



## A quantitative approach to painting styles

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### HIGHLIGHTS

- Applied statistical mechanics methods to the analysis of painting styles.
- Philosophical concepts like dialectics were modeled as quantitative metrics.
- Wider dispersion of characteristics for Modern Art while superposition for Baroque.
- Confirms art history: Moderns are independent in style while Baroque share techniques.
- Painting shows increasing innovation. High opposition in Baroque–Modern transition.

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### ABSTRACT

This research extends a method previously applied to music and philosophy (Vilson Vieira et al., 2012), representing the evolution of art as a time-series where relations like *dialectics* are measured quantitatively. For that, a corpus of paintings of 12 well-known artists from baroque and modern art is analyzed. A set of 99 features is extracted and the features which most contributed to the classification of painters are selected. The projection space obtained provides the basis to the analysis of measurements. These quantitative measures underlie revealing observations about the evolution of painting styles, specially when compared with other humanity fields already analyzed: while music evolved along a master–apprentice tradition (high dialectics) and philosophy by opposition, painting presents another pattern: constant increasing skewness, low opposition between members of the same movement and opposition peaks in the transition between movements. Differences between baroque and modern movements are also observed in the projected “painting space”: while baroque paintings are presented as an overlapped cluster, the modern paintings present minor overlapping and are disposed more widely in the projection than the baroque counterparts. This finding suggests that baroque painters shared aesthetics while modern painters tend to “break rules” and develop their own style.

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## 1. Introduction

Painting classification is a common field of interest for applications such as painter identification – e.g. assessing the authenticity of a given art work – style classification, paintings database search and more recently, automatic aesthetic judgment in computational creativity applications. Determining the best features for painting style characterization is a complex task on its own. Many studies [1–4] applied image processing to feature extraction for painter and art movements

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identification. Manovich [5–7] uses features like entropy, brightness and saturation to map paintings and general images into a 2-dimensional space and, in this way, to visualize the difference between painters. There are also many related works dealing on feature selection for painting classification. Penousal et al. [8] use features based on aesthetic criteria estimated by image complexity while Zujovic et al. [9] evaluate a large set of features that most contribute to classification.

This study also analyzes a set of features which most contribute to the classification of paintings. Although, in contrast with previous works, it goes forward: the historic evolution of painting styles is analyzed by means of geometric measures in the feature space. Those measures are based on key concepts from Philosophy: *opposition*, *skewness* and *dialectics*. The dialectics, for instance, is defined by Hegel [10] as a method of argument where a synthesis solves the tension between two opposing ideas: thesis and antithesis. Those concepts are originally qualitative. In this study, thesis, antithesis and synthesis are defined as states in a time-series. The dialectics is then calculated as a quantitative measure: it is defined as the inverse distance between the synthesis state and the perpendicular bisector between thesis and antithesis states. The lower the distance, the greater the dialectics, because the synthesis state is near the perpendicular bisector that models the *ideal synthesis*. This quantitative approach is not meant to surpass the qualitative approach but to contribute in the understanding of human history.

To create the feature space, a set of 99 features is extracted from 240 images of 12 well-known painters. The first six painters of this group represent the baroque movement while the remaining six represent the modern art period. A feature selection process yields the pair of features which most contributed for the classification. Similar results using LDA (Linear Discriminant Analysis) are obtained, which reinforce the feature selection method.

After feature selection, a centroid for each group of paintings is calculated which defines a *prototype*: a representative work-piece for the respective cluster. The set of all prototypes following a chronological order defines a time-series where the main purpose of this study is performed: the quantitative analysis of the historical evolution of art movements. Extending a method already applied to music and philosophy, [11] *opposition*, *skewness* and *dialectics* measurements are taken. These concepts are central in philosophy – e.g. philosophers from antiquity like Aristotle and Plato developed their ideas using the dialectics method while it is also found in modern works like Hegelian and Marxist dialectics – and humanistic fields, however lack studies from a quantitative perspective [10]. Represented as geometric measures, these concepts reveal interesting results and patterns. Modern paintings groups show minor superposition when compared with baroque counterparts suggesting the independence in style found historically in modernists and strong influence of shared painting techniques found in baroque painters. Dialectics and opposition values presented a peak in the transition between baroque and modern periods – as expected considering history of art – with decreasing values in the beginning of each period. Skewness index is presented with oscillating but increasing values during all the time-series, suggesting a constant innovation through art movements. These results present an interesting counterpart with previous results in philosophy – where opposition is strong in almost entire time-series – and in music—where the dialectics is remarkable [11].

The study starts describing the corpus of paintings used and a review of both aesthetic and historic facts regarding baroque and modern movements (Section 2). The image processing steps used to extract features from these paintings are presented followed by the feature selection. The results are then discussed in Section 3 with basis on geometric measurements in the projected feature space—considering the most clustered projection and LDA components.

## 2. Modeling painting movements

### 2.1. Painting corpus

A group of 12 well-known painters is selected to represent artistic styles or movements from baroque to modernism. Six painters are chosen to represent each of these movements. The group is presented in Table 1 together with their more representative style, in chronological order. It is known that painters like Picasso covered more than one style during his life. For example, only the Cubist style is considered for Picasso, even though the artist developed other styles during his career.

For each painter, 20 raw images are considered from the database of public images organized by Wikipedia. Examples of selected paintings titles and their respective creation years are listed in Table 2 and all the paintings are listed in Table B.1 in Appendix B.<sup>1</sup>

It is interesting to review some historical and aesthetic characteristics from baroque and modern movements before entering into the quantitative analysis in Section 3 where those hypotheses are further discussed. Baroque is marked by tradition, a desire to portray the truth (found in Caravaggio, Frans Hals and Velázquez), the beauty (Poussin, Vermeer), the nature and the sacred (Caravaggio, Rembrandt). A remarkable use of light contrast (as in the “*chiaroscuro*” technique mastered by Caravaggio), disregarding simple equilibrium in composition and preference for complex oppositions, both compound aesthetic characteristics which baroque artists used to represent their ideas. The transmission of those techniques from one painter to another is common in baroque. Modernists, on the other hand, did not follow “rules”. Each modern painter employed or created new ways to represent ideas. As noted by Gombrich: “[they] craved for an art that does not consist of tricks that could be learned, for a style that is not a mere style, but something strong and powerful like the human

<sup>1</sup> The source code together with all the 240 raw images are available online at <http://github.com/automata/ana-pintores>.

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