The Shape of Design History: Exploring Evolution of Sneakers Design at Scale Using Neural Embedding

Sungkyu Park, Hyeonho Song, Sungwon Han, Lev Manovich, Emanuele Arielli and Meeyoung Cha

July 3, 2021

7^{th} International Conference on Computational Social Science IC^2S^2
July 27-31, 2021, ETH Zürich, Switzerland

The Shape of Design History: Exploring Evolution of Sneakers Design at Scale Using Neural Embedding

Sungkyu Park[1] Hyeonho Song[2] Sungwon Han[2] Lev Manovich[3,1]
Emanuele Arielli[4] Meeyoung Cha[1,2]

[1]Data Science Group, Institute for Basic Science (IBS) [2]School of Computing, KAIST
[3]City University of New York, USA [4] Università Iuav di Venezia, Italy

Keywords: Sneaker design; Deep representation learning; Neural-net embedding; Contrastive learning; Unsupervised clustering; Global fashion trends

Extended Abstract

As many designers and researchers have pointed out, fashion trends constantly change and sometime trends revert to cycles of previous decades. Meanwhile, street fashion trends and sport cloves including sneakers have become very influential in mass fashion [1]. The collaboration of luxury and street brands has been the subject of study in sociology and marketing research [2]; it looks at the dynamics of global and social networks as well as digital communication work of the brands but leaves out specific observations on form and design development.

In this light, our paper for the first time applies data science methods to a new research domain – analysis of product design evolution over a long historical period. Analyzing group interactions (as studied by social science) cannot always explain trends comprehensively: formal and aesthetic features and their evolution allow us to get additional insights about the evolutionary success of a product or cultural artifact, since human or consumer behavior is also shaped by formal taste. In our work, we apply state-of-the-art deep learning methods to a dataset of 23,492 sneakers models from 92 brands released in 2001–2020, along with their descriptive metadata and resale prices on the global leading online sneaker reselling shop StockX.[1]

The following are our initial research questions: 1) Does the evolution in sneakers design exhibit systematic temporal patterns, and what are these patterns? (For example, does the variability in design attributes and their combinations increases or decreases gradually over time); 2) Are such patterns shared across key sneakers brands, or do the brands evolve in different ways? 3) Are there some latent dimensions that account for the design evolution? (In other words, can we reduce changes in many sneakers attributes to a few dimensions?)

To represent the sneaker designs in our dataset, we set up three embedding models with three attributes, shape, color, and segment. For shape, we construct an embedding model as shown in Figure 1(a). Our basic concept is to extract embeddings from the 2D sneakers images based on the ImageNet pre-trained ResNet-18, a 18 layers-deep convolutional neural network, and then fine-tune them using an unsupervised contrastive learning approach [3]. This method allows us to generate latent vectors with 512 dimensions for each image from the trained encoder. For color, it can be represented with the mean (μ) and standard deviation (SD) for the

[1]StockX. https://stockx.com/.

RGB and HSV values as in. For segment, it can be represented via a segmentation model named Unsupervised Image Segmentation by Backpropagation that partitions an image into groups of pixels containing similar traits [4]. We extracted five features by image: μ and SD for each segment's area, its surrounding, and the number of segments. Finally, we concatenated all three attributes as 529 feature dimensions as the latent sneaker vector.

We then run a k-means clustering and test the quality of clustering via visualizing the embedding on a reduced two-dimensional UMAP plane after clustering. We qualitatively investigate images within clusters and confirm that the sneaker models are successfully clustered based on their shape, color, and segmentation patterns. As a next step, we examined the design changes for each brand over time. For visual comprehensiveness, we use PCA to reduce embedding to a single dimension value, which we call the sneaker design index. Figure 1(b) shows the trajectory for five example key brands that are known for their distinct style. The sneaker design indices vary widely for these brands. Mainly, the indices were diverging until 2016 among 5 brands. Over the 23 years, we see the design patterns gradually become similar. Also, it is intriguing to note that the temporal design patterns of Nike and Jordan are similar, possibly because these brands are rooted in the same company.

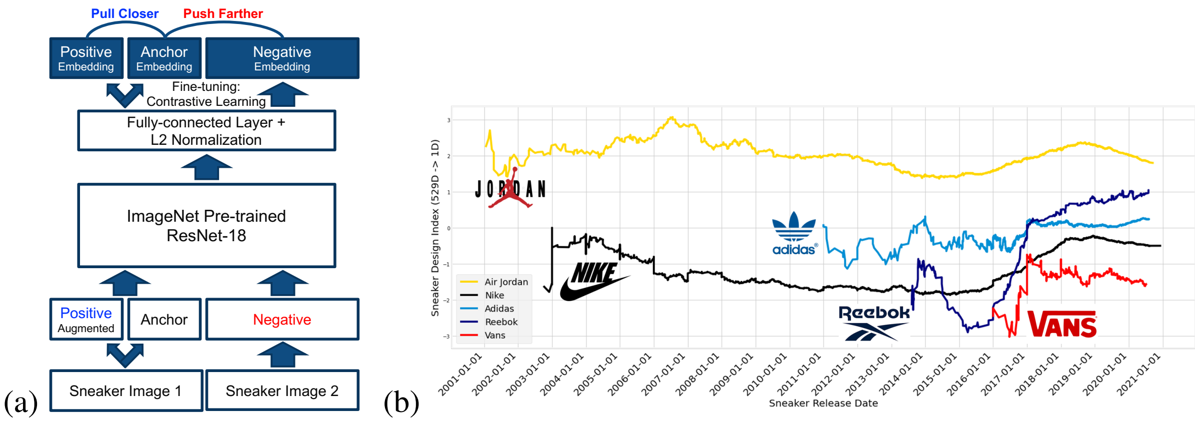

Figure 1: (a) Illustration of the proposed sneaker design embedding model for the shape attribute; (b) Temporal sneaker design patterns with five global key brands.

Our model is unsupervised, which means it can be extended to other fashion items, allowing broader applications. Our findings can be compared or assist efforts in existing qualitative or non-neural methods in understanding the evolution of style in mass fashion. Methods like ours can have practical usages by helping designers understand the crucial traits of fashion trends otherwise not visible from qualitative analysis.

References

[1] N. Groce, "The Biggest Trends of the Decade," in *Hyperbeast*, Dec 26, 2019. https://hypebeast.com/2019/12/biggest-popular-trends-style-streetwear-athleisure-sneakers.

[2] N. Kalbaska, T. Sádaba, F. Cominelli, and L. Cantoni, "Fashion communication in the digital age," in *Cham, Switzerland: Springer*, p.79, 2019.

[3] M. Shin, S. Han, S. Park, and M. Cha, "A Risk Communication Event Detection Model via Contrastive Learning," in proc. of the *NLP4IF Workshop on NLP for Internet Freedom*, Dec 2020.

[4] A. Kanezaki. "Unsupervised image segmentation by backpropagation," in proc. of the *2018 IEEE International Conference on Acoustics, Speech and Signal Processing*, pp.1543-1547, April 2018.