VISIBLE REAL AREA OF AVERAGE KOREAN ADULT*

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요 약

이 연구의 목적은 표준 한국 성인을 구성하고 있는 3012개의 삼각형들의 각각의 실제면적과 임의의 좌표에서 볼 수 있는 각 삼각형의 실제 면적을 구하는 방법을 기술하고자 한다. 이 방법을 이용한 결과들은 표준 한국 성인의 투사 면적, 임의의 좌표에서 볼 수 있는 실제 투사면적, 형태 계수, 그리고 Mean Radiant Temperature을 구하는데 꼭 필요한 자료들이다. 이 논문은 네단계로 구성되어있는데, 그것들은 1) 시점의 Cartesian 좌표, 2) 실제 삼각형들의 면적 계산방법, 3) 가려진 삼각형들을 포함한 실제 삼각형들의 면적 계산방법, 그리고 4) 가려진 삼각형들을 제외한 보이는 삼각형들의 면적 계산방법이다. 이 방법을 이용한 임의의 좌표에서 볼 수 있는 표준 한국 성인의 실제 면적은, 시점의 좌표가 ALFA 15.0 도, BETA 0.0 도 일 경우가 가장 큰 면적(7,138.7cm^2)을 볼 수 있고, 가장 적은 면적(2,326.6 cm^2)은 ALFA 0.0 도, BETA 90.0 도 일 경우이다.

I. INTRODUCTION

People respond to their environment in many ways, and many factors affect their health and attitude: the size of the space in which they work and live, air quality (heat, humidity, odors, air movement), noise, light, etc. Thermal radiation is also a significant factor affecting thermal comfort in many types of artificial environments. Mean radiant temperature is a measurement of this thermal exchange. Previous paper[4] described the methods for finding geometrical surface data for an average Korean adult. The first step to find mean radiant temperature for Korean adult is to determine visible real area of an average Korean adult Developing visible real area of an average Korean adult, visible projected area, effective radiation area, visible project area factor, and form factor of an average Korean adult will be found.

This paper describes methods for finding the Cartesian components of view point of an average Korean male, determining the visible real area of an averaged Korean male for

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each separate part of human body with hidden surfaces, and computing the visible real area of an average Korean male for each separate part of human body with hidden surfaces subtracted.

II. FINDING THE CARTESIAN COMPONENS OF VIEW POINT(X0,Y0,Z0) OF AN AVERAGE KOREAN MALE

To find the visible real area, the Cartesian components of the view point(x0,y0,z0) are needed. To convert the view point expressed in the spherical coordinate system to this view point in the Cartesian coordinate system, the following process is needed[6].

$$\sin(\beta) = \frac{y}{r}$$

$$y = r\sin(\beta) \qquad \text{--- (1)}$$

$$\tan(\beta) = \frac{y}{z} \qquad \text{--- (2)}$$

substitute equation (2) into equation (1):

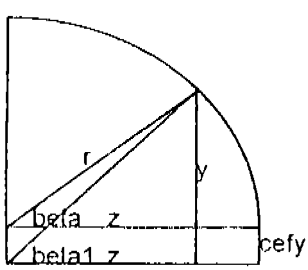

Figure 1 View point in spherical coordinate system

$$z = \frac{y}{\tan(\beta)} = \frac{r\sin(\beta)}{\tan(\beta)} \qquad \text{---(3)}$$

$$\tan(\beta1) = \frac{(y + cefy)}{z} \qquad \text{---(4)}$$

substitute equation (1) and equation (3) to equation (4):

$$\tan(\beta1) = \frac{r\sin(\beta) + cefy}{r\cos(\beta)}$$

$$\beta1 = \tan^{-1}\frac{r\sin(\beta) + cefy}{r\cos(\beta)}$$

where cefy = 100.0 cm for adult

Finally, the components of the view point in the Cartesian coordinate system can be found using the spherical coordinate system.

$$x0 = r\cos(\beta1)\sin(\alpha)$$

$$y0 = r\sin(\beta1)$$

$$z0 = r\cos(\beta1)\cos(\alpha)$$

III. DETERMINING THE REAL AREA OF A TRIANGLE FOR AN AVERAGE KOREAN MALE

Using data file of Korean adult, the x, y, and z components of each triangle can be known. After the components of A1, A2, and A3 are found, the real triangle area of triangle can be found using the following formula:

real or perpendicular area of triangle = $\sqrt{(s(s-a1)(s-a2)(s-a3)}$

where $2s = a1 + a2 + a3$

$a1, a2, \text{and } a3 =$ length of triangle

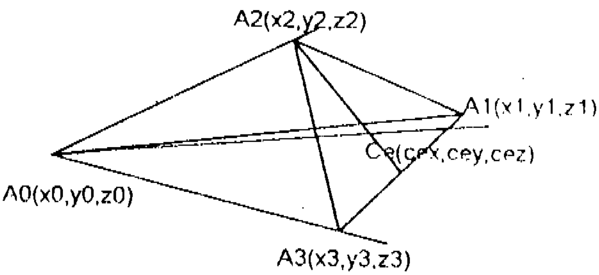

Figure 2 Real area of a triangle

IV. COMPUTING THE VISIBLE REAL AREA OF AN AVERAGE KOREAN MALE FOR EACH SEPARATE PART OF THE HUMAN BODY WITH HIDDEN SURFACES

