.6 [97.3, 97.8]
2	79.5 [78.8, 80.2]	83.3 [82.7, 84.0]	92.9 [92.5, 93.3]
3	71.8 [71.0, 72.6]	76.4 [75.6, 77.1]	86.3 [85.7, 86.9]
4	61.9 [61.1, 62.7]	67.8 [66.9, 68.5]	78.2 [77.5, 78.9]
5	46.2 [45.4, 47.1]	51.7 [50.9, 52.5]	65.2 [64.4, 66.0]
6	37.0 [36.3, 37.8]	42.2 [41.2, 43.0]	52.2 [51.3, 53.0]
7	27.2 [26.5, 28.0]	32.1 [31.3, 32.9]	39.5 [38.7, 40.3]
8	15.2 [14.6, 15.9]	19.7 [19.0, 20.4]	24.9 [24.1, 25.6]

Table 28: For all subjects, Percentage that a particular friction ridge generalized position was correctly segmented. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Finger	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Index	55.4 [54.7, 56.1]	59.4 [58.7, 60.0]	65.6 [64.9, 66.2]
Middle	46.3 [45.6, 47.0]	48.1 [47.4, 48.7]	49.6 [49.0, 50.3]
Ring	52.4 [51.7, 53.0]	54.9 [54.3, 55.5]	58.0 [57.4, 58.7]
Little	57.3 [56.6, 58.0]	62.1 [61.5, 62.7]	85.9 [85.4, 86.3]
Left			
Index	56.6 [55.9, 57.3]	65.0 [64.3, 65.6]	78.0 [77.5, 78.6]
Middle	53.4 [52.7, 54.1]	55.1 [54.4, 55.8]	63.2 [62.6, 63.9]
Ring	61.3 [60.6, 62.0]	64.2 [63.6, 64.9]	72.4 [71.8, 73.1]
Little	55.7 [55.0, 56.5]	68.4 [67.7, 69.1]	78.4 [77.8, 78.9]

Table 29: Percentage that a particular type of fingerprint was correctly segmented on *Either* or *Both* hands. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Index			
Either	73.9 [73.2, 74.7]	79.7 [79.0, 80.4]	87.6 [87.1, 88.2]
Both	34.9 [34.2, 35.7]	41.0 [40.2, 41.9]	51.4 [50.5, 52.3]
Middle			
Either	68.3 [67.5, 69.1]	70.0 [69.2, 70.8]	75.2 [74.4, 75.9]
Both	29.2 [28.4, 29.9]	30.8 [29.9, 31.6]	34.9 [34.1, 35.7]
Ring			
Either	74.3 [73.5, 75.0]	76.8 [76.0, 77.5]	82.5 [81.9, 83.1]
Both	36.0 [35.2, 36.8]	39.0 [38.2, 39.9]	44.8 [43.9, 45.6]
Little			
Either	74.7 [73.9, 75.5]	82.8 [82.2, 83.4]	94.7 [94.3, 95.1]
Both	34.8 [34.0, 35.6]	43.5 [42.7, 44.3]	65.8 [65.0, 66.6]

Table 30: Percentage of segmentation success by hand for combinations of all eight fingers of a TwoInch slap. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Any	70.4 [72.7, 73.5]	72.9 [76.4, 77.1]	89.0 [89.7, 90.2]
At Least Two	59.4 [61.4, 62.3]	62.6 [65.7, 66.6]	71.6 [75.6, 76.4]
At Least Three	48.6 [49.8, 50.7]	51.8 [54.6, 55.5]	57.0 [62.1, 63.0]
All Four	33.0 [33.0, 33.9]	37.3 [39.2, 40.1]	41.5 [45.5, 46.4]
Left			
Any	76.2 [72.7, 73.5]	81.2 [76.4, 77.1]	91.0 [89.7, 90.2]
At Least Two	64.6 [61.4, 62.3]	70.3 [65.7, 66.6]	81.1 [75.6, 76.4]
At Least Three	52.2 [49.8, 50.7]	58.9 [54.6, 55.5]	69.0 [62.1, 63.0]
All Four	34.0 [33.0, 33.9]	42.4 [39.2, 40.1]	51.1 [45.5, 46.4]

