1. INTRODUCTION

With the spread of social networking services (SNS) and the digitalization of the entire consumer space, consumer values and lifestyles have changed significantly. In the case of luxury brands, they are divided into a cluster that maintains its own style while being aware of the trend and a cluster that reacts to the trend first. The brands belonging to the former are called “old luxury” and also “Haute Couture” and “Prêt-à-porter,” whereas the brands belonging to the latter are called “new luxury” and “designer’s brands” [1-3].

Consumer preferences and values for brands are constantly changing. For this reason, collection designers in charge of luxury brands capture the characteristics of brand clusters, infer the future values and sensibility lifestyles of consumers, and create innovative and sophisticated images. Luxury brand sales are limited to certain wealthy people. However, a younger generation called “millennials” has recently entered the “luxury brand market.” This young generation enjoys styles that combine low-price and high-end products, while maintaining the style and silhouettes proposed by the luxury brands [3].

Thus, millennials are fashion-sensitive consumers who can tailor high-end, low-priced products. We infer that millennials’ preferences and values for brands are constantly changing. For this reason, collection designers in charge of luxury brands capture the characteristics of brand clusters, infer the future values and sensibility lifestyles of consumers, and create innovative and sophisticated images. Luxury brand sales are limited to certain wealthy people. However, a younger generation called “millennials” has recently entered the “luxury brand market.” This young generation enjoys styles that combine low-price and high-end products, while maintaining the style and silhouettes proposed by the luxury brands [3].

In addition, time-bound changes appear in the silhouette design. When the fashion trend changes in the apparel industry, it is known that the silhouettes of products sold in the market change greatly. In women’s clothing, a specific silhouette of a garment is often called a “*-line” (e.g., X-line, I-line, Y-line), especially with regard to dresses, suits (two-pieces), etc. “Line” is an abbreviation for “silhouette line” and represents the outline of the clothing [4-6].

A collection refers to a series of works presented at a show or exhibition held by a brand designer in the fashion industry, prior to the season. We tried to classify the silhouettes from the show images by digitizing them. About 10,000 luxury brand images were collected from the Spring/Summer 2011–Autumn/Winter 2018 collections and manually classified based on the silhouette categories in Fig. 1 that are considered standard in the
apparel industry [7]. As a result, about 30% of the silhouettes were not included in the industry classification category. This is thought to be because the silhouette categories [7-10] had been generalized over time by the addition of new ones on a patchwork basis from 1804 and stopped increasing in 1976.

In this study, in order to renew the silhouette category for this day and age, we selected collection images of luxury brands and studied the classification method of silhouettes, which are an element of fashion design. Thus, this study grasps the trend change of silhouette design visually by systematizing and classifying silhouettes that are important in predicting the future of fashion design.

2. MATERIALS AND METHODS

In the experiment, we chose three luxury brands that have a substantial influence on trends: Dior, a traditional luxury brand; Sacai, a new Japanese brand; and Doris Van Noten, one of the Antwerp Six, from the WGSN [11] site. And then we selected 56 images from the 2012 Autumn/Winter Dior (Christian Dior) collection and 167 images from the 2017 Spring/Summer collection (Dior 64, Dries Van Noten 60, Sacai 43), a total of 223 sheets. Each silhouette digitized into an image was measured as shown in Fig. 2. The silhouette classification method proposed in our previous study [12] was adopted. We focused on the 11 positions of the clothing: Total height, Neck, Shoulder, Sleeve width, Waist, Hem high, Hips, Length high, Hem line, Knee, and Length, considering that the feature values are the positions measured by the pattern maker during design. These positions are indicated for four typical silhouettes in Fig. 2a, from left to right, the separate skirt type, separate pants type, dress flutter type, and dress type. Shoulder, waist, and hem are common with those in the pioneering study by Kroeber [13], which measured silhouettes in 1919.

In the analysis, the measurement results were standardized against the Total height of each model in target images. Two analysis methods effective for silhouette classification were used to perform multivariate analyses. One is multidimensional scaling (MDS) and the other is cluster analysis.

2.1 Multidimensional Scaling (MDS) analysis

Multidimensional scaling is used to reduce the distance matrix created from multidimensional data to low dimensions such as 2D and 3D. The reduced results are reproduced in a low-dimensional Euclid space with the positions between objects from the dissimilarity matrix distance calculation. Objects with a higher dissimilarity value (dissimilarity) are placed farther away whereas those with a lower dissimilarity value (similarity) are placed closer. Therefore, the features between objects can be visually grasped from the reproduced arrangement. Thus, the corresponding silhouette can be visualized in two dimensions using dissimilarity values as coordinates.
2.2 Cluster analysis
Hierarchical cluster analysis using the condensation method was performed. The calculation steps are as follows: In the first step, one individual is regarded as one cluster. The proximity matrix distance between n individuals is calculated. In the second step, one cluster is created by merging two clusters with the highest similarity. In the third step, the distance between the merged cluster and other clusters is calculated, and the proximity matrix is updated. The calculation is repeated until the number of clusters is one. The distance calculation after a merger can be performed using the shortest distance method, longest distance method, median method, centroid method, group average method, or the Ward method [14]. In this study, the distance calculation is performed using the Ward method. The cluster of each silhouette is determined based on the tree diagram output obtained from the Euclidean distance calculation performed according to the Ward method.

