

Statistical Analysis of Widths and Heights of Fingerprint Images in Terms of Ages from Segmentation Data

October 15, 2008

Jin Chu Wu

In the July Report, the statistical analysis of widths and heights of fingerprint images from segmentation data was presented. In this October Report, the statistical analysis in terms of ages is carried out. All these results will provide references for designing targets for the evaluation of the fast tenprint capture (FTC) devices. As stated in the draft of “Specifications for Fast Tenprint Capture Devices”, Version 1.0, one of the three aspects in the evaluation of FTC devices is the absolute measurement, i.e., stipulating the specifications and designing targets to implement specifications. One of many aspects in the absolute measurement is the geometric accuracy. And the geometric accuracy is related to the finger sizes.

As pointed out in the July Report, in order to obtain the finger sizes, one way is to collect samples. For instance, the human finger sizes can be collected in any public areas. Then, an inferential statistical analysis follows. The alternative is to analyze the segmentation data.

Here we need to emphasize again that while analyzing the segmentation data, 1) the sizes of two thumbs cannot be obtained, 2) only the widths and heights but not the thicknesses of the fingers can be estimated, 3) the widths and heights shown in the segmentation data are the widths and heights of fingerprint images, respectively, that are smaller than the widths and heights of real fingers, which is because only the front part of a finger touches the platen of a live scanner to form a flat fingerprint image during a capture process. This third point is the most important issue. Nonetheless, the analysis of the segmentation data can provide some information, for example, the proportion between two finger sizes, etc., for designing the simulated fingers to be the targets in the absolute measurement.

The segmentation data were provided by Craig Watson’s subgroup and they included data from dos3s and lacnty (LA County). Some data contained the age information, but some data didn’t. In addition, some data were corrupted, in which the sizes of width and/or height were inappropriately recorded, or the birth date and the capture date did not match properly, or the age of the subject was less than 10. The corrupted data were deleted.

The set of the segmentation data is the direct product of the set of gender (male and female), the set of eight fingers (R2, R3, R4, R5, L7, L8, L9, and L10), and the set of the dimension (width and height). They can be mathematically expressed as,

$$\{\text{segmentation data}\} = \{\text{male, female}\} \otimes \{\text{R2, R3, R4, R5, L7, L8, L9, L10}\} \otimes \{\text{width, height}\}$$

As a result, the segmentation data can be subdivided into 32 subsets in terms of gender, finger, and the dimension, such as M_R2_w, M_R2_h, etc.

Further, as far as the age is concerned, the age is divided into three groups: age 10 to 30, age 31 to 60, and age 61 and up. Therefore, the total is 96 subsets. All these 96 subsets are denoted, respectively, as M_R2_w_30, M_R2_w_60, M_R2_w_90, and so on.

In each subset of the 96 subsets, the statistical analysis was carried out. And the results, such as the number of data (i.e., the sample size), the median, the mean, the standard error (SE) of the sample mean, and the 95% confidence interval (CI) of the sample mean, are provided. The unit of the sizes in the segmentation data was in pixel, as requested, which is more accurate than other units. However, only the results in terms of the unit millimeter, which were converted from the results using the unit of pixel, are provided. Otherwise, too many tables would be listed. The results in the unit of pixel are available on request.

The results of the statistical analysis are listed from Table 1 to Table 6. It is shown in these six tables that the median and the mean are quite close in each subset. This indicates that the distribution in each subset is quite symmetric. Therefore, the standard errors and the 95% confidence intervals of the sample mean instead of the median were computed. The standard error for female is generally greater than the one for male. This is because the sample size for female is smaller than the sample size for male in the segmentation data, especially for the age group of “10 to 30”, and “31 to 60”.

Generally speaking, it follows from these six tables that the fingerprint image sizes extracted from the segmentation data do not vary too much with respect to the age. Moreover, by comparing these six tables with the two tables in the unit of millimeter as shown in the July Report, it seems that while designing the targets of fingers, the age may not be a factor for the majority of cases.

Fingers	Number	Median	Mean	SE	95% CI
M_R2_w_30	11922	14.63	14.66	0.0127	(14.63, 14.68)
M_R3_w_30	11922	15.29	15.17	0.0132	(15.15, 15.20)
M_R4_w_30	11922	14.63	14.70	0.0122	(14.68, 14.73)
M_R5_w_30	11922	13.82	13.65	0.0137	(13.62, 13.68)
M_L7_w_30	11275	14.53	14.40	0.0127	(14.37, 14.42)
M_L8_w_30	11275	15.04	14.97	0.0137	(14.94, 15.00)
M_L9_w_30	11275	14.43	14.36	0.0127	(14.33, 14.38)
M_L10_w_30	11275	13.41	13.37	0.0142	(13.34, 13.39)
F_R2_w_30	5829	13.31	13.31	0.0163	(13.28, 13.34)
F_R3_w_30	5829	13.72	13.64	0.0183	(13.60, 13.68)
F_R4_w_30	5829	13.41	13.40	0.0168	(13.36, 13.43)
F_R5_w_30	5829	12.19	12.17	0.0188	(12.13, 12.21)
F_L7_w_30	5799	13.00	13.00	0.0163	(12.97, 13.03)
F_L8_w_30	5799	13.31	13.28	0.0183	(13.24, 13.31)
F_L9_w_30	5799	13.00	12.89	0.0173	(12.85, 12.92)
F_L10_w_30	5799	11.58	11.66	0.0188	(11.62, 11.70)