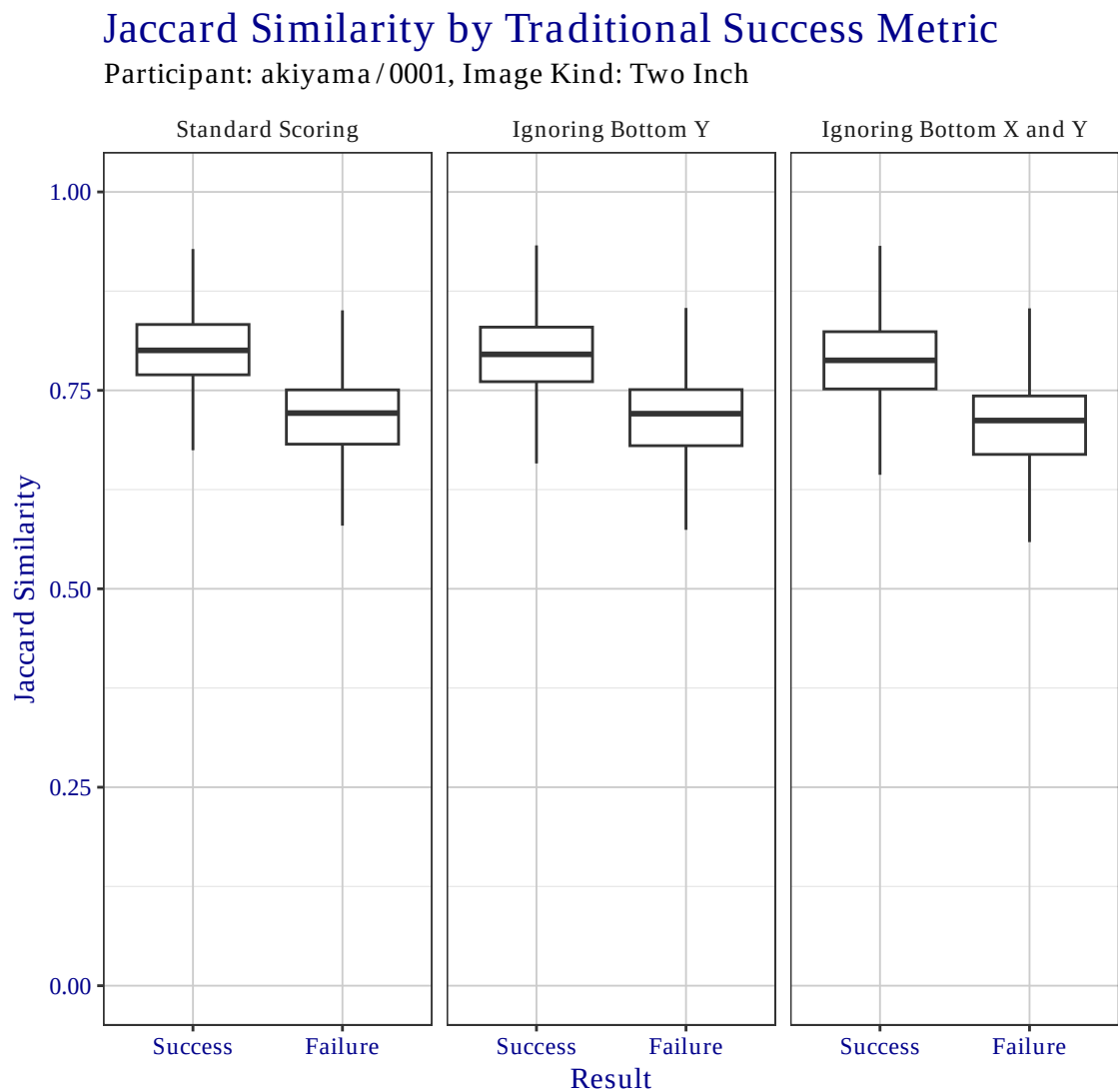
Table 31: Percentage of segmentation success by hand when only considering combinations of index and middle fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Either Index or Middle	60.9 [62.8, 63.7]	63.7 [66.5, 67.3]	69.1 [75.2, 76.0]
Both Index and Middle	40.8 [41.9, 42.8]	43.7 [46.0, 46.9]	46.1 [51.3, 52.3]
Left			
Either Index or Middle	66.0 [62.8, 63.7]	70.6 [66.5, 67.3]	83.0 [75.2, 76.0]
Both Index and Middle	44.0 [41.9, 42.8]	49.5 [46.0, 46.9]	58.2 [51.3, 52.3]

Table 32: Percentage of segmentation success by hand when only considering combinations of index, middle, and ring fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

