AN ANTHROPOMETRY USING MOIRE' INTERFEROMETRY

Keun B. Lee*

Abstract

This study presents a systematic and more economical method to acquire 3-D anthropometric data by the use of Moire' interferometry, image processing and computer vision techniques. An experiment was performed to measure sixty-one anthropometric variables, such as height, weight, neck-base circumference, contained areas of various contours etc.., of thirty-six male subjects with wide range of ages (14 years to 43 years old).

Cluster analysis was performed with contour information, and somatotyping was performed to obtain four distinct types of body shape. The results were then compared with classifications obtained from traditional somatotyping methods which showed 71.88% consistency. This study developed a simple and inexpensive method for 3-D anthropometric data acquisition and suggests the quantification and interpretation scheme that will enable us to utilize the data for industrial applications.

1. Introduction

Anthropometry is a branch of physical anthropology which deals with human body measurements. This includes body dimensions, range of motion and muscle strength.. Anthropometric data serves as basic ergonomic data for diverse engineering applications. One application can be the developing engineering design standards. Obtaining 2-D anthropometric data is relatively simple and easy. However, acquiring 3-D anthropometric data can be quite complicated and costly. Most widely used technique for 3-D data uses the stereo photogrammetry, the multiplex projection and the silhouette [3]. There is a need to develop a simple and inexpensive method for 3-D data acquisition system.

The somatotyping method and the discriminating method are suggested as the basic data for industrial design. Following the suggestion, this study developed the somatotyping equipment and the measuring scheme that guarantees reliability and economical efficiency as well as the algorithm to reconstruct the anthropomorphic data. This study presents a systematic and more economical anthropometric technique to acquire 3-D anthropometric data by the use of Moire' interferometry [2], image processing and computer vision techniques.

* Dept. of Industrial and System Engineering, ChongJu University

The experiment followed the theory related to light source and grating for measuring Moire interferometry equipment as well as computer vision [4] were used for the experiment. Experimental equipments consisted of the visual processing system [4]- to perform Moire' interferometry and Ar-ion laser, light source, grating, etc, that produces Moire' fringe. The cluster analysis was used to seize the relation between the different somatotypes from the acquired data. A comparative study between the above data and the classified somatotype using the discriminant function is made.

2. Experiments

An experiment was performed to measure sixty-one anthropometric variables, such as height, weight, neck-base circumference, contained areas of various contours etc., of thirty-six male subjects with wide range of ages (14 years to 43 years old).

1.1 Subjects

Thirty six male subjects whose age range from 14 to 43,voluntarily participated in the experiments. Table[1] shows subjects' physical characteristics.

Table 1. Anthropometric data of subject

N O	A1	A2	A3	A4	A5	A6
1	171.0	75.0	42.0	99.0	93.0	97.0
2	173.0	81.0	42.0	105.0	88.0	102.0
3	172.0	63.0	37.0	95.1	76.0	90.0
4	158.8	50.0	32.4	82.5	65.0	85.0
5	175.0	64.0	39.0	89.0	73.0	96.0
6	167.0	56.5	33.5	84.0	70.0	90.0
7	170.0	64.5	38.0	89.4	75.6	96.0
8	171.0	74.0	39.0	98.5	83.0	98.0
9	162.0	63.0	37.0	90.0	78.4	95.0
10	169.0	61.0	35.0	91.4	72.0	93.0

2.2 Experimental equipments

The experiment was performed according to the theory related to light source and grating for measuring Moire' interferometry equipments. Computer vision[2] was also used for the experiment. The equipments and the specification for the visual processing system, light source system and grating are as follows.

A. Vidicon camera: In this research, the data was obtained by using SONY video camera model HYC-80.
B. Image processor: The images produced by the Moire' fringe system under test was captured using an image processing board.In this experiment,UT2853-60hz was used for hardware board of image processing. It has 512*512*256 resolution level to obtain input data compatible to

RS-170,MTSC,RS-330. Image-Pro and PC SEMPER was utilized for preprocessing and application software.

C. The gratings: Moire' contour is a system showing equal depth from the plane of grating if the light source and observing point lie on a plane parallel to the grating[1].A plane grating was placed in front of the subjects with 0.5cm clearance. The grating was constructed by thin nylon fishing line of 0.5mm diameter on a 270mm*370mm frame using long screws of 0.5mm pitch for local grating. Relatively thick nylon fiber was used for analyzing somatotype to classify into similar or dissimilar body characteristics. Moreover, grating diameter with 2mm gap and ,1100mm*2000mm efficiency area was used. Grating was coated with black optical spray.

D. Light source: The point light source was generated by Ar-ion laser of 5W and beam expander. Among them, laser was a product of Spectra Physics. A rear prism which was magnified with micro scope lenz of 20*(f=1.25) was used.. The specification of laser is shown in Table 2.