Table 1 The statistical results for the widths in millimeter of the 2nd, 3rd, 4th, and 5th finger of the right hand and the 7th, 8th, 9th, and 10th finger of the left hand for both male and female, in the age group of 10 to 30, where the number stands for the sample size.

Fingers	Number	Median	Mean	SE	95% CI
M_R2_h_30	11922	23.98	23.86	0.0203	(23.82, 23.90)
M_R3_h_30	11922	24.38	24.34	0.0244	(24.29, 24.39)
M_R4_h_30	11922	24.79	24.80	0.0229	(24.76, 24.85)
M_R5_h_30	11922	21.54	21.47	0.0224	(21.43, 21.51)
M_L7_h_30	11275	23.57	23.67	0.0198	(23.63, 23.71)
M_L8_h_30	11275	24.38	24.14	0.0264	(24.08, 24.19)
M_L9_h_30	11275	24.79	24.87	0.0229	(24.83, 24.91)
M_L10_h_30	11275	21.13	20.94	0.0254	(20.88, 20.98)
F_R2_h_30	5829	21.95	21.76	0.0279	(21.71, 21.82)
F_R3_h_30	5829	22.45	22.43	0.0325	(22.37, 22.50)
F_R4_h_30	5829	22.35	22.34	0.0325	(22.28, 22.41)
F_R5_h_30	5829	19.51	19.24	0.0305	(19.18, 19.30)
F_L7_h_30	5799	21.64	21.56	0.0274	(21.50, 21.61)
F_L8_h_30	5799	22.35	22.33	0.0315	(22.27, 22.39)
F_L9_h_30	5799	22.25	22.25	0.0305	(22.19, 22.31)
F_L10_h_30	5799	19.10	19.06	0.0310	(19.00, 19.12)

Table 2 The statistical results for the heights in millimeter of the 2nd, 3rd, 4th, and 5th finger of the right hand and the 7th, 8th, 9th, and 10th finger of the left hand for both male and female, in the age group of 10 to 30, where the number stands for the sample size.

Fingers	Number	Median	Mean	SE	95% CI
M_R2_w_60	12383	15.44	15.22	0.0127	(15.20, 15.25)
M_R3_w_60	12383	15.44	15.60	0.0132	(15.57, 15.62)
M_R4_w_60	12383	15.14	15.13	0.0127	(15.11, 15.16)
M_R5_w_60	12383	13.82	13.92	0.0142	(13.89, 13.95)
M_L7_w_60	11818	15.04	15.02	0.0127	(15.00, 15.05)
M_L8_w_60	11818	15.44	15.48	0.0132	(15.45, 15.50)
M_L9_w_60	11818	14.94	14.86	0.0127	(14.83, 14.88)
M_L10_w_60	11818	13.82	13.71	0.0142	(13.68, 13.74)
F_R2_w_60	5891	13.82	13.95	0.0178	(13.91, 13.98)
F_R3_w_60	5891	14.22	14.16	0.0188	(14.12, 14.19)
F_R4_w_60	5891	13.82	13.75	0.0173	(13.71, 13.78)
F_R5_w_60	5891	12.29	12.38	0.0193	(12.34, 12.42)
F_L7_w_60	5884	13.61	13.58	0.0173	(13.55, 13.62)
F_L8_w_60	5884	13.82	13.79	0.0183	(13.76, 13.83)
F_L9_w_60	5884	13.21	13.26	0.0178	(13.23, 13.30)
F_L10_w_60	5884	11.99	11.91	0.0193	(11.87, 11.95)

Table 3 The statistical results for the widths in millimeter of the 2nd, 3rd, 4th, and 5th finger of the right hand and the 7th, 8th, 9th, and 10th finger of the left hand for both male and female, in the age group of 31 to 60, where the number stands for the sample size.