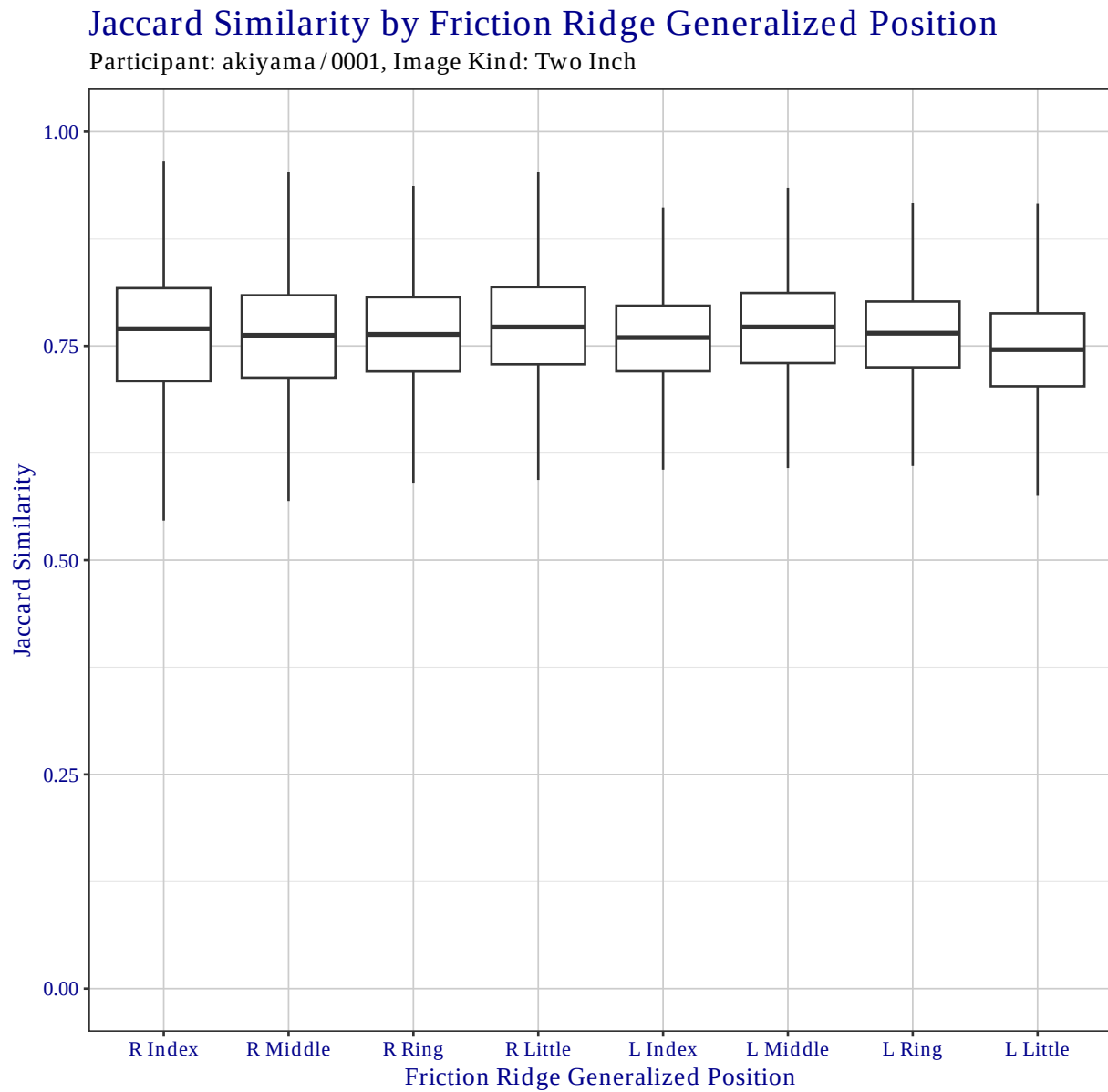
Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Any	65.6 [68.4, 69.2]	67.9 [71.1, 72.0]	73.4 [79.2, 79.9]
At Least Two	52.0 [54.6, 55.6]	54.7 [57.9, 58.9]	57.6 [64.2, 65.1]
All Three	36.5 [37.7, 38.7]	39.7 [42.2, 43.1]	42.2 [47.4, 48.3]
Left			
Any	72.4 [68.4, 69.2]	75.7 [71.1, 72.0]	86.7 [79.2, 79.9]
At Least Two	58.7 [54.6, 55.6]	62.6 [57.9, 58.9]	72.7 [64.2, 65.1]
All Three	40.2 [37.7, 38.7]	46.0 [42.2, 43.1]	54.3 [47.4, 48.3]

A.2 Jaccard Index



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Figure 13: Boxplot of Jaccard similarity indices as compared to the traditional success metrics. Outliers have been removed for clarity.



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Figure 14: Boxplot of Jaccard similarity indices for each friction ridge generalized position. Outliers have been removed for clarity.

Table 33: For each subject, the percentage that at least *Number of Fingers* fingers were segmented with a Jaccard index in the indicated range.

