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

In our Region of Interest (ROI) analysis, we targeted specific segments of the images such as the background, hair, eye shadows, and face. We began by converting the images to the HSV color space using OpenCV's conversion functions, which facilitate more effective identification and segmentation of specific color ranges. By manually determining the minimum and maximum HSV values within selected regions, we created color masks using OpenCV's masking functions to isolate these target areas. These masks highlighted the pixels that fell within the specified HSV range, effectively isolating the desired colors from the rest of the image. Once the masks were applied, we used image processing techniques to extract only the parts of the image that matched the mask, discarding the rest. This allowed us to focus on the color features of interest. The resultant ROIs were then processed and saved for detailed analysis. This method, enhanced by the precise capabilities of OpenCV and guided by best practices from Culjak et al. (2012), enabled us to highlight specific color features in Warhol's artwork, providing nuanced insights into his use of color and its variations, and ensuring accurate and efficient color segmentation and analysis.

2.4 K-Nearest Neighbors Repair

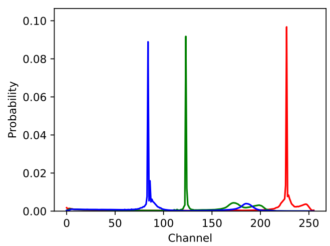
To address the damaged sections of the "Blue Marilyn" image, we employed K-Nearest Neighbors (KNN) regression for image repair. This method involves identifying the coordinates of the damaged pixels and using the surrounding undamaged pixels to predict their values. The KNN regression model, with a specified number of neighbors, was trained on the undamaged pixels' RGB values. The model then predicted the RGB values for the damaged pixels, effectively restoring the affected area. This approach allowed us to maintain the image's visual consistency by leveraging the spatial color information of the undamaged regions. The repaired images were subsequently saved and analyzed to ensure the accuracy and aesthetic integrity of the restoration process.

3 Data Description

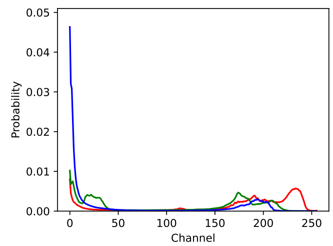
Our study utilized a dataset comprising five images titled Orange Marilyn, Red Marilyn, Turquoise Marilyn, Blue Marilyn, and Eggblue Marilyn. These images are digitally encoded in the RGB color channels, which synthesize a spectrum of colors through the additive mixing of Red, Green, and Blue lights. To enhance future data visualizations, we also converted the RGB values into Hexadecimal representations. Each image measures 960 by 960 pixels, resulting in 921,600 unique data points per image, each specified by a distinct location and chromatic composition. In this additive color model, the intensity of each primary color (Red, Green, and Blue) is quantized into discrete levels ranging from 0 to 255, providing a finite palette within this cubic color space. Each pixel's color is quantified based on the RGB values, making it part of a discrete color space where the combination of these three channels can reproduce a wide array of colors.

Our initial analysis involved examining the distribution profiles of the RGB channels in the images. Figure 2 illustrates the variations in the red, green, and blue distributions across the five images. Notably, images (a) and (d) exhibit significant differences compared to the others.

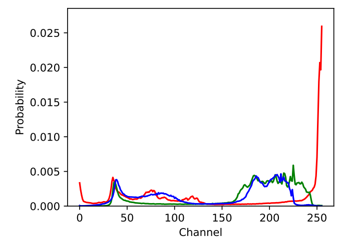
In the Orange Marilyn image (a), the blue channel's highest probability density is localized within the [50, 100] range, reaching approximately 8.5%. The green channel peaks between [120, 130] with a probability



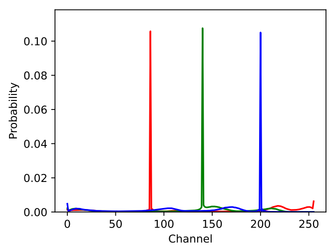
(a) Orange Marilyn



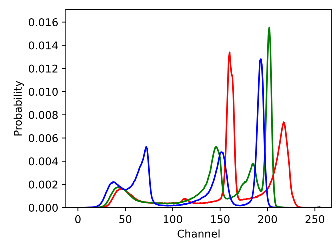
(b) Red Marilyn



(c) Turquoise Marilyn



(d) Blue Marilyn



(e) Eggblue Marilyn

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

around 9%. Additionally, the blue channel shows another notable concentration in the [220, 240] range, with a likelihood of about 10%.