Table.2 Specification of Ar-ion laser

Component	Secification
ManufactureModel	Spectra Physic
Model No.	M165
Output power	5W
Plaxma tube	Be O
Beam diameter	1.58 mm
Beam divergence	0.56 mm rad
Polarization	Vertical

3.3 Implementing experiment

A. Calibration of Vidicon camera.magnification: An algorithm to calculate the skewness of lenz.was developed. The key issue was to achieve an accuracy because changes in distance would result in alteration of image. This algorithm calculates the ratio of changing area screen with respect to different distance. Table[3] reveals the results for the ratio of area vs. distance calculated by the algorithm.

Table3. Ratio of area vs. distance

Distance(cm)	Number of pixel	Ratio of area
13	21	1.0
127	35	0.6
117	60	0.58
107	103	0.58
97	175	0.58
87	296	0.59
77	503	0.58
67	852	0.59
57	1445	0.59
47	2492	0.59
37	3969	0.62

B. Image processing: In this experiment, subjects were positioned behind the center of the grating and Moire' fringe was generated and visualized by Vidicon camera and then processed by digitizer[5]. Post order tree traversal method[4] was used for binary image analysis,as shown in Figure 1.

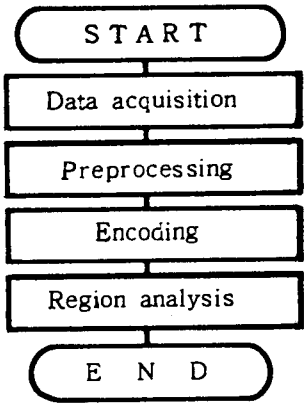

Fig.1. Image analysis by Post order tree traversal

Image information from the head and breast of each Agrepa and Venus statues was collected as a pilot study. The head and breast of human are difficult to be measured and represented.
Contouring is a method used to reveal the 3-D shape of a subject by producing its surface fringes similar to the lines of constant elevation that are used on geological maps. The contours of the test objects were stored in the computer memory. However they were represented as multiple line wide in digital image which might result in low accuracy. Therefore they were changed into binary

image in order to improve the accuracy and then the skeleton was extracted. Fig.2 shows the step by step procedures for this task.

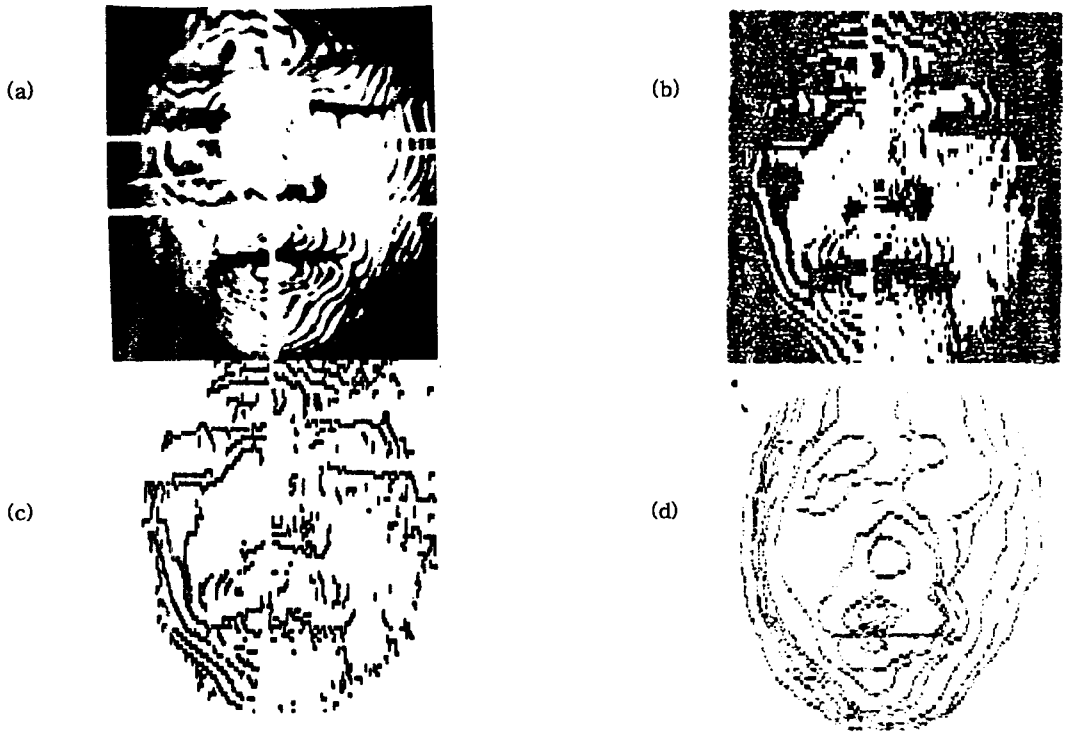

Fig.2 (a) photograph of original
(b) hardcopier of original image
(c) illustration of thinning after 3steps
(d) illustration of final contour

3. Somatotype Using Contouring

Although there are several Moire' methods for anthropometry available, none of them used absolute area between contours. However, this study uses absolute area between contours to classify the somatotype of the sample population through cluster analysis.

