

Temporal variations in frequency of color use relative to position in portrait paintings

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Abstract: As the times change, various styles and techniques of paintings have been created, and in recent years, advances in generative AI have made it possible to create very natural and realistic artificial paintings. In this paper, we focus on paintings obtained from WikiArt that are labeled as portrait and self-portrait, divide the canvas of the painting into sections, and focus on the temporal variations in the frequency of color use in each section over the years. The results of the experiments showed that red was used above a certain quantity, green was hardly used at all, and blue had been used less frequently since the 17th century. No significant differences were observed in these characteristics across the years for each section. In the future, when generative AI is used to create portraits, it is conceivable that there will be two possibilities: one is to simulate human creative activities by reflecting these characteristics, and the other is to overturn it by using new methods of using color.

Keywords: Paintings, WikiArt, Portrait, Hue, Frequency of color use relative to position

1. Introduction

Painting is one of the artistic mediums that has been used since ancient times, for example, cave paintings date back as far as ancient times before Christ. Painters express on canvas the impressions and emotions they feel when they look at a scene in front of their eyes, therefore the status of painting has in no way declined, even in today's world where photography has advanced. They may also depict things that could never happen in reality or that do not exist. In recent years, advances in generative AI have made it possible to create extremely natural and realistic artificial paintings.

As paintings change over time, various styles and techniques have emerged, and there are studies that analyze them from that perspective [1, 2, 3]. In contrast, this study divides the canvas of a painting into sections, focuses on changes in the frequency of color use in each section over the years, and examines the relationship between color and position on the painting and changes over time.

2. Research Methods

2.1 Obtaining painting images

We use a Python program (hereafter called downloader) that downloads painting images from the

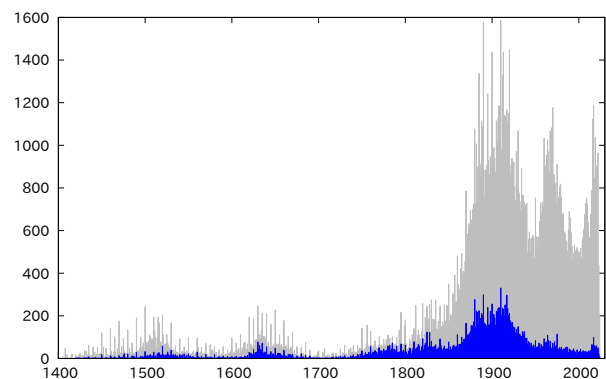


Fig.1 Changes in the number of works by year. Gray: Number of artworks in all genres. Blue: Number of artworks labeled *portrait* or *self-portrait* in the *genre* field in the artwork information JSON file.

WikiArt website [4]. Running the downloader, it first obtains information about the artworks categorized by artist in JSON format (for example, for Van Gogh, it is `vincent-van-gogh.json`). Next, in the contents of the JSON file, `image` indicates the URL of the painting image, and the painting image is actually downloaded based on that information.

We obtained 158,848 painting images from WikiArt. The images are included some works that are (estimated) to have been created before Christ, but the number of works is small and the dates of creation are scattered. For this reason, in this study we only deal with the works created after 1400 AD. In addition, we focus on the works that are labeled as portrait or self-portrait in