Interestingly, the green channel probabilities in image (d) closely mirror those in image (a), predominantly in the [120, 130] range. However, image (d) differs significantly in the red and blue spectra. The red channel in image (d) peaks in the [70, 80] range with an 11% likelihood, while the blue channel's highest probability is within the [190, 210] range, also accounting for an 11% probability. These differences in the red and blue channel distributions between images (d) and (a) highlight their unique color distribution attributes.

Images (b) Red Marilyn and (c) Turquoise Marilyn display highly skewed patterns. Image (b) shows a right-skewed distribution with the blue channel having the highest probability around 0.05, while the red and green channels are not as distinctive. In contrast, image (c) is left-skewed, with the red channel showing the highest probability around 0.025. Both images exhibit less distinct differences between the red, green, and blue distributions.

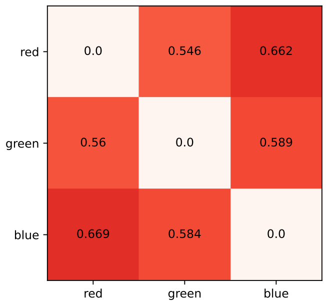
The Eggblue Marilyn image (e) presents a harmonious entanglement of the red, blue, and green channels. Each channel has a relatively similar probability distribution, with no single color dominating significantly. The red, blue, and green channels each have their highest probabilities around 0.015, indicating a balanced color distribution across the image.

This analysis reveals the diverse color distribution patterns in Warhol's "Shot Marilyns," highlighting the unique attributes and artistic techniques employed in each painting.

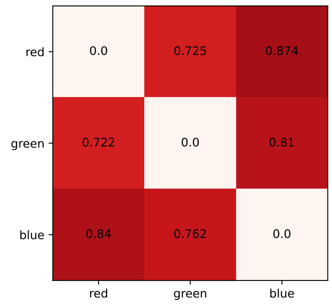
After analyzing the RGB distribution of each image, we further investigated the relationship between pairs of primary colors in the five images by calculating their relative conditional entropy (HR) (see Methods 2.1). This metric quantifies the shared information or dependency between two color channels, with lower HR values indicating stronger dependencies and higher values suggesting greater independence. HR ranges from 0 to 1, where 0 signifies complete dependency and 1 represents total independence.

Figure 3 presents the HR values for nine color pairs in each of the five images: Orange Marilyn, Red Marilyn, Turquoise Marilyn, Blue Marilyn, and Eggblue Marilyn. As expected, comparing a color to itself yields a conditional entropy of zero. High HR values for different color pairs indicate minimal dependency between them.

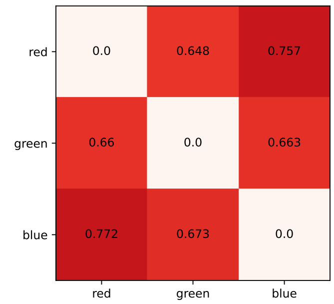
In the Orange Marilyn image (a), the HR values are relatively high between different color pairs, with the blue and red channels showing an HR value of 0.669, indicating a moderate level of independence.



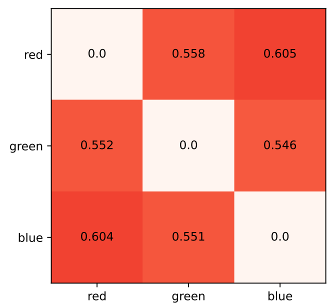
(a) Orange Marilyn Relative Conditional Entropy



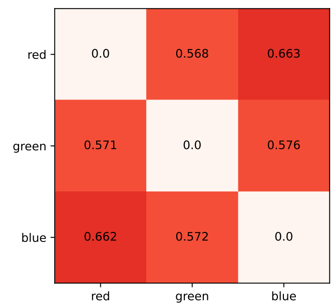
(b) Red Marilyn Relative Conditional Entropy



(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

In the Red Marilyn image (b), all the pairs has higher HR values compare to the other images which indicated red, blue, and green colors high independence each other. Notably, the HR value for the red channel relative to the blue channel is 0.874, signifying very strong independence between these two channels.