Fingers	Number	Median	Mean	SE	95% CI
M_R2_h_60	12383	23.98	23.91	0.0198	(23.87, 23.95)
M_R3_h_60	12383	24.38	24.24	0.0234	(24.19, 24.29)
M_R4_h_60	12383	24.38	24.48	0.0224	(24.44, 24.52)
M_R5_h_60	12383	21.54	21.27	0.0218	(21.23, 21.32)
M_L7_h_60	11818	23.77	23.78	0.0198	(23.74, 23.82)
M_L8_h_60	11818	24.38	24.20	0.0249	(24.15, 24.25)
M_L9_h_60	11818	24.79	24.71	0.0218	(24.67, 24.76)
M_L10_h_60	11818	21.13	21.07	0.0234	(21.02, 21.11)
F_R2_h_60	5891	21.95	21.77	0.0284	(21.72, 21.83)
F_R3_h_60	5891	22.35	22.31	0.0325	(22.25, 22.38)
F_R4_h_60	5891	21.95	22.05	0.0320	(21.99, 22.11)
F_R5_h_60	5891	19.00	18.99	0.0300	(18.93, 19.05)
F_L7_h_60	5884	21.64	21.58	0.0284	(21.53, 21.64)
F_L8_h_60	5884	22.25	22.23	0.0320	(22.17, 22.30)
F_L9_h_60	5884	21.95	21.98	0.0305	(21.92, 22.04)
F_L10_h_60	5884	18.90	18.87	0.0305	(18.81, 18.93)

Table 4 The statistical results for the heights in millimeter of the 2nd, 3rd, 4th, and 5th finger of the right hand and the 7th, 8th, 9th, and 10th finger of the left hand for both male and female, in the age group of 31 to 60, where the number stands for the sample size.

Fingers	Number	Median	Mean	SE	95% CI
M_R2_w_90	1004	15.85	15.89	0.0503	(15.80, 15.99)
M_R3_w_90	1004	16.26	16.08	0.0488	(15.98, 16.18)
M_R4_w_90	1004	15.65	15.68	0.0472	(15.59, 15.78)
M_R5_w_90	1004	13.87	13.99	0.0544	(13.89, 14.10)
M_L7_w_90	1013	15.95	15.87	0.0523	(15.77, 15.98)
M_L8_w_90	1013	16.15	15.98	0.0478	(15.89, 16.08)
M_L9_w_90	1013	15.44	15.33	0.0488	(15.24, 15.43)
M_L10_w_90	1013	13.82	13.84	0.0549	(13.74, 13.95)
F_R2_w_90	1003	15.04	14.95	0.0457	(14.86, 15.04)
F_R3_w_90	1003	15.14	14.99	0.0472	(14.90, 15.08)
F_R4_w_90	1003	14.63	14.48	0.0452	(14.39, 14.56)
F_R5_w_90	1003	13.00	12.93	0.0503	(12.83, 13.03)
F_L7_w_90	1004	14.53	14.40	0.0472	(14.31, 14.50)
F_L8_w_90	1004	14.63	14.53	0.0462	(14.44, 14.62)
F_L9_w_90	1004	13.82	13.91	0.0457	(13.82, 14.00)
F_L10_w_90	1004	12.19	12.22	0.0508	(12.12, 12.32)

Table 5 The statistical results for the widths in millimeter of the 2nd, 3rd, 4th, and 5th finger of the right hand and the 7th, 8th, 9th, and 10th finger of the left hand for both male and female, in the age group of 61 and up, where the number stands for the sample size.

Fingers	Number	Median	Mean	SE	95% CI
M_R2_h_90	1004	24.28	24.11	0.0762	(23.96, 24.26)
M_R3_h_90	1004	24.38	24.37	0.0813	(24.21, 24.53)
M_R4_h_90	1004	23.88	23.87	0.0828	(23.71, 24.04)
M_R5_h_90	1004	21.03	20.88	0.0823	(20.72, 21.04)
M_L7_h_90	1013	24.28	24.10	0.0747	(23.95, 24.24)
M_L8_h_90	1013	24.38	24.43	0.0823	(24.27, 24.59)
M_L9_h_90	1013	24.28	24.21	0.0798	(24.06, 24.37)
M_L10_h_90	1013	21.13	20.90	0.0823	(20.74, 21.06)
F_R2_h_90	1003	21.95	22.04	0.0737	(21.89, 22.18)
F_R3_h_90	1003	22.35	22.39	0.0798	(22.24, 22.55)
F_R4_h_90	1003	21.74	21.67	0.0716	(21.53, 21.81)
F_R5_h_90	1003	18.69	18.62	0.0721	(18.48, 18.76)
F_L7_h_90	1004	21.64	21.58	0.0716	(21.44, 21.72)
F_L8_h_90	1004	22.15	22.21	0.0767	(22.06, 22.36)
F_L9_h_90	1004	21.44	21.51	0.0732	(21.36, 21.65)
F_L10_h_90	1004	18.69	18.50	0.0777	(18.35, 18.65)

Table 6 The statistical results for the heights in millimeter of the 2nd, 3rd, 4th, and 5th finger of the right hand and the 7th, 8th, 9th, and 10th finger of the left hand for both male and female, in the age group of 61 and up, where the number stands for the sample size.