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TREATMENT OF ANTHROPOMETRIC DATA FOR THE DESIGN OF CHILDREN'S GLASSES

ABSTRACT

To be able to improve the construction of glasses for children, 600 children were photographed. The photographs were measured in a stereocomparator and the measurements consisted partly of certain "distinct" details as the centre of the pupils, the bridge of the nose etc, but also of twelwe nose profile points, giving a numerical description of the form of the nose.

A first statistical treatment of the data showed that there exists no correlation between the "distinct" details, which could be used as a basis for production of children's glasses. In this paper a further statistical analysis is described, where the data are divided into classes with respect to the form of the nose. For practical reasons the number of classes is limited to six, and the consequence of such a restriction is studied.

1 INTRODUCTION

The design of frames is today empirical. Successful and less successful frames have been analyzed to give experiences for new designs. Since the majority of the users are adults and children older than six years, it is quite natural that the frames have been designed to satisfy their demands of fit. The design of frames for children with age less or equal to six years, has been limited to just a reduction of size and no consideration has been given the fact that the younger children have other facial dimensions, compared to adults and children older than six years. As a consequence, most of the younger children who wear glasses, have frames which are not suited for them.

To be able to improve the design of frames for these younger children, anthropometric data are needed. To obtain these data, 600 children in the age between one and six years have been photographed. In this paper, a photogrammetric evaluation and a classification of the material are discussed. These classes are supposed to be used as a basis for the future production of children's glasses.

2 THE PHOTOGRAMMETRIC METHOD

2.1 Equipment and Photographic Method

The camera used was an ordinary amateur camera, Pentax f = 55 mm. It was equipped with a stereoadapter with a base of 6 cm. The distance between the camera and the child was about 70 cm. This choice of equipment provides a fast and simple collection of data. The camera is rather inexpensive and can easily be replaced in case of damage without extra calibration procedure.

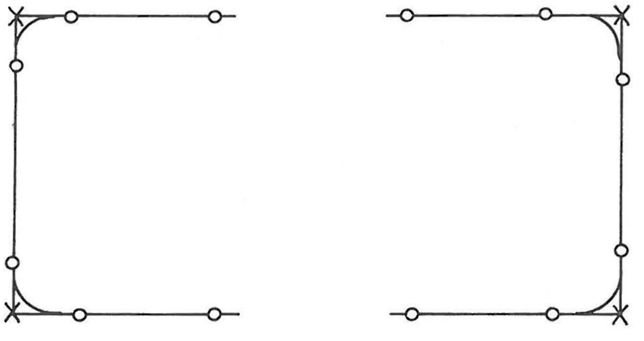
In order to aid the stereooperator in making the measurements a grid was projected on the face (figure 1).

Figure 1 A photograph of a girl with projected grid

A non-metric camera must be calibrated for each photograph, to minimize the effect of systematic errors. Therefore a testobject for the calibration of the system was photographed each time it was suspected that the focussing ring on the stereoadapter had been disturbed. The testobject consisted of a metal plate with a painted grid and eight metal pegs fixed to the plate.

2.2 Measurements

Before the measurements could be made, the film was cut into halves, to separate the left and the right image of each stereo-pair. The camera used, lacked proper fiducial marks. Instead a ficticious point in each corner of the photograph was used. They are defined by producing the edges of the photograph to intersection. To determine four such fiducial marks, twelwe points along the edges of each photograph were measured (figure 2).



o measured edge points

X calculated corners

Figure 2 Location of edge points and corners

The points measured in the calibration procedure were the top of the eight pegs and 36 points of the grid.

The points measured on the faces, consisted partly of distinct details (figure 3, points 1-8) and partly of nasal profile points giving a numerical description of the nose (figure 3, points 9-20).