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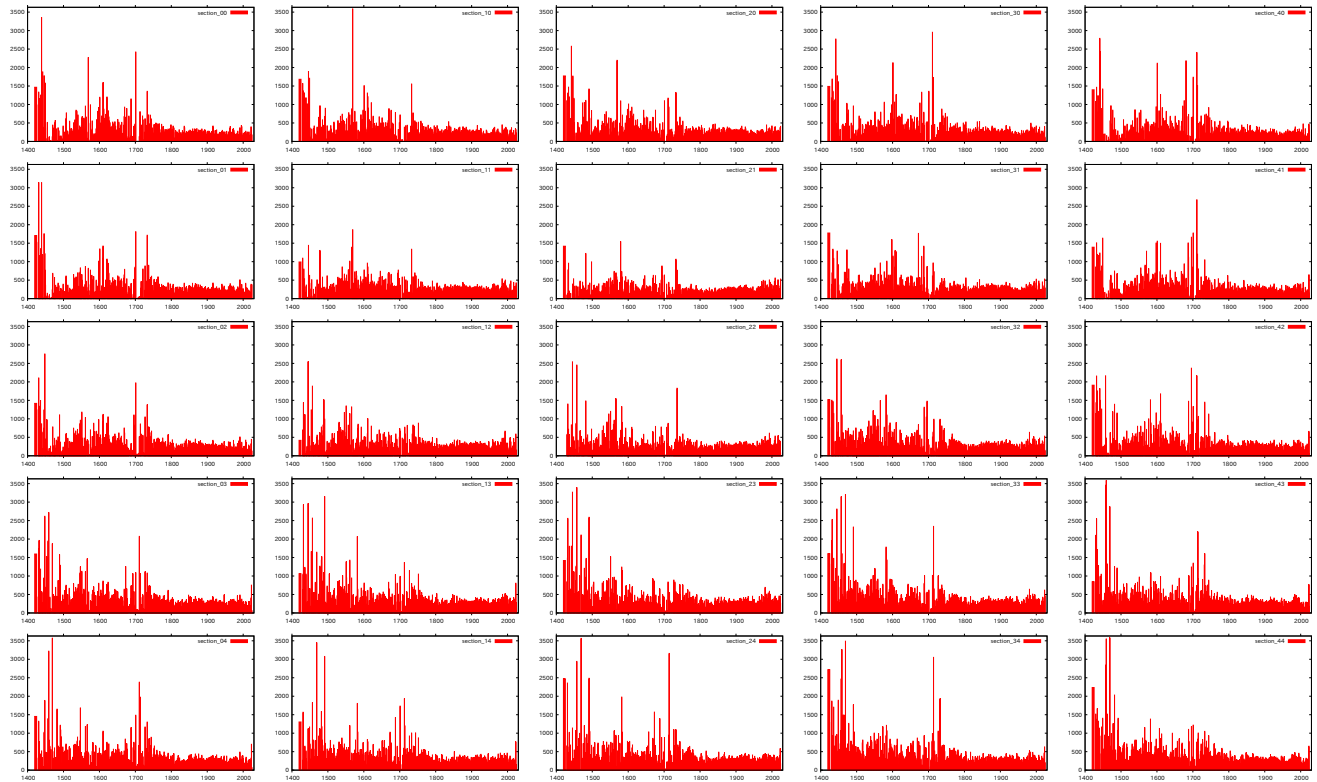


Fig.2 Average frequency of use of red in each section according to the year of paintings

the genre in the JSON file of the artwork information, and we target 25,418 painting images that satisfy these conditions.

2.2 Calculation of the average frequency of color use for each image section

To simplify voting process for each section of the image described later and to speed up processing, we use Imagemagick’s `convert` command on Ubuntu 24.04 to perform reduction processing. In addition, to forcibly change the size of the output image to 300×300 pixels regardless of the size or aspect ratio of the input image, add `!` when specifying the image size. The following command creates `oFile` by reducing the input image `iFile` to a size of 300×300 .

```
$ convert -sample 300x300! iFile oFile
```

We divide `oFile` into 5×5 sections (each section is 60×60 pixels) and count up a number of pixels which use certain color in each section. Each image is converted from RGB color space to HSV color space using OpenCV’s `cvtColor()`.

The colors used to count the number of pixels are red, green, and blue respectively, and if the hue of the pixel of

interest is within $\pm 5^\circ$ of the hue being counted, it is considered to be a similar hue, and then the count value for that section is increased by 1. In this case, the hue in the HSV color space ranges from 0 to 360, but in OpenCV the hue ranges from 0 to 180 so that it can be expressed in 8 bits. Therefore, the range of analogous hues for red ($H=0$), green ($H=60$), and blue ($H=120$) is as follows:

$$0 \leq H_{red} < 5 \text{ or } 175 \leq H_{red} < 180$$

$$55 \leq H_{green} < 65$$

$$115 \leq H_{blue} < 125$$

Note that if the saturation is less than 20, the hue value becomes unstable, so such pixel is excluded from the counting target.

Finally, for each section, we normalize the count by dividing it by the number of works in each year. By this calculation, we can observe the temporal variations in the average frequency of color use in each section.

3. Experimental results

First, for the obtained painting images, Fig. 1 shows the distribution of the number of works in all genres and the number of works that have the portrait or self-portrait label assigned to genre in the JSON file of the artwork information. Next, Fig. 2, 3, 4 show the average

