Statistical Analysis of Widths and Heights of Images from Segmentation Data

July 15, 2008

Jin Chu Wu

In the draft of "Specifications for Fast Tenprint Capture Devices", Version 1.0, it states that the evaluation of FTC devices is threefold: the absolute measurement stipulating the specifications and designing targets to implement specifications, the relative measurement for interoperability matching 2-d rolled-equivalent fingerprint images produced using FTC devices against those collected from certified live scanners, and the real-time speed of completing one transaction carried out by an FTC device. Further, the absolute measurement requires the evaluation regarding the geometric accuracy. Thus, a target that can simulate the human fingers needs to be designed. Now the question is what sizes these simulated fingers should be.

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. However, it must be noticed that 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 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 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 provided by Craig Watson's subgroup 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.

As a matter of fact, 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,

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

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. In each subset of the 32 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, the results in terms of the unit millimeter, which were converted from the results using the unit of pixel, are also provided. The statistical analysis regarding the age divisions is not included this time.

The results of the statistical analysis are listed from Table 1 to Table 4. It is shown in these four 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 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. In addition, the size of the middle finger should be larger than the sizes of the index finger, the ring finger, and the little finger, respectively. However, this does not hold good for the subsets of male and heights (See Table 2 and Table 4). This is probably due to the segmentation issue. Nonetheless, while designing a simulated finger to be a target, the information for the widths is more important than the information for the heights.

Fingers	Number	Median	Mean	SE	95% CI
M_R2_w	25913	296	294.82	0.18	(294.47, 295.16)
M_R3_w	25913	304	303.32	0.18	(302.96, 303.68)
M_R4_w	25913	296	294.24	0.17	(293.90, 294.57)
M_R5_w	25913	272	271.30	0.19	(270.93, 271.68)
M_L7_w	24809	288	290.50	0.18	(290.15, 290.85)
M_L8_w	24809	304	300.23	0.18	(299.87, 300.59)
M_L9_w	24809	288	288.14	0.18	(287.80, 288.49)
M_L10_w	24809	268	266.52	0.19	(266.14, 266.90)
F_R2_w	13341	272	270.24	0.24	(269.77, 270.71)
F_R3_w	13341	274	275.08	0.25	(274.59, 275.58)
F_R4_w	13341	270	268.39	0.23	(267.94, 268.84)
F_R5_w	13341	240	242.38	0.25	(241.89, 242.88)
F_L7_w	13434	262	263.31	0.23	(262.85, 263.76)
F_L8_w	13434	270	267.91	0.25	(267.43, 268.39)
F_L9_w	13434	257	258.73	0.23	(258.27, 259.18)
F_L10_w	13434	232	232.32	0.25	(231.83, 232.81)

Table 1 The statistical results for the widths in pixel 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, where the number stands for the sample size.

Fingers	Number	Median	Mean	SE	95% CI
M_R2_h	25913	472	470.29	0.27	(469.76, 470.82)
M_R3_h	25913	480	478.22	0.32	(477.59, 478.85)
M_R4_h	25913	486	484.37	0.31	(483.78, 484.97)
M_R5_h	25913	424	420.05	0.30	(419.46, 420.63)
M_L7_h	24809	464	467.15	0.27	(466.63, 467.68)
M_L8_h	24809	480	476.07	0.34	(475.40, 476.74)
M_L9_h	24809	488	487.26	0.30	(486.67, 487.85)
M_L10_h	24809	416	413.33	0.33	(412.69, 413.97)
F_R2_h	13341	432	428.76	0.37	(428.03, 429.49)
F_R3_h	13341	440	440.30	0.42	(439.47, 441.12)
F_R4_h	13341	434	435.88	0.42	(435.06, 436.69)
F_R5_h	13341	376	375.41	0.39	(374.65, 376.18)
F_L7_h	13434	426	424.58	0.36	(423.87, 425.29)
F_L8_h	13434	438	438.44	0.41	(437.64, 439.25)
F_L9_h	13434	432	434.20	0.39	(433.42, 434.97)
F_L10_h	13434	374	372.65	0.40	(371.87, 373.43)

Table 2 The statistical results for the heights in pixel 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, where the number stands for the sample size.

Fingers	Number	Median	Mean	SE	95% CI
M_R2_w	25913	15.04	14.98	0.0091	(14.96, 14.99)
M_R3_w	25913	15.44	15.41	0.0091	(15.39, 15.43)
M_R4_w	25913	15.04	14.95	0.0086	(14.93, 14.96)
M_R5_w	25913	13.82	13.78	0.0097	(13.76, 13.80)
M_L7_w	24809	14.63	14.76	0.0091	(14.74, 14.78)
M_L8_w	24809	15.44	15.25	0.0091	(15.23, 15.27)
M_L9_w	24809	14.63	14.64	0.0091	(14.62, 14.66)
M_L10_w	24809	13.61	13.54	0.0097	(13.52, 13.56)
F_R2_w	13341	13.82	13.73	0.0122	(13.70, 13.75)
F_R3_w	13341	13.92	13.97	0.0127	(13.95, 14.00)
F_R4_w	13341	13.72	13.63	0.0117	(13.61, 13.66)
F_R5_w	13341	12.19	12.31	0.0127	(12.29, 12.34)
F_L7_w	13434	13.31	13.38	0.0117	(13.35, 13.40)
F_L8_w	13434	13.72	13.61	0.0127	(13.59, 13.63)
F_L9_w	13434	13.06	13.14	0.0117	(13.12, 13.17)
F_L10_w	13434	11.79	11.80	0.0127	(11.78, 11.83)

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, where the number stands for the sample size.

Fingers	Number	Median	Mean	SE	95% CI
M_R2_h	25913	23.98	23.89	0.0137	(23.86, 23.92)
M_R3_h	25913	24.38	24.29	0.0163	(24.26, 24.33)
M_R4_h	25913	24.69	24.61	0.0157	(24.58, 24.64)
M_R5_h	25913	21.54	21.34	0.0152	(21.31, 21.37)
M_L7_h	24809	23.57	23.73	0.0137	(23.70, 23.76)
M_L8_h	24809	24.38	24.18	0.0173	(24.15, 24.22)
M_L9_h	24809	24.79	24.75	0.0152	(24.72, 24.78)
M_L10_h	24809	21.13	21.00	0.0168	(20.96, 21.03)
F_R2_h	13341	21.95	21.78	0.0188	(21.74, 21.82)
F_R3_h	13341	22.35	22.37	0.0213	(22.33, 22.41)
F_R4_h	13341	22.05	22.14	0.0213	(22.10, 22.18)
F_R5_h	13341	19.10	19.07	0.0198	(19.03, 19.11)
F_L7_h	13434	21.64	21.57	0.0183	(21.53, 21.60)
F_L8_h	13434	22.25	22.27	0.0208	(22.23, 22.31)
F_L9_h	13434	21.95	22.06	0.0198	(22.02, 22.10)
F_L10_h	13434	19.00	18.93	0.0203	(18.89, 18.97)

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, where the number stands for the sample size.