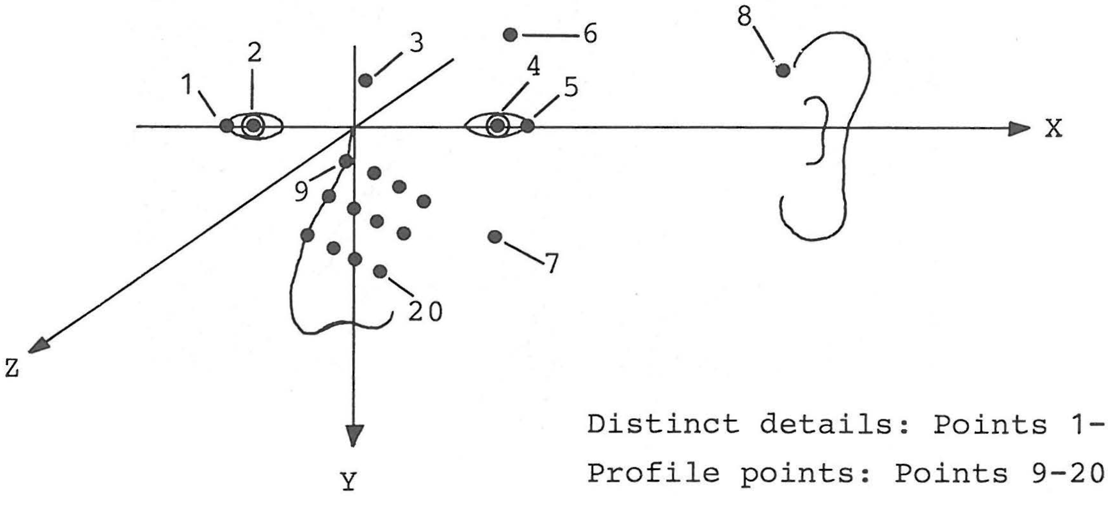


Figure 3 Measured points on the face and the facial co-ordinate system

2.3 Calibration and Calculation

In the calibration step all of the orientation and correction parameters were determined, for later use in the calculation. Image deformation is in this case a combination of many different deformations. A suitbale method for obtaining these corrections was to determine a correction polynomial of a certain degree. By using array algebra, the correction in the x-direction was separated from the one in y-direction. So two correction polynomials were determined, each of the fourth degree and each consisting of 25 coefficients.

The calibration consisted of the following steps:

a) calculation of image co-ordinates

b) perspective transformation of image co-ordinates into testfield co-ordinates

c) bilinear interpolation of residuals from the perspective transformation, giving the correction polynomials

d) resection to determine the co-ordinates of the two projections centres.

When all calibration parameters were determined, the model co-ordinates of the measured points were calculated and transformed into a facial co-ordinate system (figure 3).

The form of the nose was described by the polynomial:

$$z = f(x,y) = a_1 + a_2x^2 + a_3x^4 + a_4y + a_5y^2 + a_6x^2y + a_7x^2y^2$$

Symmetry with respect to the bridge of the nose was assumed.

3 POPULATION

In all, measurements from 600 children have been used in the investigation. They have been photographed at two children's care centres in the city of Jönköping and information about their age, sex and nationality (Swedish or non-Swedish) has been recorded. The ages of the children varied between one and six years. Because of improper photographs a number of children has been deleted from the investigation. The distribution of the remaining 482 children is described in table 1.

	Swedish		Nonswedish		Total				
Age	Boys	Girls	Boys	Girls	Swedish	Nonswedish	Boys	Girls	Total
1	28	32	4	2	60	6	32	34	66
2	30	32	6	2	62	8	36	34	70
3	32	32	8	4	64	12	40	36	76
4	38	33	6	2	61	8	34	35	69
5	23	31	10	9	54	19	33	40	73
6	59	55	9	5	114	14	68	60	128
Sum	200	215	43	24	415	67	243	239	482

Table 1 Distribution of the population

4 CALCULATION OF FIT

The frames are suggested to consist of three parts, which can be combined independently of each other (figure 4).