For the Turquoise Marilyn image (c), the HR values also reflect notable independence between color pairs. The HR value between the red and blue channels is 0.757, and between the blue and green channels, it is 0.673, indicating a significant level of independence among the color channels.

The Blue Marilyn image (d) exhibits moderate HR values between the color pairs. The red and blue channels showing an HR value of 0.605 and the green and blue channels at 0.546. This suggests a balanced dependency among the color channels in other images.

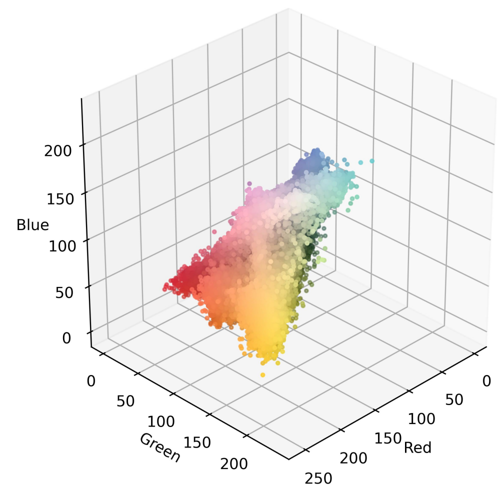
Finally, the Eggblue Marilyn image (e) shows harmonious HR values among the color pairs, with the red and blue channels having an HR value of 0.663 and the green and blue channels at 0.572. These values indicate a moderate level of independence among the color channels.

Overall, these HR values highlight the unique color relationships and dependencies within each of Warhol's "Shot Marilyns" paintings, providing insights into his use of color to create depth and visual interest.

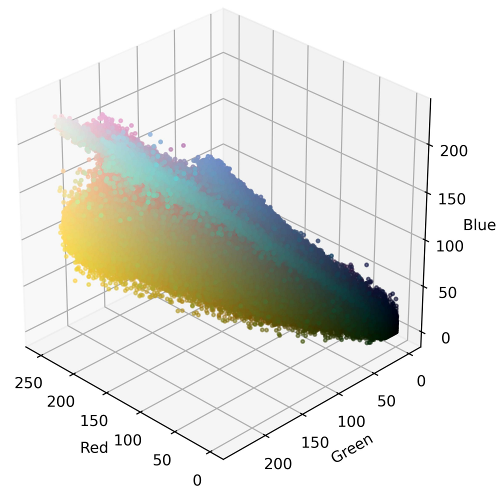
4 Data Exploration and Visualization Analysis

The figures below display the RGB space occupied by the pixels of various Marilyn paintings from four different angles. Each subplot reveals the distribution and density of pixel colors in the 3D RGB color space, providing insights into the color composition and variations within the images.

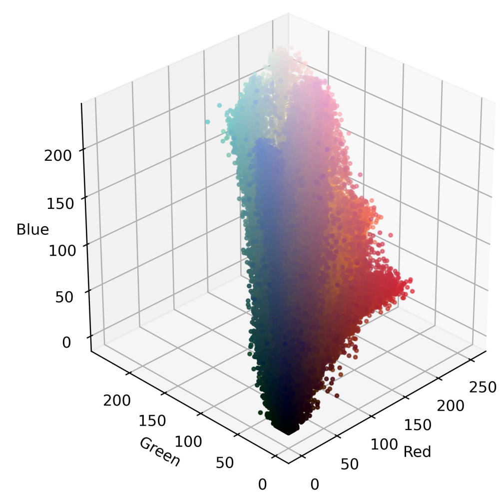
Figure 4 displays the RGB space of "Orange Marilyn" from four different angles. In (a), the density of pixels representing the background part of the image is shown, revealing a balanced mix of colors including orange, yellow, pink, red, and blue. These colors reflect the different dominant areas of the painting: the orange background, yellow hair, pink face, red lips, and blue eye shades. The shape of the 3D scatter plot in (a)



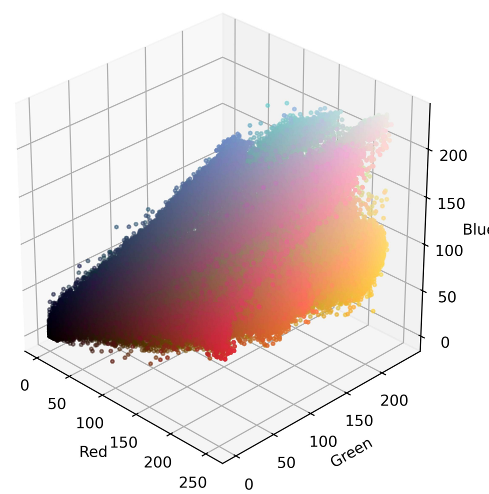
(a) Orange Marilyn RGB Space - 30 °elevation, 45 °azimuth



(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.

