Unveiling Color Dynamics in Andy Warhol's "Shot Marilyns": A Study on Visual Variations and Perception

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Abstract

This study delves into the comparative analysis of five distinct versions of Andy Warhol's "Shot Marilyns," focusing on the intricacies of their color composition and distribution. Employing a range of analytical methods, including relative conditional entropy, this research investigates the unique color distributions and interrelations present in each artwork. Through the clustering of the artworks and the meticulous examination of specified regions of interest (ROIs)—namely, the backgrounds, hair, eyeshadow, and faces—we have unearthed profound insights into the constructional variances and similarities among the images. Our findings reveal that the presupposed uniformity in the coloration of certain elements stands contradicted, thereby underscoring the complexity and illusionary nature of color perception in visual art.

***K*eywords** shot marilyns · marilyn monroe · andy warhol · region of interest · python

1 Introduction

In May 2022, one of Andy Warhol's "Shot Marilyn" portraits set a new auction record, selling for $195 million, as reported by the Los Angeles Times. This unprecedented sale has renewed both public and scholarly interest in Warhol's work, highlighting the enduring impact of his art on contemporary culture. The "Shot Marilyns" series holds immense value, not only monetarily but also in its profound impact on contemporary art and its reflection of societal themes. The record-breaking auction underscores its continued relevance and fascination (Vankin 2022). Furthermore, Marilyn Monroe remains an iconic figure whose image has permeated popular culture. Her tragic life story, coupled with her enduring allure, makes her an intriguing subject for artistic exploration (Gallery 2019). Warhol's unique art style, characterized by his use of silkscreen printing and vibrant color schemes, offers a rich field for visual analysis. His method of mass-producing images and manipulating colors challenges traditional notions of art and celebrity, making the "Shot Marilyns" series a perfect case study for understanding his innovative approach (Lanchner and Warhol 2008). Through this analysis, we aim to uncover new insights into the interplay between celebrity, media, and art, enriching our understanding of both Warhol's work and Monroe's legacy.

In 1964, amidst the bustling atmosphere of Andy Warhol's studio, The Factory, a significant event led to the creation of the "Shot Marilyns" series. Warhol, deeply influenced by Marilyn Monroe's tragic death in 1962, began producing silkscreen portraits of her, capturing the iconic actress's image through repetitive, vivid depictions (Christie's 2022). The "Shot Marilyns" series features five portraits shown in Figure 1, each rendered in different color schemes.

(a) Orange Marilyn

(b) Red Marilyn

(c) Turquoise Marilyn

(d) Blue Marilyn

(e) Eggblue Marilyn

Figure 1: The five portraits in Andy Warhol's "Shot Marilyns" series, each showcasing Marilyn Monroe in distinct color schemes: (a) Orange Marilyn, (b) Red Marilyn, (c) Turquoise Marilyn, (d) Blue Marilyn, and (e) Eggblue Marilyn. These variations exemplify Warhol's innovative use of color and his unique approach to portraiture. Image source: The Interior Review. Retrieved from https://www.theinteriorreview.com/story/2022/5/10/critically-assessing-warhols-shot-sage-blue-marilyn.

The name "Shot Marilyns" originates from an incident involving Dorothy Podber, a performance artist and frequent visitor to The Factory. One day, Podber, accompanied by Warhol's friend and photographer Bill Name, observed the Marilyn portraits lined up against a wall. She asked Warhol for permission to "shoot" them, which Warhol, interpreting it as a request to photograph the artworks, granted. Unexpectedly, Podber pulled out a revolver and fired a shot, piercing four of the five canvases through the forehead (Ghighi 2022). This act of violence not only created physical damage but also added a layer of historical intrigue and controversy to Warhol's work, further embedding it into the fabric of pop culture and art history.