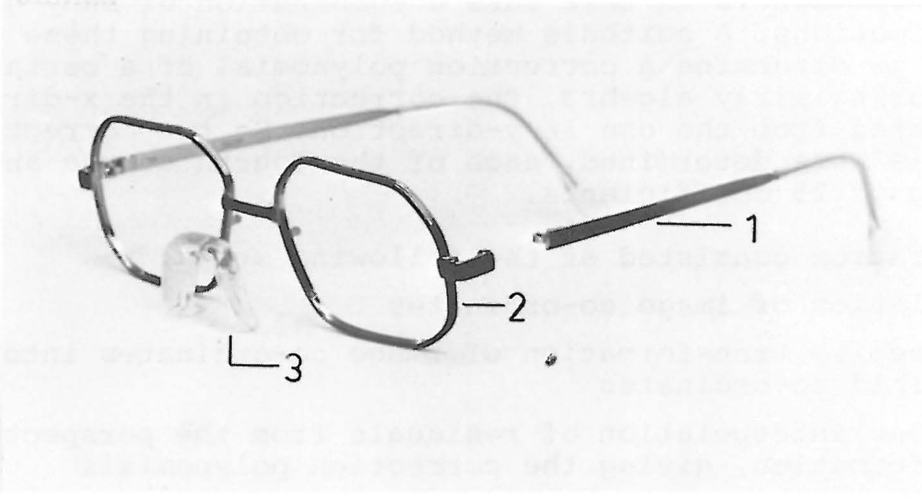


Figure 4 The three parts of the frame, which are the bow (1), the central part (2) and the nasal part (3)

This work deals only with the shape of the nose, but the collected data also allow determination of parameters belonging to the other parts of the frame.

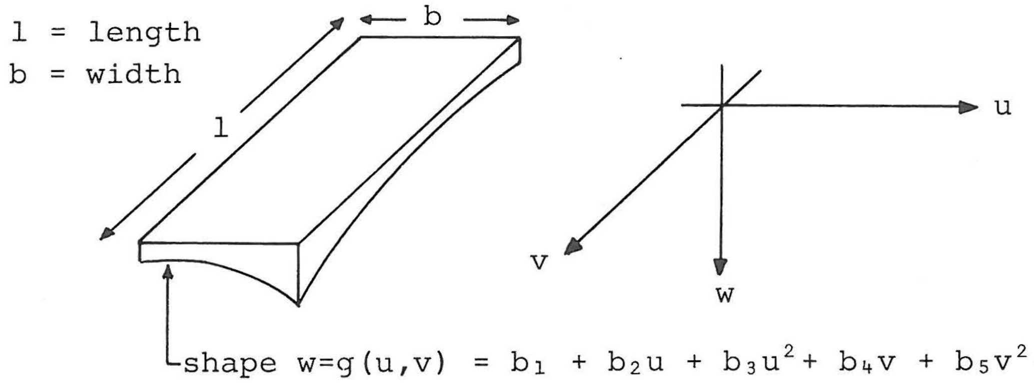
It is, for practical reasons, desirable to limit the number of different nasal designs to six. Since it is assumed that the noses are symmetric with respect to the bridge of the nose, only the left side of the nose is discussed.

Fit is defined as the area of contact between the frame and the nose, when the frame is placed on the nose (figure 7).

The variables used for defining the nasal part of the frame are:

a) The size of the nasal part is defined by the length (l) and the width (b) (figure 5). It is assumed that the nasal part is rectangular

b) The shape of the nasal part is described by a polynomial with six coefficients (figure 5)



shape $w=g(u,v) = b_1 + b_2u + b_3u^2 + b_4v + b_5v^2 + b_6uv$

Figure 5 Size and shape of the nasal part of the frame

Other variables which have an effect on the fit are:

c) Position and orientation for the nasal part, defined by x_O, y_O and α (figure 6)

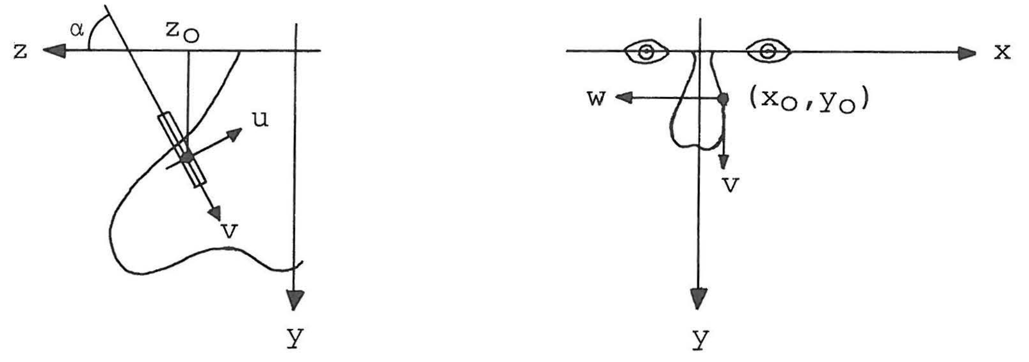


Figure 6 Position and orientation of the nasal part of the frame

d) For each nasal part the position (x_O, y_O) is fixed. Each nose is described by the polynomial $z = f(x, y)$ and each child has his own coefficients a_1-a_7. This means that the position (x_O, y_O) gives different $z_O = f(x_O, y_O)$ for each child. For optical reasons, these z_O-values must lie within an interval β

e) The permitted impression is strongly correlated with the area of contact. Increasing impression yields larger area of contact (figure 7)