The triangle's vertices and the location of the view point are arbitrary.The steps to find the visible real area of a triangle in each part of an human body are as follows;

1) find the normal vector **N**, **N** = a x b
vectora=vector **A1A2** = (x2-x1,y2-y1,z2-z1)
vectorb=vector **A1A3** = (x3-x1,y3-y1,z3-z1)
normal vector **N** = (Nx,Ny,Nz) = **a x b**
Nx = (y2-y1)(z3-z1)-(z2-z1)(y3-y1)
Ny = (z2-z1)(x3-x1)-(x2-x1)(z3-z1)
Nz = (x2-x1)(y3-y1)-(y2-y1)(x3-x1)

2) find a line of sight vector **W** extending from a center point of triangle A1A2A3(Cex,Cey,Cez) to the view point A0(x0,y0,z0)

vector**W** = (Wx,Wy,Wz) = (x0-Cex,y0-Cey,z0-Cez)

3) find the visible surface(triangle)
If the surface is visible, the dot product of vector N from 1) and vector **W** from 2) must be positive.

V. FINDING THE VISIBLE REAL AREA OF AN AVERAGE KOREAN MALE COMBINING ALL PARTS OF THE HUMAN BODY WITH THE HIDDEN SURFACES SUBTRACTED

Using step 2) and step 3), the visible real area of each triangular element of each part of human body was found. The next step is to find the visible real area with hidden surfaces subtracted. The procedure to find these is as follows:

(1) find the equation of the plane passing through three points (each triangle plane equation).

1) general equation of plane;
ax + by + cz + d = 0 --- (1)

2) substitute the components of three points, (x1,y1,z1), (x2,y2,z2), and (x3,y3,z3) into general equation of plane in equation (1).
ax1 + by1 + cz1 + d = 0 --- (2)
ax2 + by2 + cz2 + d = 0 --- (3)
ax3 + by3 + cz3 + d = 0 --- (4)

3) equation (2) minus equation (3),
a(x1-x2)+b(y1-y2)+c(z1-z2) = 0 ---- (5)

equation(2) minus equation(4),

a(x1-x3)+b(y2-y3)+c(z2-z3) = 0 --- (6)

4) from equation (5),

$$b=\frac{1}{(y1-y2)}[(x2-x1)a+(z2-z1)c] \quad \text{--- (7)}$$

from equation (6),

$$c=\frac{1}{(z1-z3)}[(x3-x1)a+(y3-y1)b] \quad \text{--- (8)}$$

5) substitute equation (8) into equation (7):

$$b=ka \quad \text{--- (9)}$$

where

$$k=\frac{(z1-z3)(x2-x1)+(z2-z1)(x3-x1)}{(y1-y2)(z1-z3)-(y3-y1)(z2-z1)}$$

6) substitute equation (9) into equation (8):

$$c=\frac{(x3-x1)+(y3-y1)k}{(z1-z3)}a \quad \text{--- (10)}$$

7) substitute equation (9) and (10) into equation (2):

$$d=-a[x1+ky1+\frac{(x3-x1)+(y3-y1)k}{(z1-z3)}z1] \quad \text{--- (11)}$$

8) substitute equation (9), (10), and (11) into equation (1).

Finally, equation of the plane passing through the three points is as follows;

$$x+ky+\frac{(x3-x1)+(y3-y1)k}{(z1-z3)}z-[x1+ky1+\frac{(x3-x1)+(y3-y1)k}{(z1-z3)}z1]=0$$

(2) find point of intersection of the line and plane

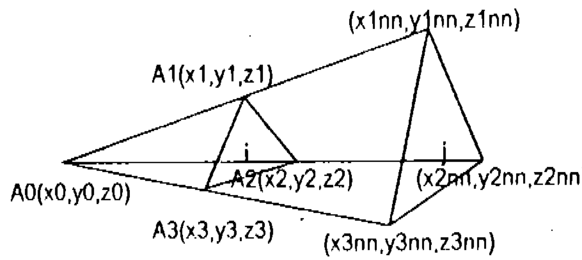

Figure 3 Line and plane intersection point

1) find equation A0A1, A0A2, and A0A3 which is not perpendicular

$$\frac{(x-x0)}{(x1-x0)}=\frac{(y-y0)}{(y1-y0)}=\frac{(z-z0)}{(z1-z0)}=c10 \quad \text{--- (1)}$$

$$\frac{(x-x0)}{(x2-x0)}=\frac{(y-y0)}{(y2-y0)}=\frac{(z-z0)}{(z2-z0)}=c20 \quad \text{--- (2)}$$

$$\frac{(x-x0)}{(x3-x0)}=\frac{(y-y0)}{(y3-y0)}=\frac{(z-z0)}{(z3-z0)}=c30 \quad \text{--- (3)}$$