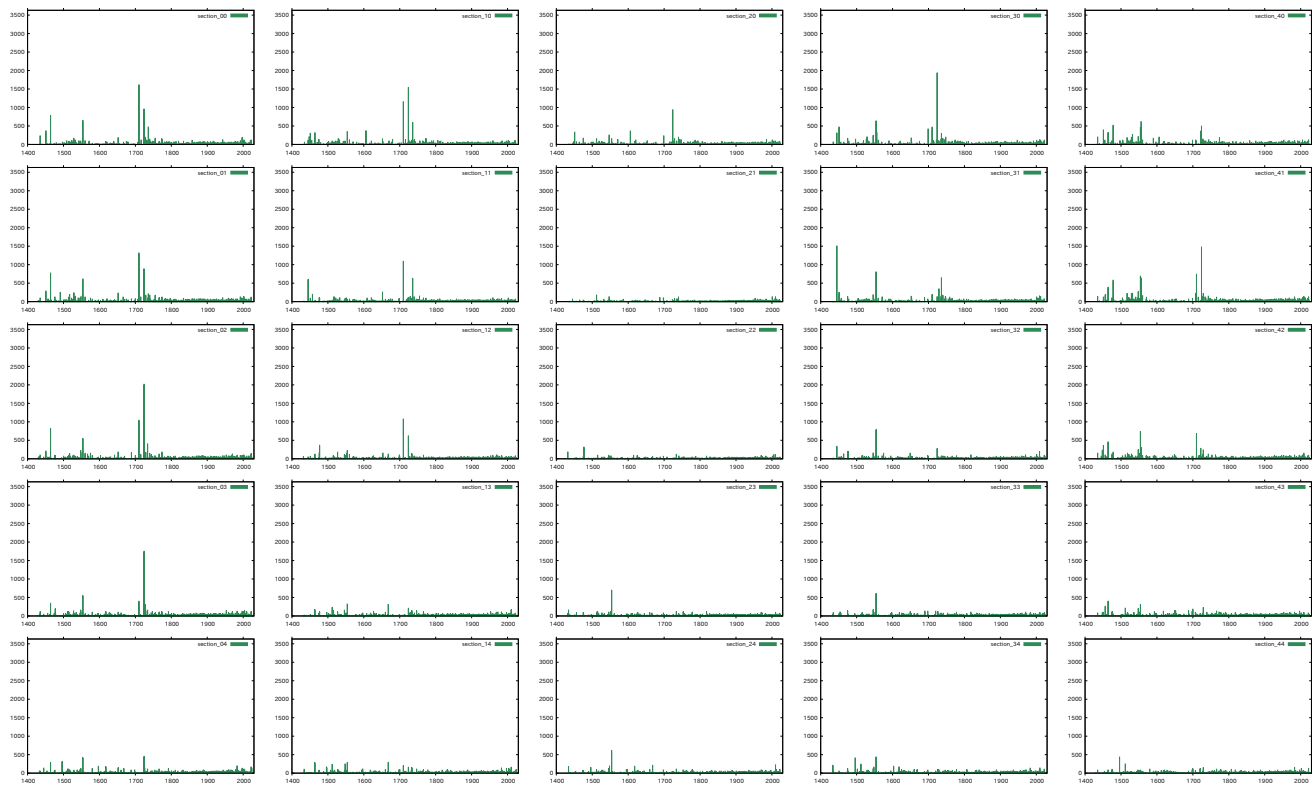


Fig.3 Average frequency of use of green in each section according to the year of paintings

frequency of use of each color in each section against the year of production of the work.

Red is used as a common skin color in these portraits, and it can be observed that it is used in more than 10% of cases in every section in every era.

Green is distinctive and is used much less frequently than red and blue. This is common to each section and every era.

Blue is used less frequently than red, but has been used roughly equally in every section since 1750. It is used to express the darkness of the background, and perhaps also the clothing, especially in the lower sections of the canvas.

4. Discussion

Based on past situations, in this section, we consider how color will be used in the future, including with generative AI.

It was suggested that green is not often used in portraits. This characteristic is likely to remain unchanged in the future. Generative AI generates *probable works* by learning from existing data. Based on this framework, it is considered that the frequency with which

green is used in portrait paintings will continue to be low. On the other hand, green may attract attention from the perspective of pursuing new forms of expression, and its frequency of use may increase significantly compared to the past. Whether or not generative AI can overcome the "wall" of past learning characteristics is conceivable to be important to depend on whether or not it can avoid being bound by the framework of existing characteristics. The color red, which has been routinely used in portraits, is thought to occupy an important position; from the above perspective, however, it is possible that it may fall out of use in the future. Since it is a portrait painting, it is basically unavoidable to use a reddish color for the face of the central figure, except in avant-garde examples. On the other hand, it has free to choose color in the clothing and background, and it is not necessary to use red colors for them. Therefore a generative AI that deliberately chooses to exclude red colors from these could bring a fresh feel to the portrait.