Number of Fingers	≥ 0.5	≥ 0.6	≥ 0.7	≥ 0.8	≥ 0.9	≥ 0.95	≥ 0.98
1	99.8	99.8	99.2	70.5	7.1	0.4	0.1
2	99.8	99.7	98.0	54.8	1.3	0.0	0.0
3	99.7	99.3	95.8	40.1	0.2	0.0	0.0
4	99.1	98.5	91.8	26.4	0.0	0.0	0.0
5	95.6	95.2	84.2	15.1	0.0	0	0
6	95.5	94.1	75.5	8.0	0	0	0
7	94.7	91.0	61.5	3.3	0	0	0
8	91.4	80.7	37.9	0.8	0	0	0

Table 34: For all subjects, percentage that a particular friction ridge generalized position was segmented with a Jaccard index in the indicated range.

Finger	0-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1.0
Right						
Index	1.9	4.8	15.8	43.4	32.4	1.7
Middle	1.3	3.0	16.3	50.3	27.8	1.3
Ring	0.5	1.3	14.5	55.3	27.2	1.2
Little	0.6	1.2	12.0	52.1	31.7	2.4
Left						
Index	0.4	1.5	14.5	60.4	22.9	0.3
Middle	0.7	1.4	11.0	55.0	31.0	0.9
Ring	0.5	1.2	12.6	59.7	25.5	0.5
Little	1.1	2.5	20.1	56.4	19.0	0.9

Table 35: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of all eight fingers of a TwoInch slap.

Fingers	≥ 0.5	≥ 0.6	≥ 0.7	≥ 0.8	≥ 0.9	≥ 0.95	≥ 0.98
Right							
Any	99.9	99.7	95.3	54.8	5.5	0.2	0.0
At Least Two	99.7	98.9	89.5	38.4	0.9	0.0	0.0
At Least Three	99.2	96.7	80.5	23.5	0.1	0.0	0.0
All Four	97.0	90.1	61.7	9.1	0.0	0.0	0.0
Left							
Any	99.9	99.8	97.5	50.6	2.3	0.1	0.0
At Least Two	99.8	99.6	93.3	30.8	0.2	0.0	0.0
At Least Three	99.5	98.5	83.5	15.0	0.0	0.0	0.0
All Four	98.1	92.8	58.2	4.5	0.0	0.0	0.0

Table 36: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index and middle fingers of a TwoInch slap.

Fingers	≥ 0.5	≥ 0.6	≥ 0.7	≥ 0.8	≥ 0.9	≥ 0.95	≥ 0.98
Right							
Either Index or Middle	99.4	97.5	87.1	44.2	2.9	0.1	0.0
Both Index and Middle	97.5	91.5	69.9	19.0	0.1	0.0	0.0
Left							
Either Index or Middle	99.8	99.5	94.2	41.2	1.2	0.1	0.0
Both Index and Middle	99.1	96.5	76.3	13.8	0.0	0.0	0.0

Table 37: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index, middle, and ring fingers of a TwoInch slap.

Fingers	≥ 0.5	≥ 0.6	≥ 0.7	≥ 0.8	≥ 0.9	≥ 0.95	≥ 0.98
Right							
Any	99.8	99.1	91.7	49.5	3.8	0.1	0.0
At Least Two	99.3	97.1	83.1	29.8	0.4	0.0	0.0
All Three	97.3	91.1	65.9	12.4	0.0	0.0	0.0
Left							
Any	99.8	99.7	96.5	47.8	1.7	0.1	0.0
At Least Two	99.6	99.1	89.8	25.4	0.1	0.0	0.0
All Three	98.9	95.5	69.9	7.9	0.0	0.0	0.0

B Identification Flats (“ThreeInch” Data)

B.1 Bootstrap Confidence for Segmentation Statistics

This section shows the same detailed results of segmentation of ThreeInch data from Section 3.3, but with an added bootstrap confidence interval. For each observation, a bootstrap routine with 1 000 replicates was run, and a 95 % confidence interval extracted. The lower and upper confidence from that confidence interval are printed in each column within square brackets.

In Table 38, results are shown of how successful akiyama+0001 segmented fingers for each subject in the test corpus. Table 39 shows success for specific finger positions over the entire test corpus. Similarly, Table 40 shows success for segmenting the same finger position from both hands.

The remainder of the tables show success per subject when considering combinations of subsets of the fingers in each slap image. Table 41 shows success for combinations of all fingers, Table 43 for the all except the little finger, and Table 42 for just the index and middle fingers.

