Abstract

**Purpose:** This study aims to reduce the failure rate due to excessive surgery (procedure) by consumers who want to satisfy their appearance through cosmetic plastic surgery. Most plastic surgery consumers want to know their face (especially their eyes and eyebrows) in advance to achieve results that look physiognomically good ahead of procedures or surgery. Until now, however, the characteristics of each part cannot be objectively converted into data. Therefore, we intend to develop a system so that the specific part of the face to be identified can be examined before surgery (procedure). The system allows you to immediately grasp the current physiognomic results and appearance status while automatically recording feature points in coordinates when you show your face on the screen of a mobile device. Again, the purpose of this study is to prevent wrong judgment and failure in performing surgery (procedure) through the development of such a system.

**Method:** First, the name of each part of the feature points constituting the eyes and eyebrows was designated as a point on the coordinate plane.

Second, the six types of eyes and eyebrows were first defined by equation. By substituting the input coordinates into this equation, a criterion for determining what shape the user’s eyebrows fit was presented. In addition, it is possible to determine what shape the user’s eyes are according to the coordinates of the eyes.

Third, by substituting the coordinates of the eyes and eyebrows, the length and position of the eyes were compared with the position of the eyebrows to determine the image state of the physiognomy and cosmetic plastic surgery, and to what extent it is allowed in surgery (procedure) was suggested.

**Results:** Since eyes and eyebrows are the most important parts of one’s physiognomy (appearance), a method for setting standards that allow immediate judgment of each shape was suggested. The equation was defined according to the shape of the eyes and eyebrows, and when the coordinates were input, it was possible to determine which shape they were, so that good results could be derived.

**Conclusion:** In physiognomy, the color of the pupils and the degree of clarity of the eyes are important. Eyes can be said to be “windows to the mind,” and they are important parts of judging one’s personality and character because they convey thoughts. Eyebrows, along with the eyes, are in an important position to determine large parts of physiognomy and beauty. There are times when you have to decide on surgery for better physiognomy and appearance, but it takes time and effort to learn the correlation between your eyes and eyebrows professionally. Therefore, if you have a tool to analyze it when you do not have knowledge on physiognomy (appearance), you can expect much more efficient results. Based on this paper, it is believed that it will be possible to establish a system that presents the direction or limitations of physiognomy (appearance) and surgery (procedure) because the user’s appearance image status can be immediately known by reflecting eyes and eyebrows on the screen of devices.

**Keywords** Objective Standards, Cosmetic Plastic Surgery, Face Recognition, Eyes, Eyebrows
1. Introduction

Everyone is interested in their beauty and physiognomy. Since customers' physiognomic needs can be consulted on the Internet, there are countless physiognomic information service sites that currently exist offline and online[1]. In addition, an automatic face avatar generation system capable of automatically generating a face avatar most suitable for a user's face on the Internet[2]. This system uses the screen of a mobile device to acquire face images in real time, detect and recognize acquired face images, and classify face features in detail to create avatars of images resembling the user's face[3][4].

However, there are many services that build databases and utilize multimedia devices, but they only compare rough facial shapes, and there is no facial analysis technology based on geometric concepts and numerical objectivity yet. Therefore, a tool that can be objectified as a numerical indicator is needed, which becomes possible as the system of this study. Using the existing avatar generation technology, feature points may be displayed as coordinates on the face input on the screen. At this time, it is important to accurately detect facial feature points such as eyes, nose, and mouth for facial recognition, physiognomy, beauty, and facial expression analysis[5]. Methods for face recognition include statistical-based methods[6], neural network-based methods[7], connection structure methods[8], hidden Markov models[9], etc.

The goal of this paper is to provide information on the user's appearance status and physiognomy by setting feature points as coordinates and creating and calculating a mathematical formula. The coordinates of the individual face are characterized by the ability to protect information.

No one says that physiognomy is entirely unscientific. Beauty comes from a good impression, and a good impression is based on a good physiognomy[10]. Therefore, physiological analysis is an essential process for makeup, plastic surgery, and tattoo procedures. The practitioners have a professional habit of analyzing the shape of the faces to satisfy customers' needs. At this time, the practitioners who have learned physiognomy will be able to provide better results to their customers, but those who have not will need related tools.

Appearance is attracting attention as one of the most important capital in modern society[11]. Appearance is a comprehensive concept that includes face and body, and appearance management includes taking good care of oneself and respecting others[12][13]. In particular, people today can play an important role in determining their appearance by cultivating their appearance, showing off their various personalities[14], and expressing visual beauty through appearance change[15]. Therefore, in modern society, the concept of appearance management is changing in a broader sense and being replaced by beauty. Therefore, in order to create an individual image of individuality[16][17], with the help of cosmetic plastic surgery, appearance is managed according to social standards and one's own standards[18].