The color blue was a very rare and expensive painting material [5]. The vivid color of lapis lazuli is difficult to reproduce with other minerals or natural pigments, and being able to use the natural ultramarine blue color in

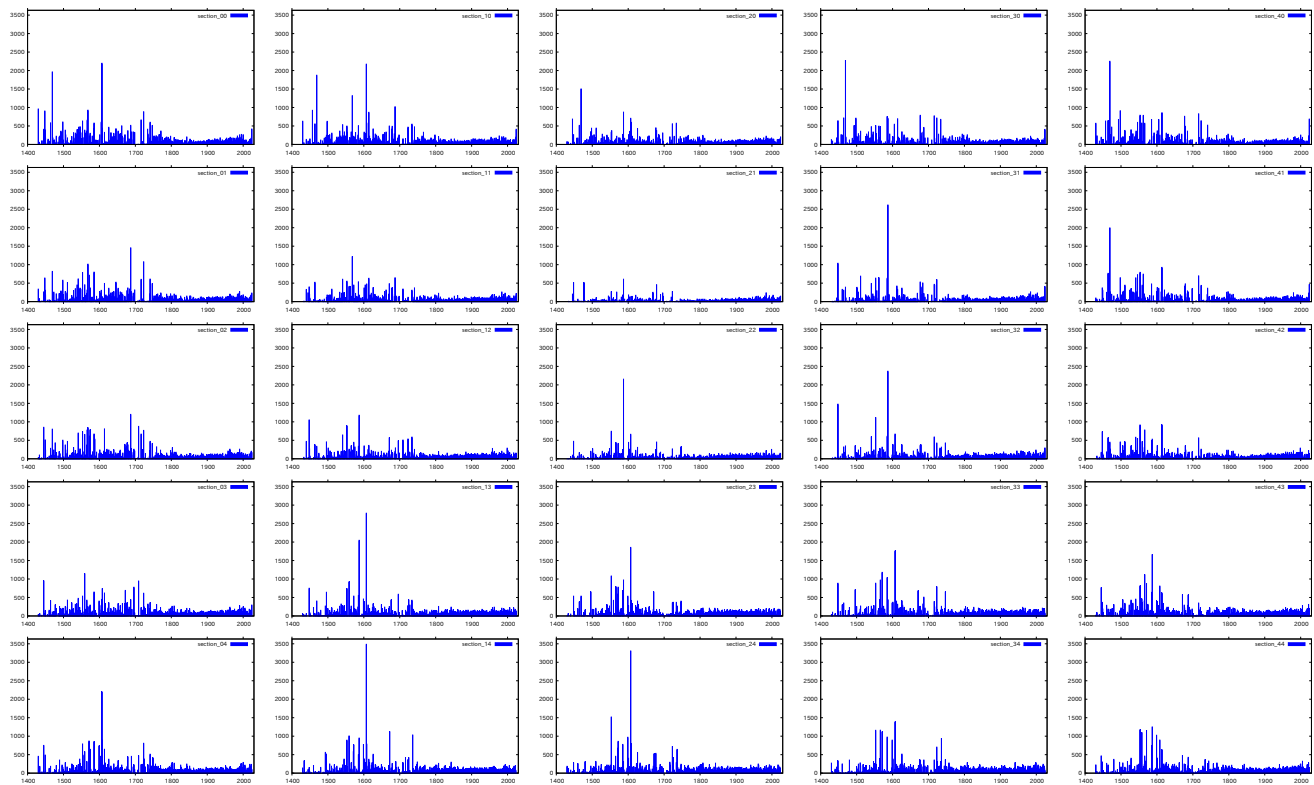


Fig.4 Average frequency of use of blue in each section according to the year of paintings

artwork was a symbol of nobility and power. In particular, lapis lazuli was highly valued as a noble art material in ancient Egypt and in the European world from the Middle Ages onwards due to its rarity and beauty. For this reason, especially, it was often used for the clothing of high-ranking figures in religious paintings. However, recently, obtaining blue painting materials has become relatively easy due to technological advances. The range of color choices is expanding as color refining technology advances and media changes; it is possible that future digital paintings will use even more diverse colors.

5. Conclusions

In this study, we focused on painting images obtained from WikiArt that are labeled as portraits or self-portraits, and examined the frequency of color use relative to the year of production; We observed changes in the frequency of color use at each position on the canvas. We noticed that, almost regardless of the production year of works, the color red is used with a certain degree of frequency, while in contrast, green is hardly used at all. In addition, the use of the color blue decreased from the mid-17th century onwards. For each

color, the distribution of frequency of use within each section did not change significantly.

As the future work, first, we will examine the yearly changes in frequency of use of intermediate colors. In addition, while we only targeted painting images labeled as portraits or self-portraits in this study, we plan to cover other genres as well. Furthermore, we will analyze how color arrangement techniques have been disseminated within the framework of cultural evolution, and also discuss future painting styles.

References

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