Table 38: For each subject, the percentage that at least *Number of Fingers* fingers were correctly segmented, regardless of hand, for a maximum of eight correctly-segmented fingers. In *Standard Scoring*, scoring rules are followed exactly. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Number of Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
1	98.8 [98.7, 99.0]	98.8 [98.7, 99.0]	98.9 [98.7, 99.0]
2	98.1 [97.9, 98.2]	98.1 [97.9, 98.2]	98.2 [98.0, 98.4]
3	97.2 [96.9, 97.4]	97.2 [97.0, 97.4]	97.6 [97.5, 97.8]
4	95.3 [95.0, 95.5]	95.3 [95.0, 95.6]	96.3 [96.1, 96.6]
5	91.2 [90.9, 91.6]	91.3 [90.9, 91.6]	93.5 [93.2, 93.8]
6	85.1 [84.7, 85.6]	85.1 [84.7, 85.6]	89.9 [89.6, 90.3]
7	73.0 [72.4, 73.6]	73.0 [72.5, 73.6]	82.3 [81.8, 82.8]
8	53.5 [52.8, 54.1]	53.5 [52.9, 54.1]	66.5 [65.9, 67.1]
9	29.0 [28.4, 29.5]	29.0 [28.4, 29.5]	40.5 [39.8, 41.1]
10	9.6 [9.2, 10.0]	9.6 [9.3, 10.0]	15.8 [15.4, 16.2]

Table 39: For all subjects, Percentage that a particular friction ridge generalized position was correctly segmented. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Finger	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Thumb	50.6 [50.0, 51.3]	50.6 [50.0, 51.2]	55.1 [54.4, 55.7]
Index	79.7 [79.2, 80.2]	79.7 [79.2, 80.2]	81.3 [80.8, 81.8]
Middle	89.8 [89.5, 90.2]	89.8 [89.5, 90.2]	93.3 [93.0, 93.6]
Ring	82.3 [81.8, 82.8]	82.3 [81.8, 82.8]	85.8 [85.4, 86.3]
Little	76.4 [75.8, 76.9]	76.4 [75.8, 76.9]	87.6 [87.2, 88.0]
Left			
Thumb	49.1 [48.4, 49.7]	49.1 [48.4, 49.7]	52.2 [51.6, 52.8]
Index	81.0 [80.5, 81.5]	81.0 [80.5, 81.5]	85.4 [84.9, 85.8]
Middle	81.3 [80.9, 81.8]	81.4 [80.9, 81.8]	86.0 [85.6, 86.4]
Ring	86.2 [85.8, 86.7]	86.3 [85.8, 86.7]	89.0 [88.6, 89.3]
Little	73.9 [73.4, 74.4]	73.9 [73.3, 74.4]	84.6 [84.2, 85.1]

Table 40: Percentage that a particular type of fingerprint was correctly segmented on *Either* or *Both* hands. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Thumb			
Either	67.3 [66.8, 67.9]	67.3 [66.8, 67.9]	71.4 [70.8, 72.0]
Both	32.5 [31.9, 33.1]	32.5 [31.9, 33.1]	36.0 [35.4, 36.6]
Index			
Either	94.7 [94.4, 95.0]	94.7 [94.4, 95.0]	95.9 [95.7, 96.2]
Both	64.1 [63.6, 64.7]	64.1 [63.6, 64.7]	68.8 [68.2, 69.4]
Middle			
Either	96.7 [96.5, 96.9]	96.7 [96.5, 96.9]	98.0 [97.9, 98.2]
Both	72.2 [71.7, 72.8]	72.2 [71.7, 72.8]	79.0 [78.4, 79.5]
Ring			
Either	95.8 [95.5, 96.0]	95.8 [95.5, 96.1]	97.0 [96.8, 97.2]
Both	70.6 [70.1, 71.2]	70.6 [70.1, 71.2]	75.6 [75.1, 76.1]
Little			
Either	91.8 [91.4, 92.1]	91.8 [91.4, 92.1]	96.8 [96.5, 97.0]
Both	56.5 [55.8, 57.1]	56.5 [55.8, 57.1]	73.3 [72.7, 73.8]

Table 41: Percentage of segmentation success by hand for combinations of all ten fingers of a ThreeInch slap. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Any	98.1 [97.7, 98.0]	98.1 [97.8, 98.0]	98.4 [98.1, 98.3]
At Least Two	95.3 [94.5, 94.9]	95.3 [94.5, 94.9]	96.4 [96.0, 96.4]
At Least Three	87.3 [85.8, 86.3]	87.3 [85.8, 86.3]	91.4 [90.4, 90.9]
At Least Four	66.0 [64.4, 65.2]	66.0 [64.4, 65.3]	75.7 [74.4, 75.1]
All Five	25.7 [25.0, 25.7]	25.7 [25.0, 25.7]	34.3 [33.0, 33.8]
Left			
Any	97.6 [97.7, 98.0]	97.7 [97.8, 98.0]	98.1 [98.1, 98.3]
At Least Two	94.0 [94.5, 94.9]	94.0 [94.5, 94.9]	96.0 [96.0, 96.4]
At Least Three	84.9 [85.8, 86.3]	84.9 [85.8, 86.3]	89.9 [90.4, 90.9]
At Least Four	63.6 [64.4, 65.2]	63.7 [64.4, 65.3]	73.7 [74.4, 75.1]
All Five	25.0 [25.0, 25.7]	25.0 [25.0, 25.7]	32.6 [33.0, 33.8]