As for the development tool of this study, when the face appears on the screen facing a mobile device, the positions of the eyes, forehead, and ears that build the face can be automatically recorded in dozens of coordinates. The length or area between coordinates is calculated by a formula and automatically analyzed according to the conditions of the equation so that the customer's personality or past can be identified and the future can be predicted based on physiognomy. This could help with procedures to create a better image of appearance.

Recently, the beauty industry is actively developing physiognomic linkage, and it is becoming an indispensable part of the standards and principles of plastic surgery. This suggests that the physiognomic point of view is still showing its utility value from an academic and practical application point of view, and that interest in the beauty industry, which combines physiognomy, is also high.

Among the many parts that make up the face, this paper deals with eyes and eyebrows. The
eyes are the first place people encounter when talking to each other. It is said that the eyes are windows to the mind. In physiognomy, eyes are also an important criterion for determining one’s character and fate. Eyebrows are also called the roof of the face because they are at the highest point in the face. Eyebrows are an important part of functional eye protection. Eyebrows transmit a clear image and can make changes easier than in other areas.

As people get older, they try to slow down the aging of their faces to manage their appearance[19][20]. In particular, they are interested in resolving the natural phenomenon of drooping eyes and philtrum. As a method, surgery to reduce philtrum and widen jeontaekgung (the “property area” between the eyebrows) are used to pull the drooping philtrum and widen the area under the stuffy eyebrows. In physiognomy, it is considered to have the effect of securing financial resources as a result of this surgery (procedure). In particular, middle-aged women are considered an important customer base in the beauty industry due to hormonal changes and social status changes, and they are highly interested in eye and eyebrow surgery[21][22][23].

In Chapter 3, the names and coordinates of the characteristic points of the eyes and eyebrows are displayed, and the characteristics are classified by mathematical formulas. Criteria for determining the shape of eyebrows were prepared according to the calculation result in which coordinates were input to the equation. The figures of the criteria referred to the opinions of experts. The experts consisted of four professors in beauty-related departments, and the numbers converged into common figures.

It is important to increase the satisfaction of cosmetic plastic surgery for customers. It is also important to understand how consumers of beauty-enhancing services receive the services they want. Service quality can increase customer preference and emotional bond and provide satisfaction, increasing utilization[24][25]. Korea’s beauty and personal care market is growing. In order to provide high-quality beauty-enhancing services, efforts to expand and specialize from the viewpoint of emphasizing the differentiation of the beauty service industry are required[26][27][28]. Currently, the cosmetic plastic surgery industry is playing a public role in realizing changes in various consumer markets[29]. The facial image analysis technology pursued in this paper will be an important part of the cosmetic plastic surgery industry.

2. Name, Coordinate, and Term Definition of Each Point of the Eye and Eyebrow

2.1. Name and location of each point

When there is a rectangular picture of a human face, the lower center (0.0) is set as the point above the coordinate plane, and the upper center of the face is set as (0,100). Name each feature point characterizing the eyes and eyebrows and set a coordinate name.

Figure 1. Coordinate name.
When the face is reflected on the screen, the coordinate values of each feature point around the eyes and eyebrows are automatically input immediately. Considering that the face is symmetrical left and right, it will not interfere with the flow much without recording the half, so only the right side of each point was designated.

The coordinates of each point are input to the prepared equation, and features of physiognomy and beauty may be automatically output depending on whether the output value meets each criterion.

The name and coordinate value of each coordinate of <Figure 1> are shown in <Table 1>.

Table 1. Coordinate name and value.

<table>
<thead>
<tr>
<th>Point</th>
<th>Location</th>
<th>x-coordinate</th>
<th>y-coordinate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Top point</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>C</td>
<td>Eyebrow front</td>
<td>6.8</td>
<td>69.5</td>
</tr>
<tr>
<td>D</td>
<td>Eyebrow top</td>
<td>23.5</td>
<td>72.7</td>
</tr>
<tr>
<td>F</td>
<td>Eye front</td>
<td>8.2</td>
<td>55.4</td>
</tr>
<tr>
<td>I</td>
<td>The end of cheekbones</td>
<td>36.1</td>
<td>46.0</td>
</tr>
<tr>
<td>Q</td>
<td>Bottom point</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

If the conditions meet by substituting the coordinate values of these feature points into the input formula, the results of physiognomy or cosmetics are output.

According to <Table 1>, the ratio of face size in <Figure 1> is 1:1.38. It is rather long for a Korean face, but rather short for Westerners.