1.1 Somatometry

The experimental equipments mentioned above were used to measure 36 male subjects. In this step the head and trunk of a living body were measured. In the head, the Menton-Sellion length were produced after calculating with 7 contours.. Also the trunk length measured from the acromion, to omphalion through sternum which describe the central figure was processed by the same method. The cluster analysis using SPSS of Ward[7] was performed to find the minimum variance and the result is shown in Table 4.

Table 4. Result from cluster analysis

Cluster category ss	Subj. No. in the cluster	No. of cases
1	2,9,16,26,3,10,15,18,29,19, 17,21,1,22,30,20	16
2	25,36,32,33,13,14,35	7
3	11,27,5,12,6,7,31,4,34	9
4	8,28,23,24	outlier value

** The cluster 4 was eliminated because of its isolation from the others.

4. Determination of The Discrimination Function

In this study, the step-wise regression was performed to find the relationships between somatotype attained from cluster analysis and Martin-type anthropometric variables. The discriminating function was calculated in order to decide whether somatotype classification [6] can be made or not. The calculation produced the following two equations that can be used for body-shape type classification.. These equations are functions of three anthropometric variables, namely, Chest circumference (B3), Weight (B6), and Neck-base (B11).

$$F1=1.53 - 0.00164 * B3 + 0.25414 * B6 - 0.04459 * B11 \quad \text{--- (1)}$$

$$F2 = -13.19530 + 0.00570 * B3 + 0.00228 * B6 - 0.002219 * B11 \quad \text{--- (2)}$$

Also the results reveals that the classified group data of 36 subjects by current study shows 71.88% consistency with the Martine-type anthropomorphic data. as shown in Table 5. This means the proportion of group belongs to the population when the discriminant function contains 3 classification variables (B3,B6,B11). Fig.3 shows the result of the 36 subjects to be grouped by the above equations.

Table 5. Classification results

Actual group	No. of cases	Predicted group membership
1	16	10 (62.5%) 1 (6.3%) 5 (32.3%)
2	7	1 (14.3%) 5 (71.4%) 1 (14.3%)
3	9	1 (11.7%) 0 (0.0%) 8 (88.9%)

An additional test on 43 new subjects was performed to verify Equations 1 and 2. The result was compared with the one from the test of original 36 subjects as shown in Figure 4. Figure 4 reveals good agreement between two tests.

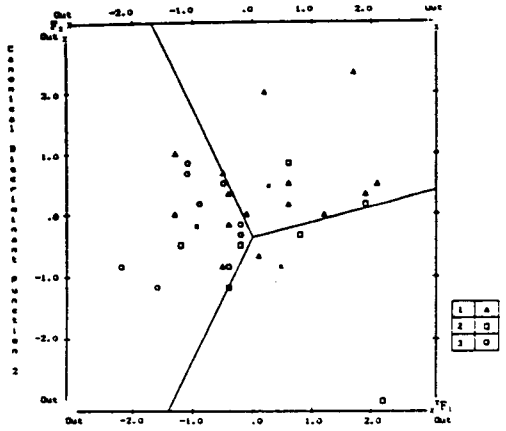

Fig.3 Groups scatter plot map and classification results

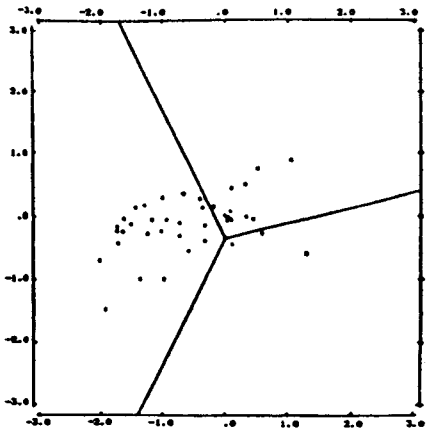

Fig.4 Groups plot another subjects

5. Conclusion

In this study, the methods and equipment that can be used to detail the anthropomorphic data were developed. This new method that utilizes the Moire' interferometry and computer vision technique is less expensive than the conventional methods. Also this new method can automate the anthropometric measuring tasks that can be accomplished rather rapidly without sacrificing accuracy. . Also the quantification and the interpretation scheme of the anthropomorphic data that will enable us to use for the industrial design were suggested.

References

1. Hiroshi Takasaki. "Moire' Topography." App. opt.Vol.9,No.6, 1970 pp.1475-1472
2. Horn P. ."Robot Vision." MIT Press, 1986.
3. Ignazi, G.,Mollary.R. and A.Coblentz,"Progress and Prospects in Human Biometry Evalution of Measurement Techniques and Data Handling Methods." John wiley. 1975
4. K.B.Lee,"Analsis of Human Motion Using Micro Computer." Trends in Ergonomics/Human Factors,edited by F.Aghazadeh, North Holland,1988,pp.63-70.
5. Thomas S Huang. "Image Enhancement Using the Median and the Interquartile Distance." CGIP.. 1984, pp. 236-251.
6. N.S.Lee,"Computer Aided Anthropomorphic Modeling for 3d Human Body Shape Representation and Reconstruction. "The thesis Dept.I.E.,KAIST.,1988.
7. Chatfiled,C. and A.T.Collins,"Introduction to Multivariate Analysis." Chapman and Hall.1980.