2) find any point p which is not perpendicular on line A0A1:

x = (x1-x0)c10+x0

y = (y1-y0)c10+y0

z = (z1-z0)c10+z0 --- (4)

on line A0A2:

x = (x2-x0)c20+x0

y = (y2-y0)c20+y0

z = (z2-z0)c20+z0 --- (5)

on line A0A3:

x = (x3-x0)c30+x0

y = (y3-y0)c30+y0

z = (z3-z0)c30+z0 --- (6)

3) substitute equations (4), (5), and (6) into plane equation 2-4-1):

$$c10=\frac{(z1-z3)[(x1-x0)+k(y1-y0)]+(z1-z0)[(x3-x1)+(y3-y1)k]}{(z1-z3)[(x1-x0)+k(y1-y0)]+(z1-z0)[(x3-x1)+(y3-y1)k]} \quad ---(7)$$

$$c20=\frac{(z1-z3)[(x1-x0)+k(y1-y0)]+(z1-z0)[(x3-x1)+(y3-y1)k]}{(z1-z3)[(x2-x0)+k(y2-y0)]+(z2-z0)[(x3-x1)+(y3-y1)k]} \quad ---(8)$$

$$c30=\frac{(z1-z3)[(x1-x0)+k(y1-y0)]+(z1-z0)[(x3-x1)+(y3-y1)k]}{(z1-z3)[(x3-x0)+k(y3-y0)]+(z3-z0)[(x3-x1)+(y3-y1)k]} \quad ---(9)$$

4) substitute equation (7) into equations (4):

x1nn = (x1-x0)c10+x0
y1nn = (y1-y0)c10+y0
z1nn = (z1-z0)c10+z0

5) substitute equation (8) into equations (5):

x2nn = (x2-x0)c20+x0
y2nn = (y2-y0)c20+y0
z2nn = (z2-z0)c20+z0

6) substitute equation (9) into equations (6):

x3nn = (x3-x0)c30+x0
y3nn = (y3-y0)c30+y0
z3nn = (z3-z0)c30+z0

VI. CONCLUSION

After the hidden components of A1, A2, and A3 are found, the hidden real area of triangle can be found using the same method as in step III. Finally, the visible real area can be found by using the result of step III minus that of step V.

Developing visible real area of an average Korean adult, visible projected area, effective radiation area, visible project area factor, and

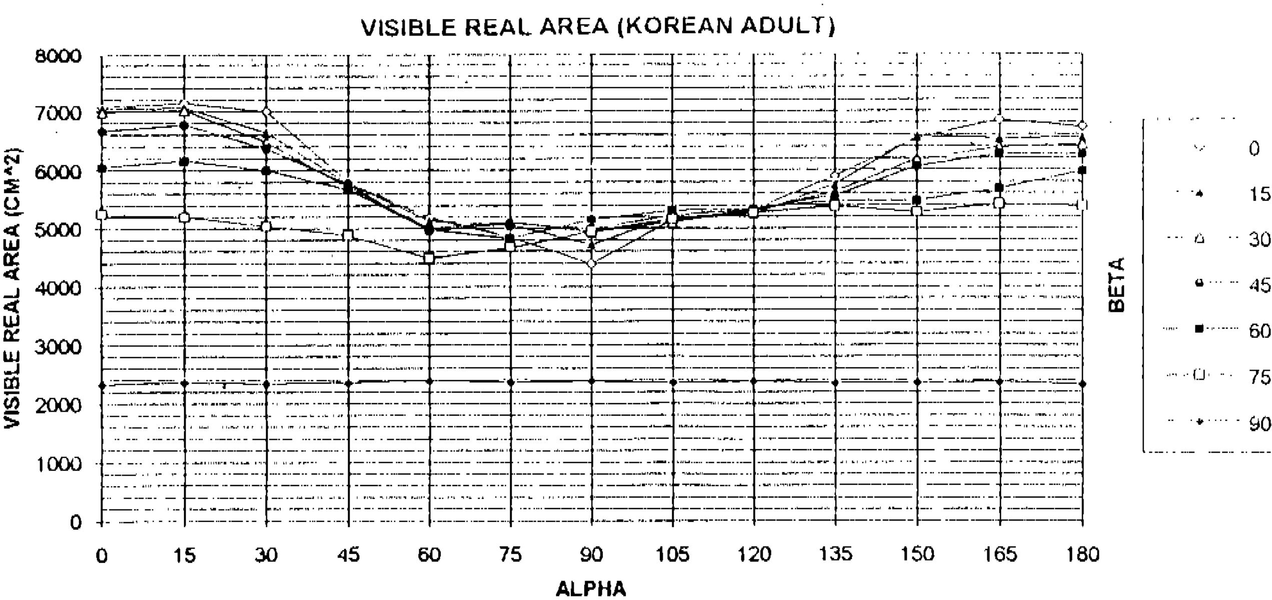

Figure 4 Visible real area of average Korea adult

form factor of an average Korean adult will be found.

The visible real areas with hidden surfaces subtracted for a Korean adult (Figure 4) are in the following page.

Future work will include the development of visible project area, effective radiation area and factor, form factor, and mean radiation temperature of an average Korean adult.

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