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Toward a Predictive Genealogy of the *PX* Sculpture Series
A Quantitative Analysis of Artist-Directed Evolution Using Bioinformatic Methods

Motivation

The creation of art can be understood as an evolutionary process: ideas mutate and transform, rearrange and recombine, and materialize themselves as concrete artifacts – all under the supervision of an artist's mind that selects, organizes and discards. Such an evolutionary process appears to be at work for the vast majority of art that is being created. Even where the traces of evolution are difficult to detect in the finalized work of art, they tend to be abundantly visible in the notes, sketches and prototypes that document the process of its creation. In much the same way as biologists study fossils and genetic fingerprints to dissect the laws of biological evolution, evolutionary analysis provides a promising approach for studying the conditions and processes involved in the creation of art.

The *PX* series of sculptural objects by Dorothee Golz is particularly suited for an evolutionary analysis. In this series, the artist embraces the concepts of mutation and recombination (which are also at the core of biological evolution) in order to develop a language of sculptural forms that is flexible and expressive in a broad range of contexts. In aggregate, the *PX* series documents a decade-long and still unfinished process of creation; and by using quantitative methods of evolutionary analysis, we can start dissecting concepts and patterns that are at the heart of this sculpture series. This approach might not only provide a first step toward establishing a genealogy of the *PX* series as it stands today, but it could also suggest relevant building blocks for developing the series toward an increasingly dense language of sculpture.

Analysis

Our analysis employs bioinformatic methodology that is widely and successfully used for dissecting the processes of biological evolution. To be able to analyze sculptures in the same way as we may also analyze the descent of man from his great ape ancestors or the evolution of viruses in an HIV patient, each object is encoded by a binary vector representing the object's key attributes. We can then use statistics software to identify and visualize relevant associations between the objects and thereby delineate characteristic patterns that are implicitly present in the dataset. And in a final step we can go beyond descriptive analysis and start predicting the attributes of new objects that would naturally complement the *PX* series.

Codifying the objects. At the time of the analysis in October 2013, the *PX* series comprised 99 sculptures, which were available either as originals or represented by photographs. To prepare for a quantitative analysis, the artist defined 38 categories that capture the key characteristics of the *PX* sculptures, which included attributes such as size, material, color and shape, but also more abstract concepts such as importance and irony. Each sculpture was assigned a keyword in each of the categories, thus giving rise to a categorical matrix with 99 rows and 38 columns. To facilitate quantitative analysis, we converted this dataset into a binary matrix with 99 rows and 179 attributes that can take only the values 0 and 1 (Figure 1).

Statistical analysis. The binary matrix defines the position of each object in a 179-dimensional hypercube, where a hypercube is the generalization of three-dimensional cubes to arbitrarily high dimensions. While hypercubes are somewhat difficult to imagine visually, they are straightforward to analyze by statistical methods and ideally suited for our analysis. For example, we can calculate the relative distance between all pairs of objects in this 179-dimensional space, and we can project the distances onto a two-dimensional surface for human-readable visualization. Here we used a method called “singular value decomposition” and an open-source statistics software called “R” in order to plot the approximate distances between all 99 objects in a two-dimensional biplot (Figure 2). This plot also highlights the main attributes that govern the observed similarity; they are represented by labeled arrows and point into the direction of those objects for which these attributes are most strongly expressed.

Observations. The plot in Figure 2 provides insights into underlying patterns that seem to be characteristic of the *PX* series. For example, the arrows for importance and for large size both point into a very similar direction, suggesting that large objects tend to be regarded as important and vice versa. We also observe significant correlation between certain materials and the way the objects are made, which is hardly surprising given their physical characteristics; for example cloth can be sewn but not built, while the opposite is true for paste. Finally, there is a striking trend in the data that in recent generations (Generation5, Generation6) essentially all objects are wall-mounted and flat, while earlier generations involved a more diverse mixture of standing, lying and hanging objects. This trend is clearly not due to the lack of relevant standing forms, given the large number of such forms that have been explored in earlier generations. Perhaps the most plausible explanation would be a recent increase in the evolutionary “fitness” of hanging as opposed to standing objects – corresponding to a recent change in the artist’s deliberate or intuitive preference for certain forms over others.

Predicting new objects. Having constructed a statistical model that describes the inherent characteristics of the *PX* series as it stands today, we can now start predicting new objects that could be built to extend the series in a consistent and complementary manner. To that end, we initially generated 1000 potential *PX* objects in the computer by randomly permuting the keywords in each of the 38 categories. These computer-generated objects do not have a concrete form yet, but we know roughly how they would look like based on the values for the 38 categories. With these data in hand, we analyzed all 1000 potential *PX* objects alongside the current series of the 99 *PX* objects, and we used our statistical model in order to rank them in terms of expressiveness (by selecting against objects that carry few or no distinguishing features) and novelty (by prioritizing objects that cover regions of a 10-dimensional principal component space that is not well covered by existing *PX* objects). For the top-ranking predictions, the basic design has been reported back to the artist, who will use this information to potentially extend the *PX* series in directions that may not have been obvious otherwise and thereby increase the density of the language in its defined space.

Outlook

Here we described an evolutionary analysis of a sculpture series using quantitative methods that have been borrowed from the fields of bioinformatics and statistics. Given the ubiquity of evolutionary principles in the creation of art, this quantitative approach provides a novel and intriguing perspective on pieces of art that stand in a temporal and contextual relationship to each other. This approach is first and foremost analytical in nature, as it aims to uncover hidden patterns and principles through large-scale data analysis. But as we have seen, it can also provide a source of creative inspiration, for example by identifying gaps and filling holes in a series of related artifacts.

Quantitative methods such as those described above will of course not substitute, but rather complement, the art historian's expertise and judgment. For example, quantitative methods are powerful for identifying interesting associations, but by statistical means alone we will for example never know whether Dorothee Golz regards large sculptures as important per se – or whether it is the other way round, and she tends to build objects in relatively large way if she expects them to become important. Quantitative methods can also help the artist identify relevant gaps in a series and to provide initial building plans that could fill these gaps; but the actual creation within the predicted rules and boundaries remains the sole responsibility of the artist.

As artists have frequently set themselves rules to restrict and thereby enhance their creativity, and as art historians organize artifacts in concepts and categories, we envision that the methodology of quantitative, evolutionary analysis could become a new element in the creative and analytical toolbox of the artist as well as the art historian.