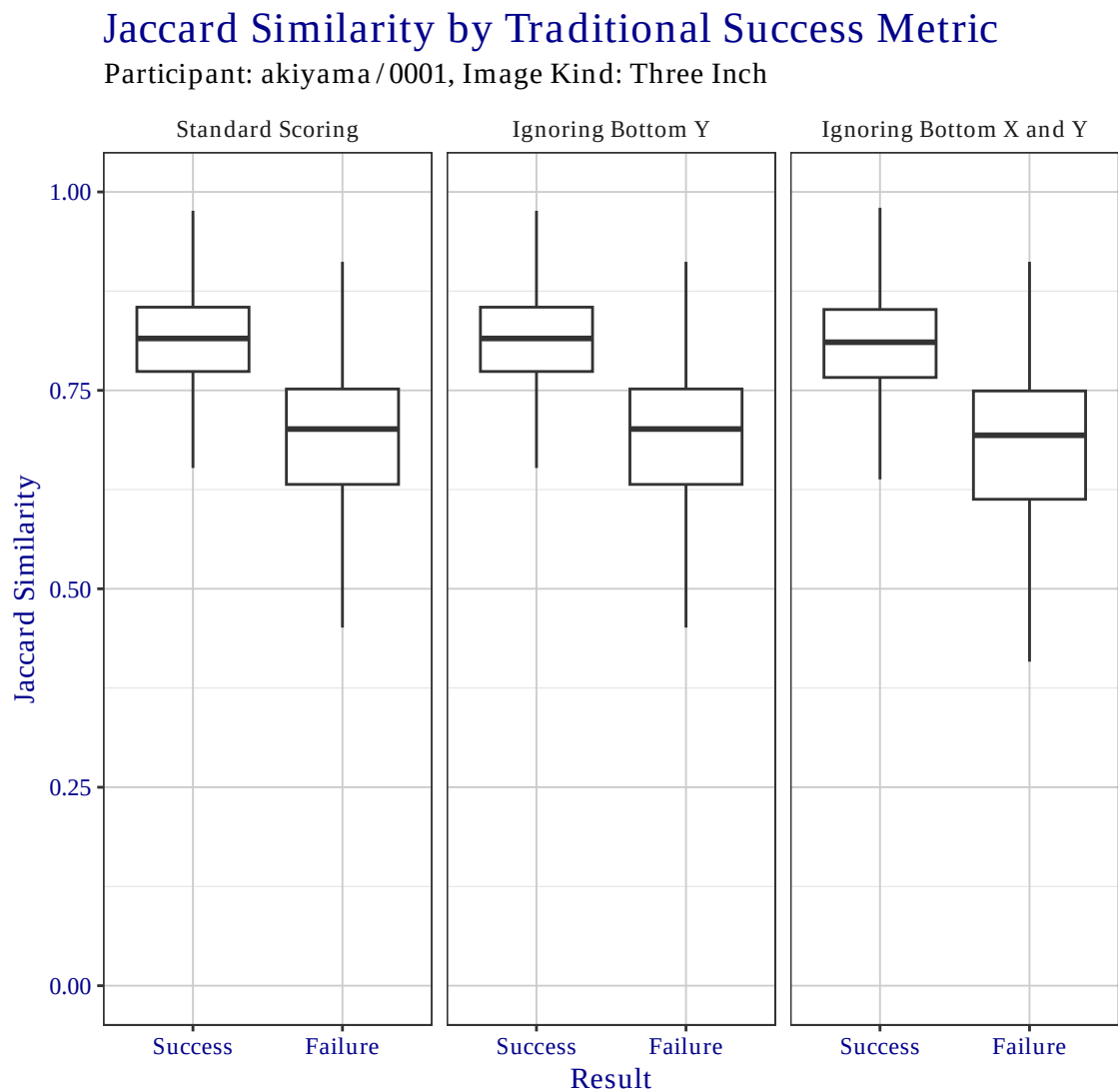
Table 42: Percentage of segmentation success by hand when only considering combinations of index and middle fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Either Index or Middle	95.6 [94.2, 94.6]	95.6 [94.2, 94.6]	96.6 [95.7, 96.0]
Both Index and Middle	74.0 [71.1, 71.9]	74.0 [71.2, 71.9]	78.0 [76.7, 77.5]
Left			
Either Index or Middle	93.2 [94.2, 94.6]	93.2 [94.2, 94.6]	95.1 [95.7, 96.0]
Both Index and Middle	69.1 [71.1, 71.9]	69.1 [71.2, 71.9]	76.3 [76.7, 77.5]