2.2. Definition of terms

2.2.1. Eyebrow line function

We define the six types of eyes and eyebrows by equation [30]. Eyebrows are made of strands. If you look closely at the eyebrows, they cannot be plane because they are a collection of lines. However, from a broader perspective, it can be viewed as a face and has a boundary line by facial recognition technology. The leftmost point is called C (cx, cy) in front of the eyebrow front, and the rightmost point is called the eyebrow tail E (ex, ey). The upper line of the eyebrows can be defined as a function. u(x): [cx, ex] → [0, 100], where u(x_0) is the upper point of the eyebrow at x=x_0. The lower line of the eyebrows can be defined by the following function: l(x): [cx, ex] → [0, 100], where(x_0) is the lower point of the eyebrow at x=x_0. u(x_0). It is the upper point of the eyebrows at x_0, and l(x_0) is the lower point of the eyebrows at x_0.

Figure 2. Eyebrow line function.
Meanwhile, the front point of the eye is referred to as \((fx, fy)\), and the endpoint of the eye is referred to as \((hx, hy)\). Now, if the eyebrow top is the top point of the eyebrow, the eyebrow top can be indicated as follows.

Eyebrow top = \((dx, dy)\), where \(dy = \max(u(x): cx \leq x \leq ex)\).

### 2.2.2. Average rate of change

Eyebrows are said to be the roof of the face, and the highest point among them is the eyebrow top. The most stable form is the position of the eyebrow top at 2/3 of the total eyebrow length. In physiognomy, the color of the pupils and the degree of clarity of the eyes are important[31]. Eyebrows are an important point from the perspective of physiognomy and beauty, and their shape can be fixed relatively easily compared to other parts. Depending on the angle of the eyebrow, it can be divided into an upward type, a horizontal type, an arch type, and a sagging type, and a clear image can be determined according to each shape. Therefore, if you go further from vague term definitions and define them as accurate figures, you may be able to set an objective criterion when your face is reflected on the screen.

A long face will not look long if the straight eyebrows are maintained, and the inverted triangular eyebrows will look sharper if they are straight eyebrows. Therefore, it is important to set the angle of the progress of the eyebrows, so it is necessary to determine the starting point of the eyebrows.

It is not accurate to specify the slope as the slope of the straight line between the two points \((cx, cy)\) and the eyebrow top, given that the leftmost point is \((cx, cy)\) and the last point of the ascending process is the eyebrow top. This is because the location of the left part of the eyebrow is unclear and is often located below the angle. Therefore, in order to measure the angle of the eyebrows, it would be more accurate to start at the point \((fx, u(fx))\), the upper part in front of your eyes where the curve begins in earnest. Therefore, the average rate of change between the starting points \((fx, u(fx))\) and the peak points \((dx, dy)\) of the eyebrow angle is as follows.

\[
\text{Average rate of change of eyebrows}[32] = \frac{dy - u(fx)}{dx - fx}
\]

The length of the eyes = \(hx - fx\)

The center of the eyes = \(gx = \frac{hx + fx}{2}\)

The length of the middle of the forehead = \(2cx\)

### 2.2.3. The curvature of eyebrows

Curved eyebrows generally have a soft image. The degree to which the curve bends is called curvature. If you think of a curve as part of a circle, the distance between the point on the curve and the center of the circle is called the curvature value. If the curve connecting the starting points \((fx, u(fx))\) of the eyebrow curve and the eyebrow top \((dx, dy)\) draws a large arch, the curvature will be large.

The curvature of the eyebrows is defined as follows. The ratio of the distance between the linear point \((dy-u(fx))\) at \((fx+dx)/2\) on the x-axis of the two points and the curved point \(u(dx)-l(dx)\) to the height of the eyebrow top is referred to as eyebrow curvature.

\[
\text{Definition: Curvature of eyebrows} = \frac{u\left(\frac{fx+dx}{2}\right) - dy - u(fx)}{dx - fx}
\]
If the eyebrows are straight, the eyebrow curvature will be zero, and the maximum value of the eyebrow curvature does not exceed 1.

3. Shape of Eyes and Eyebrows

3.1. Shape of eyebrows

3.1.1. Straight eyebrows

Straight eyebrows continue horizontally with little slope and refer to when the position of the eyebrow top exists after the middle of the eyebrows and the average rate of change is less than 0.1, and the length in front of the eyebrows should be similar to the length of the eyebrow top. In other words, the ratio of dividing the length of the eyebrow top by the length in front of the eyebrow should be 2/3 or more.