3. RESULTS AND DISCUSSION

3.1 Multidimensional Scaling (MDS) analysis
The color of “◆◆◆◆” in the MDS distribution chart in Fig. 3 is classified by brand name and time of announcement. “◆1-◆56” is Dior 2012 Autumn/Winter (A/W), “◆d01-◆d64” is Dior 2017 Spring/Summer (S/S),

![Multidimensional scaling (MDS) distribution map of 223 images](image-url)
“◆s01-◆s43” is Sacai 2017 S/S, “◆v01-◆v60” is Dries Van Noten (Van to distinguish from Dior) 2017 S/S. In Fig. 4, Fig. 5, images corresponding to the output numbers are arranged in order to visually grasp the change in the trend and silhouette of each brand. As for the image size, the image of the place with high value density is reduced.

Figures 4a and 4b are comparisons of the same brand in different years and different seasons. When performing the comparison, we observed that there are many similar silhouettes in the dresses, and that their tastes are also similar. Figures 4b, 4c, and 4d compare the differences among the various brands. In 2017, many sporty silhouettes with

Figure 4: MDS distribution map of images for each brand (Images from WGSN [11])
a length down to the knee appeared and the whole trend was distributed vertically. The brand comparison (Figs. 4b, 4c, and 4d) shows that the characteristics of the brands are strongly expressed by the silhouette distribution. This seems to reflect the difference in brand taste.

3.2 Cluster analysis

In the tree diagram of the cluster analysis of the 223 images, shown in Fig. 5, the red dotted line part is divided into nine clusters from (1) to (9). “Silhouette (10)” in the cluster (6) is very different from the other silhouettes, which is shown in the enlarged view of the cluster (6) part in Fig. 5.

The characteristics of each cluster are as follows.

- Cluster (1): The length of the clothes is from the neck point to the knee. The silhouette is a trapezoid spreading from the upper body toward the bottom in a relaxed form.
- Cluster (2): Some clothing lengths are from the neck point to above the knee and some to the knee. The silhouette is the shape of a box that falls linearly toward the hem and the upper body is loose.
- Cluster (3): The clothes’ length is from the shoulders to the ankles and the straight line toward the hem is similar to that of cluster (2). The shoulder width itself is not very wide. It is a thin rectangular silhouette that can be expressed as an I-line.
- Cluster (4): The length of the clothes is from the shoulder to the ankle. The pants are from the shoulder to the hem and taper toward the hem rather than stay straight. The silhouette is a natural V-shape.
- Cluster (5): The length is from the neck point to the calf. It is a natural V-shaped silhouette that tapers from the shoulder to the hem.
- Cluster (6): The clothes’ length is from the neck point to below the knee. The waist is thin and has an X-shaped line that spreads toward the hem.
- Cluster (7): Clothing length is from the neck point to below the knee. The X-line, which narrows toward the waist and expands toward the hem, is the same as in cluster (6), but the length is longer than (6). Therefore, it can produce an extreme spread.
- Cluster (8): The length is longer than to the ankle. The width of the garments is an X-line that narrows toward the waist and expands toward the hem. The difference from cluster (7) is that it is longer.
- Cluster (9): The length is longer than to the ankle. This characteristic is no different from that of cluster (8). However, the spread of the hem width is larger.

Figure 6 captures the characteristics of each silhouette and defines it as the “basic figure of the silhouette.” Figure 7 adds zoning of the dendrogram cluster to the MDS scatter plot. The position of “silhouette (10)” appears in the upper side of cluster (8). “Silhouette (10)” is a silhouette that should be included in cluster (1). However, as a result of measuring the position of the hem width of the pants as the length, it appears at a position shifted from the original position directly below.

In the silhouette analysis method combining the scatter plot of MDS and the dendrogram shown in Fig. 7, a measurement error at the time of measurement appeared...
as a noticeable graph. As a result, we were able to prove the authenticity of the analysis method again. Thus, Sacai (green) 87%, Dries Van Noten (yellow) 11%, Dior (black) 2% comprise cluster (1). In cluster (2), the three brands of 2017 are mixed. Furthermore, 80% of Dior 2012 is in the zones of clusters (4), (5), (6), and (7) in the middle of the height, and 97% of clusters (8) and (9) is composed of Dior (2012, 2017).

By combining results from MDS and cluster analysis, we achieved the systematization of silhouettes and the visualization of design trends, which were the objectives of this research. The results are shown in Fig. 8. By arranging the images corresponding to the numbers in this figure, one can systematically grasp the design trends that can be confirmed by the human eye. Figure 9 is a systematic diagram of the silhouettes revealed in this study.

Figure 6: Basic figures of classified silhouettes (Images from WGSN [11])

Figure 7: Combination of MSD scatter plot and clustering

Figure 8: The systematization of silhouettes and the visualization of design trends (Images from WGSN [11])
4. CONCLUSION

Silhouette is an important element of fashion design and changes significantly with fashion trends [15-20]. This study has focused on two perspectives on the changing silhouette. The first is a chronological comparison of silhouettes of the same brand. The second perspective compares silhouettes of different brands in the same season. “catwalk image analysis” was conducted to capture changes in fashion trends, and this was visualized as a silhouette location map. We could attempt to understand the changes in fashion sensibility from the perspective of “design changes in the silhouette line” created by designers. In addition, this method could be applicable to automatic silhouette classification for unknown silhouettes.

As a future work, we plan to interview experts in fashion sales and fashion design to confirm whether the location map obtained in this study is consistent with silhouette classification based on the sensibilities of experienced people. “Fashion and clothing may appear to be the same thing, but they are far from it [15].” This statement represents the difference in concept between fashion and clothing. Without understanding this concept, it is impossible to understand the strong desire of fashion lovers for silhouettes and the brand identity [21, 22] that the company originates. The study will be related to this point.

We believe that the lack of research on the relationship between “fashion concept” and “deep psychology of sensitivity [23]” in the field of “fashion meets computer vision [24]” provides ample opportunities for further research that will lead to the development of the field, which links fashion and AI.

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