In this paper, we aim to conduct a comprehensive analysis of Andy Warhol's "Shot Marilyns" series using several advanced techniques. First, we will analyze the relative conditional entropy of the pixel color distribution in RGB (red, green, blue) space to understand the variations in color across the different portraits. This will provide insights into the underlying patterns and complexity of Warhol's use of color. Next, we will create 3D scatter plots to visualize how each pixel color is distributed in the RGB space, enabling us to observe the distinct color palettes used in each image. We will also apply K-means cluster analysis to identify and compare the primary color clusters within the portraits, highlighting different regions of interest (ROI) such as the background, hair, eyeshadow, and face. Additionally, we will focus on digitally repairing the "Blue Marilyn" using K-Nearest Neighbors to model and analyze the RGB distribution around the gunshot-damaged area. This restoration will involve capturing the gunshot region and using color distribution data to reconstruct the damaged section, preserving the artwork's integrity. Through these methods, we aim to gain a deeper understanding of Warhol's artistic techniques and the visual impact of his "Shot Marilyns" series. While our analysis strives for objectivity, we acknowledge that interpretations of art can be inherently subjective.

2 Methods

An image is composed of pixels, each containing three color components: Red (R), Green (G), and Blue (B), denoted as (R, G, B) respectively. These components determine the intensity of their respective colors, with each component represented by an integer value within the range of 0 to 255 in the RGB color space. Therefore, each color component is a discrete variable capable of assuming 256 distinct values. In the equations below, $Y = y$ or $X = x$ can be selected from any of the three color components, R, G, or B. For this study, each image in the "Shot Marilyns" series has a resolution of 960 by 960 pixels.

2.1 Entropy Calculation

The probability of a specific color component, $P(Y = y)$, is determined by dividing the number of pixels with color coordinates corresponding to that component by the total number of color components in the entire image. The following equations illustrate the calculation of entropy, conditional entropy, and relative conditional entropy introduced by Shannon (1948).

The entropy of a color component Y is defined as:

$$H(Y) = -\sum_{y=0}^{255} P(Y = y) \cdot \log(P(Y = y)) \tag{1}$$

The conditional entropy of Y given X is given by:

$$H(Y|X) = \sum_{x=0}^{255} P(X = x) \cdot H(Y|X = x) = -\sum_{x=0}^{255}\sum_{y=0}^{255} P(X = x, Y = y) \log_2 \left(\frac{P(X = x, Y = y)}{P(X = x)} \right) \tag{2}$$

The relative conditional entropy is calculated using the following formula:

$$HR(X|Y) = \frac{H(X|Y)}{H(X)} \tag{3}$$

2.2 K-Means Clustering Analysis

In the clustering analysis, we applied K-Means clustering to examine the color dynamics in Andy Warhol's "Shot Marilyns" series. For each image, we specified 15 clusters and used the "k-means++" initialization method. This initialization method, introduced by Arthur and Vassilvitskii (2007), improves the convergence speed and accuracy of the K-Means algorithm by spreading out the initial cluster centers. This method is particularly effective in avoiding poor clustering results due to the random placement of initial centroids.

Mathematically, the K-Means algorithm minimizes the following objective function:

$$J = \sum_{i=1}^{k} \sum_{x \in C_i} \|x - \mu_i\|^2 \tag{4}$$

where k is the number of clusters, C_i is the set of points belonging to cluster i, x represents a data point, and μ_i is the centroid of cluster i. The "k-means++" algorithm initializes the centroids by first selecting one random data point as the first centroid. Subsequent centroids are chosen based on a probability proportional to the squared distance from the nearest existing centroid. This process can be expressed as:

$$P(x) = \frac{D(x)^2}{\sum_{x' \in X} D(x')^2} \tag{5}$$

where $D(x)$ is the distance from the point x to the nearest centroid already chosen.