A) \( \frac{dx}{\frac{fx+ex}{2}} \geq \frac{fx+ex}{2} \),

B) \( \frac{dy-u(fx)}{dx-px} \leq 0.1 \)

C) \( \frac{u(dx)-l(dx)}{u(fx)-l(fx)} \geq \frac{2}{3} \)

Eyebrows are straight eyebrows when these three conditions are satisfied at the same time. A method of determining whether the conditions of straight eyebrows are satisfied by looking at the picture <Figure 4> is as follows.

Figure 3. Curvature of eyebrows.

Figure 4. Conditions of straight eyebrows.
Table 2. Coordinates of Figure 3.

<table>
<thead>
<tr>
<th>Feature points</th>
<th>Coordinates</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(fx, u(fx))</td>
<td>(11,70)</td>
<td>The upper point at the eyebrow front</td>
</tr>
<tr>
<td>(fx, l(fx))</td>
<td>(11, 63)</td>
<td>The lower point at the eyebrow front</td>
</tr>
<tr>
<td>(dx, dy)</td>
<td>(29, 71)</td>
<td>Eyebrow top</td>
</tr>
<tr>
<td>(dx, l(dx)</td>
<td>(23, 65)</td>
<td>The lower point of the eyebrow top</td>
</tr>
<tr>
<td>(ex, ey)</td>
<td>(34, 60)</td>
<td>The endpoint of the eyebrows</td>
</tr>
</tbody>
</table>

Substituting the coordinates of Table 2 into the formula of the straight eyebrow, it is calculated as follows.

A) \( 22 > (11+22)/2 = 16.5 \),

B) \( 71-70/29-11 = 1/18 = 0.055 < 0.1 \),

C) \( 71-65/70-63 = 6/7 > 2/3 \).

The coordinates in Figure 3 satisfy all three equations and can be called straight eyebrows.

On the other hand, there may be a straight eyebrow shape while the position of the eyebrow top is front. In such a case, it will have to be measured with other exceptions.

3.1.2. Arch-shaped eyebrows

The curvature tends to increase as the position of the eyebrow top approaches the middle of the eyebrows in a curved and raised form.

The eyebrow curvature is defined as the ratio of the distance between the point in front of the eyebrow and the height of the eyebrow top by measuring the distance between the point on the straight line connecting the two points and the point on the eyebrow top. The larger the eyebrow curvature, the more curved the curve, and the smaller the eyebrow curvature, the straighter it will approach. If the eyebrow curvature is 0.05 or more, the eyebrows form an arch.

When the average change rate is 0.1 or more and the eyebrow curvature is 0.05 or more, it is defined as an arched eyebrow.

\[
A) \frac{dy-u(fx)}{dx-fx} \geq 0.1, \\
B) \frac{u(fx+dx)}{2} \frac{dy-u(fx)}{dx-fx} \geq 0.05
\]

When both of the above conditions are satisfied, it can be called arch-shaped eyebrows.

3.1.3. Semi-arched eyebrows

The average rate of change of eyebrows is equal to that of straight eyebrows and thinner.

The criterion for the ratio in which the thickness of the eyebrow top should be thinner than the thickness of the front part of the eyebrow was set to 2/3. Therefore, the thickness of the eyebrow top should be 2/3 or less thin than the ratio of the thickness in front of the eyebrow and the average rate of change should be 0.1 or less.

\[
A) \frac{u(dx)-l(dx)}{u(fx)-l(fx)} \leq \frac{2}{3}.
\]
When both of the above conditions are satisfied, it can be said to be semi-arched eyebrows.

### 3.1.4. Raised Eyebrows

These are suitable for a short face, and are suitable for a face with a height ratio of 1.3 or less or an angled face compared to the width of the face. If the average rate of change of eyebrows is low, the short face looks shorter and the angled face looks more angular. Therefore, it is considered that the raised eyebrows will be effective if the average rate of change is 0.3 or more regardless of the curvature. To meet the effect of rising, the position of the eyebrow top should be located after the middle of the eyebrow.

\[
\begin{align*}
A) \quad & dx \geq cx + \frac{\epsilon x}{2}, \\
B) \quad & \frac{dy - u(fx)}{dx - fx} \geq 0.3
\end{align*}
\]

When both of the above conditions are satisfied, it can be said to be a raised eyebrow.