Table 43: Percentage of segmentation success by hand when only considering combinations of index, middle, and ring fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

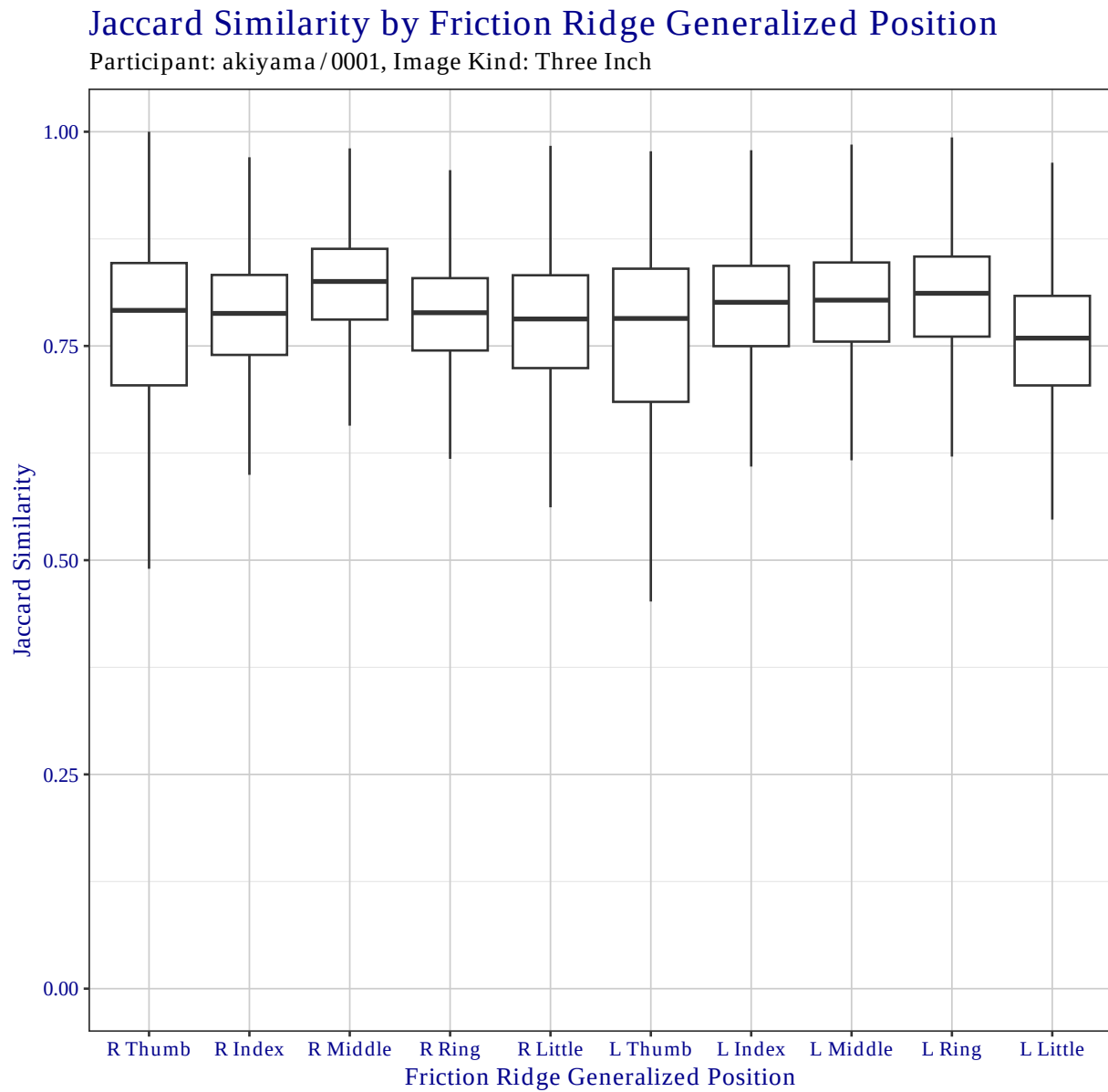
Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Any	97.7 [97.4, 97.6]	97.7 [97.3, 97.6]	98.2 [98.0, 98.2]
At Least Two	90.2 [88.7, 89.3]	90.2 [88.7, 89.3]	92.6 [91.7, 92.1]
All Three	63.9 [63.3, 64.1]	63.9 [63.3, 64.1]	69.6 [70.0, 70.7]
Left			
Any	97.3 [97.4, 97.6]	97.3 [97.3, 97.6]	98.1 [98.0, 98.2]
At Least Two	87.8 [88.7, 89.3]	87.9 [88.7, 89.3]	91.2 [91.7, 92.1]
All Three	63.5 [63.3, 64.1]	63.5 [63.3, 64.1]	71.0 [70.0, 70.7]

B.2 Jaccard Index



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Figure 15: Boxplot of Jaccard similarity indices as compared to the traditional success metrics. Outliers have been removed for clarity.