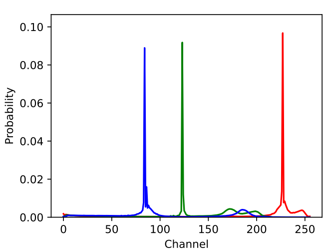
Using this method, we applied K-Means clustering to the entire images and specific regions of interest (ROI) in each image. The clustering algorithm grouped pixels into clusters based on their RGB values, effectively identifying the predominant colors in each image. This approach allowed us to quantify and visualize the distribution of colors, revealing the underlying color patterns and variations within the artworks. The resulting clusters were then analyzed to understand the prominence of specific colors across the series, as depicted in the corresponding bar charts and ribbon visualizations. These visualizations highlight the distinctive color schemes employed by Warhol, providing insights into his artistic technique and color usage.

2.3 ROI Extraction

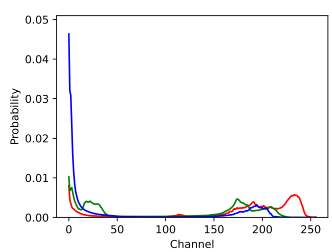
2.4 K-Nearest Neighbors Repair

3 Data Description

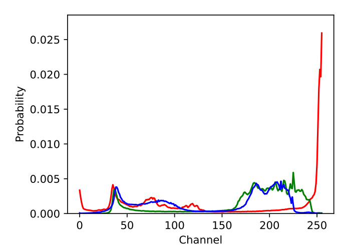
4 Data Exploration and Visualization Analysis



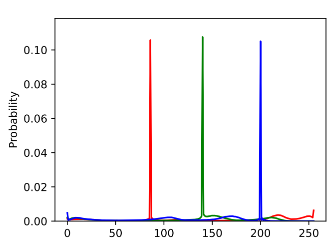
(a) Orange Marilyn RGB Distributions



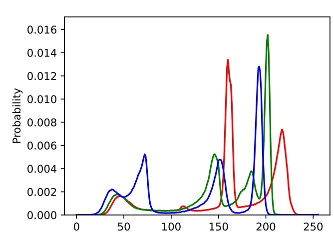
(b) Red Marilyn RGB Distributions



(c) Turquoise Marilyn RGB Distributions

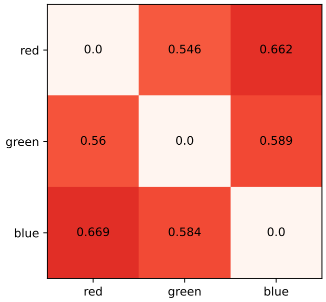


(d) Blue Marilyn RGB Distributions

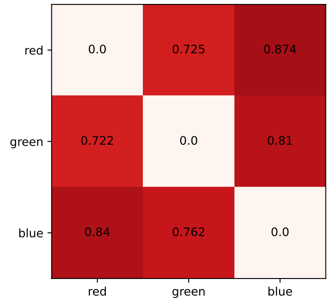


(e) Eggblue Marilyn RGB Distributions

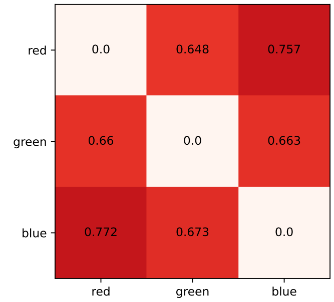
Figure 2: Distributions of values of Red, Green, and Blue channels for five images with all pixels



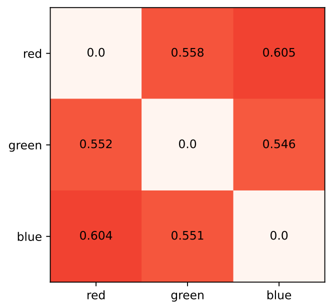
(a) Orange Marilyn Relative Conditional Entropy



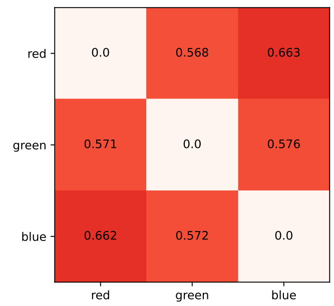
(b) Red Marilyn Relative Conditional Entropy