### 3.1.5. Standard eyebrows

The average rate of change of straight eyebrows should be 0.1 or less and the average rate of change of raised eyebrows should be 0.3 or more, and the eyebrows with the median value should be said to be standard. If the following conditions are satisfied, it can be said to be standard eyebrows.

\[
0.1 < \frac{dy - u(fx)}{dx - fx} < 0.3
\]

### 3.1.6. Angled eyebrows

This is a condition in which the average rate of change is 0.1 or more and the eyebrow curvature is less than 0.05, and because it does not draw an arch, it goes up straight and bends hard starting from the eyebrow top.

\[
\begin{align*}
A) \quad & \frac{dy - u(fx)}{dx - fx} \geq 0.1 \\
B) \quad & \frac{u(fx + dx)}{2} - \frac{dy - u(fx)}{2} < 0.05
\end{align*}
\]

### 3.2. Relationship between eyes and eyebrows

#### 3.2.1. Jeontaekgung ("property area")

The area between the eyes and eyebrows is called jeontaekgung. This area represents luck with real estate, that is, wealth. It is believed that if this area is wide, it brings a fortune. For Westerners, the eyebrow bones are developed, so the eyes look retracted, and the eyebrows come out, so the distance between the eyes and the eyebrows looks short. In physiognomy, the narrow jeontaekgung of Westerners can be considered bad in terms of Eastern physiognomy.
Recently, cosmetic surgery to expand jeontaekgung by pulling the forehead is common, and the objective criteria are to be set.

The jeontaekgung ratio is the length above the eyes and below the eyebrows divided by the length of the eyes.

\[
\text{Definition: Jeontaekgung ratio} = \frac{l(rx) - ry}{hx - fx}
\]

When jeontaekgung ratio = \(\frac{l(rx) - ry}{hx - fx}\) < 0.1, it is narrow.

When jeontaekgung ratio = \(\frac{l(rx) - ry}{hx - fx}\) > 0.5, it is wide.

<Figure 5> is a physiognomy with luck of wealth with more than 60% of Jeontaekgung ratio.

**Figure 5.** Rep. Sim Sangjung’s profile.

In the picture on the left of <Figure 6>, Jeontaekgung is about 0.05, so Jeontaekgung is narrow, but in the picture on the right, Jeontaekgung is larger than 0.1, so Jeontaekgung is not narrow.

**3.2.2. The middle of the eyebrows**

The middle of the eyebrows refers to the space between eyebrows and eyebrows. It is an important part of the physiognomy, and if it is wide, the mind is relaxed, and if it is narrow, it is delicate and impatient. The length of the middle of the eyebrows is said to be normal if it is equal to the length of the eyes, and the length is 2cx, considering that the face is symmetrical. In other words, if the length of the middle of the eyebrows is less than 2cx, it is said that it is narrow, and if the length of it is longer than the length of the eye, it has the impression that the eyebrows are short.

It is considered narrow when the following conditions are met.
The criteria for figures in this paper objectively determined the facts mentioned on the Internet. In the future, these standards will be modified from a more universal perspective.

4. Conclusion

The criteria for determining the state of physiognomy or cosmetic plastic surgery have not yet had a numerical concept, and the custom of experts and the general public judging by eye guess has continued[33]. The consumer expresses the purpose of the cosmetic plastic surgery he or she wants in words, and the operator listens to it and subjectively judges and performs on the patient's condition through examination if necessary[34][35]. Subjective explanations are also important for patients or customers, but it is natural that presenting objective data will increase reliability even more. Among the characteristics of cosmetic plastic surgery medical services, there is a reality that it is difficult to standardize them because it is not known what medical services each medical customer receives. Since it is not known what cosmetic plastic surgery medical services each medical customer receives, data standardization is a necessary process.

The number of foreigners visiting Korea, so-called the powerhouse of cosmetic plastic surgery and medical technology, is expected to increase in the future, and the Korean Wave is also expected to have a significant impact on the Korean cosmetic plastic surgery market[36]. It is believed that numerical standardization of cosmetic plastic surgery is essential in order to utilize the value of an IT powerhouse and demonstrate cutting-edge technology in this field[37]. For this goal, cooperation with the field of animation development should continue[38].

In this paper, when the eyes and eyebrows are exposed to the screen using modernized devices, the positions of feature points are automatically input and the results of physiognomy and cosmetic surgery are derived. Not only the eyes and eyebrows, but also the areas that make up numerous faces such as the forehead and nose can be digitized, so it is expected that the future task will be to create mathematics and figures of the features that make up all faces.

5. References

5.1. Journal articles


5.2. Thesis degree


5.3. Books


6. Appendix

6.1. Authors contribution

<table>
<thead>
<tr>
<th>Initial name</th>
<th>Contribution</th>
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<tr>
<td>Lead Author</td>
<td>JP</td>
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<tr>
<td></td>
<td>-Set of concepts ☑</td>
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<td>-Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑</td>
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Corresponding Author* | JM |
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