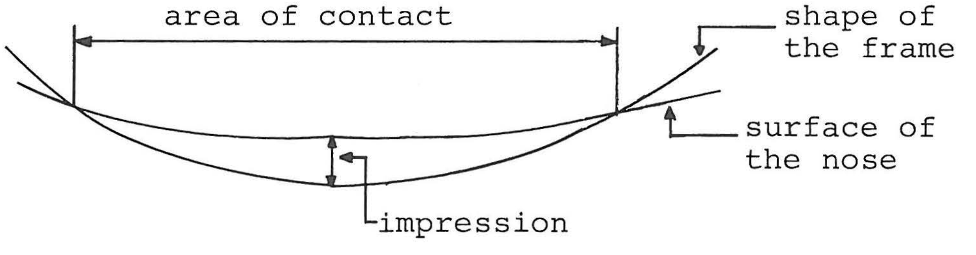


Figure 7 Section of the surface of the nose and the nasal part of the frame

5 COMPUTATIONS

Input to the computer were co-ordinates for the twelwe nasal profile points for each child. For interpolation between these points, a polynomial with seven coefficients was fitted. The polynomial used was

$$z = f(x,y) = a_1 + a_2x^2 + a_3x^4 + a_4y + a_5y^2 + a_6x^2y + a_7x^2y^2$$

The coefficients were determined by the method of least squares, with a standard error of 0.5 mm. Each child received here seven coefficients which were stored together with information about their age, sex and nationality.

The aim is to find six nasal parts of the frames providing optimal fit.

One of the conditions for fit is that the z_o-values must lie within the interval β. A first step was to find the six positions (x_o, y_o) where a maximum of children have at least one permitted z_o-value. The range of β was here fixed to $2.5 \leqq \beta \leqq 3.5$ mm. To find these six positions, the nose was divided into a grid with 13 x 9 points. Here 117 different positions were possible. Since a strict optimization was impossible, different iterative steps were made. The method used was:

a) List the number of children with a permitted z_o-value for each of the 117 possible positions

b) Select the position with a maximum number of children

c) Delete the children with a permitted z_o-value for this position. Go to step a) and repeat until six positions are received

d) Use these six positions as starting values in a gradient method.

This single condition for fit has the following consequences:

i) At least one of these six positions suits for 90% of the children

ii) There are no difference in fit between boys and girls

iii) The positions are better adapted to Swedish children compared with non-Swedish children (91% and 87% respectively)

iv) The positions are better adapted to children between three and six years compared with children younger than three years (91% and 84% respectively).

After the determination of the positions, follows the determination of the other unknowns, that is the size (length and width), the shape (six coefficients) and the altitude α, altogether nine unknowns. Also here an iterative method is used to solve the unknowns. The iterative steps are:

a) Give start values for the length (l), the width (b) and the orientation (α)

b) Determine the coefficients b_1-b_6 with the method of least squares

c) Evaluate the unknowns by calculating the number of children having sufficiently large area of contact

d) Change l, b and α and go to step b). Proceed until maximum is achieved.

Up to the time for this writing, computations have not been completed. The results of the computations are to be published later.

6 REFERENCES

Rauhala, U. Calculus of Matrix Arrays and General Polynomial and Harmonic Interpolation by Least Squares with New Solution in Photogrammetry and Geodesy. Fotogrammetriska meddelanden, Sthlm VI (1968)4

Åkerskog, G - Söderlund, J. Antropometriska primärdata för formgivning av barnglasögon. Stockholm (Department of Photogrammetry) 1978

Åkerskog, G - Söderlund, J. Children's Glasses. Stockholm (Department of Photogrammetry) 1978.