(c) Turquoise Marilyn Relative Conditional Entropy



(d) Blue Marilyn Relative Conditional Entropy



(e) Eggblue Marilyn Relative Conditional Entropy

Figure 3: The relative conditional entropy values among the red, green, and blue coordinates of pixels

5 Clustering based on Whole Images

6 Clustering based on Region of Interest (ROI)

7 Repair Gunshot of Image

8 Disuccsion

Conclusion and Future Work

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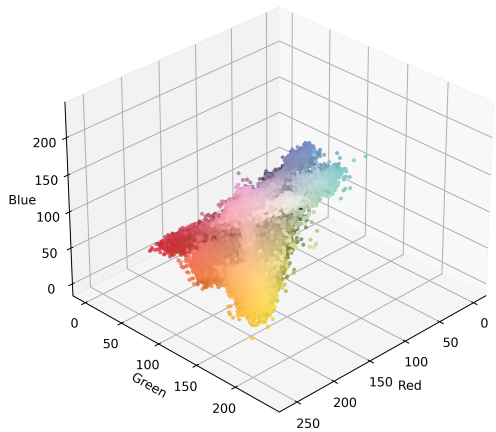
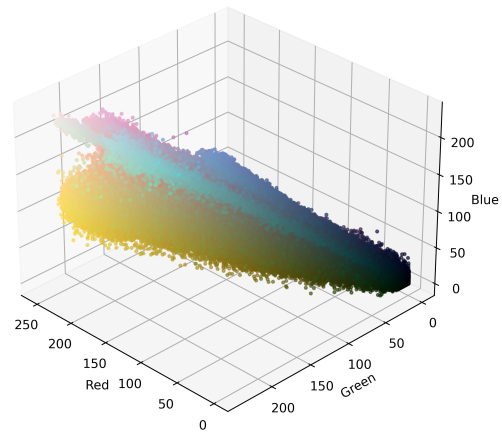
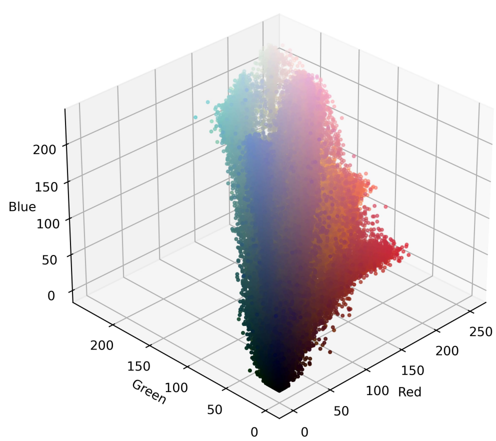


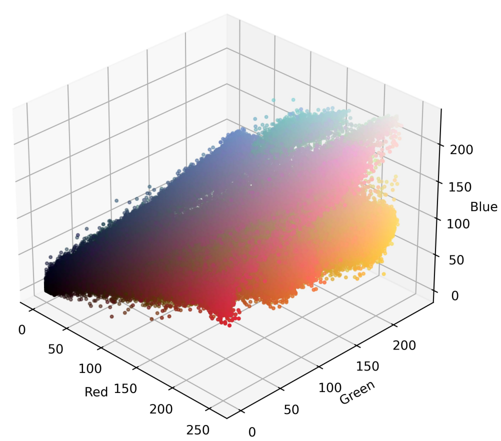
(a) Orange Marilyn RGB Space - 30 °elevation, 45 °azimuth



(b) Orange Marilyn RGB Space - 30 °elevation, 135 °azimuth



(c) Orange Marilyn RGB Space - 30 °elevation, 225 °azimuth



(d) Orange Marilyn RGB Space - 30 °elevation, 315 °azimuth

Figure 4: The RGB space occupied by the pixels for the entire image of Orange Marilyn, showing different angles: (a) 30 °elevation, 45 °azimuth, (b) 30 °elevation, 135 °azimuth, (c) 30 °elevation, 225 °azimuth, (d) 30 °elevation, 315 °azimuth. These variations highlight the color distribution within the artwork.