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Figure 16: Boxplot of Jaccard similarity indices for each friction ridge generalized position. Outliers have been removed for clarity.

Table 44: For each subject, the percentage that at least *Number of Fingers* fingers were segmented with a Jaccard index in the indicated range.

Number of Fingers	≥ 0.5	≥ 0.6	≥ 0.7	≥ 0.8	≥ 0.9	≥ 0.95	≥ 0.98
1	99.9	99.8	99.6	97.2	36.3	3.0	0.2
2	99.7	99.5	98.4	92.3	9.1	0.1	0.0
3	98.4	98.2	97.6	83.4	1.7	0.0	0.0
4	98.1	97.7	96.5	69.4	0.3	0.0	0.0
5	95.8	95.6	94.1	52.1	0.0	0	0
6	95.7	95.3	91.6	34.0	0	0	0
7	95.3	94.5	86.8	18.8	0	0	0
8	94.8	92.7	76.4	8.2	0	0	0
9	89.5	83.8	56.6	2.5	0	0	0
10	82.0	69.1	30.7	0.5	0	0	0

Table 45: For all subjects, percentage that a particular friction ridge generalized position was segmented with a Jaccard index in the indicated range.

Finger	0-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1.0
Right						
Thumb	7.9	4.7	11.7	29.2	40.1	6.4
Index	0.9	1.5	9.8	44.7	39.7	3.4
Middle	0.9	0.8	3.5	29.1	57.4	8.3
Ring	0.8	1.1	8.8	46.3	40.3	2.7
Little	1.8	2.6	13.1	42.1	36.0	4.4
Left						
Thumb	8.5	6.3	13.0	29.3	38.1	4.8
Index	0.7	1.1	9.1	38.6	46.2	4.3
Middle	0.7	1.0	7.1	39.1	46.3	5.8
Ring	0.8	1.2	7.2	34.4	49.8	6.6
Little	1.7	3.6	18.3	47.5	26.9	2.0

Table 46: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of all ten fingers of a ThreeInch slap.

Fingers	≥ 0.5	≥ 0.6	≥ 0.7	≥ 0.8	≥ 0.9	≥ 0.95	≥ 0.98
Right							
Any	99.8	99.7	99.1	91.5	21.5	1.6	0.1
At Least Two	98.2	98.0	96.8	72.3	2.8	0.0	0.0
At Least Three	98.0	97.4	93.2	45.9	0.3	0.0	0.0
At Least Four	97.2	95.4	82.8	20.1	0.0	0.0	0.0
All Five	85.6	78.1	50.7	4.6	0.0	0.0	0.0
Left							
Any	99.8	99.6	98.5	89.4	19.9	1.4	0.1
At Least Two	98.3	98.1	96.3	69.6	2.9	0.1	0.0
At Least Three	98.0	97.4	92.1	44.0	0.2	0.0	0.0
At Least Four	97.3	95.1	79.3	19.3	0.0	0.0	0.0
All Five	85.1	75.6	45.9	4.2	0.0	0.0	0.0

Table 47: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index and middle fingers of a ThreeInch slap.

Fingers	≥ 0.5	≥ 0.6	≥ 0.7	≥ 0.8	≥ 0.9	≥ 0.95	≥ 0.98
Right							
Either Index or Middle	99.5	99.1	97.4	75.2	10.9	0.8	0.0
Both Index and Middle	98.7	96.9	85.3	33.6	0.7	0.0	0.0
Left							
Either Index or Middle	99.6	99.3	96.8	70.6	9.6	0.7	0.0
Both Index and Middle	98.9	97.2	83.5	32.0	0.5	0.0	0.0

Table 48: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index, middle, and ring fingers of a ThreeInch slap.

Fingers	≥ 0.5	≥ 0.6	≥ 0.7	≥ 0.8	≥ 0.9	≥ 0.95	≥ 0.98
Right							
Any	99.7	99.5	98.5	82.1	12.9	0.9	0.1
At Least Two	99.3	98.7	94.5	51.0	1.3	0.0	0.0
All Three	98.4	95.9	78.9	18.7	0.1	0.0	0.0
Left							
Any	99.7	99.6	98.4	81.4	14.8	1.1	0.1
At Least Two	99.5	98.9	93.9	54.0	1.7	0.0	0.0
All Three	98.5	96.0	78.8	23.5	0.1	0	0