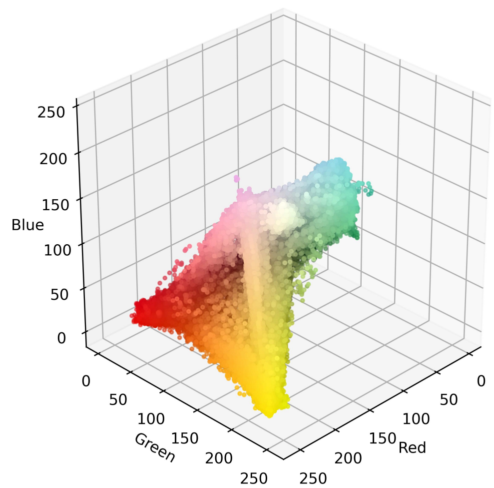
indicates a broad, dispersed distribution of colors, showing the diverse color use in the background and facial features.

In (b), the plot illustrates how colors are distributed from darker pixels at the bottom to brighter pixels at the top, highlighting shading gradients. This gradient reflects the shading around Marilyn's facial features and hair, adding depth to the portrait. The darker pixels likely represent shadows in the hair and facial contours, while the brighter pixels correspond to highlights on her face and hair.

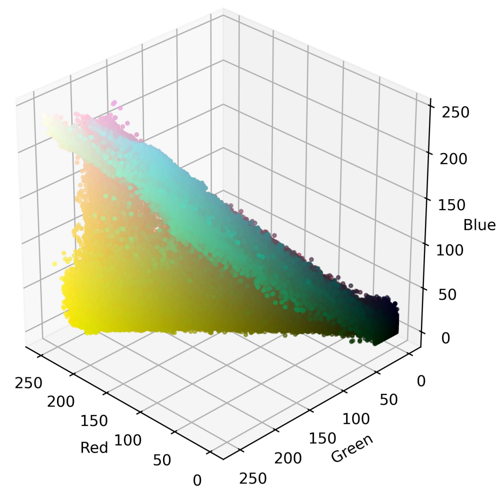
In (c), the concentration of the brightest pixels is evident, showing specific groupings likely related to prominent features. This highlights the intense colors used in Marilyn's lips, eyes, and other facial highlights.

The plot suggests a focused clustering of bright colors, indicating areas where Warhol applied more vivid hues to draw attention.

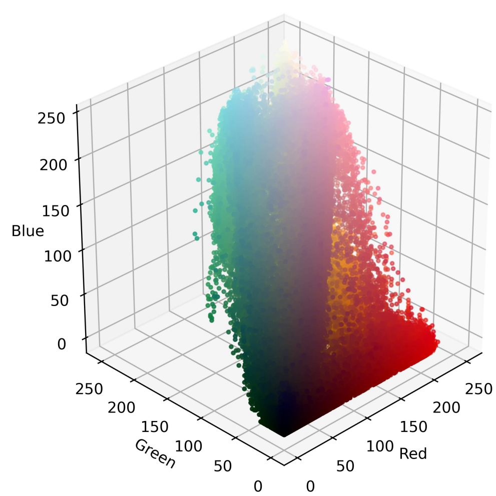
In (d), the color distribution from dark to light is presented from a different angle, allowing us to observe the distribution of colors in areas such as hair and eye shades with less red. This provides a different perspective on the artwork's color dynamics, showing how the turquoise and yellow shades in the hair and the blue in the eyes are distributed. The shapes in (b) through (d) all reflect a similar elongated form, resembling a long funnel, showing a clear gradient from dark to light colors. This consistent shape across different angles highlights the structured way Warhol applied color to create depth and contrast in the "Orange Marilyn" painting.



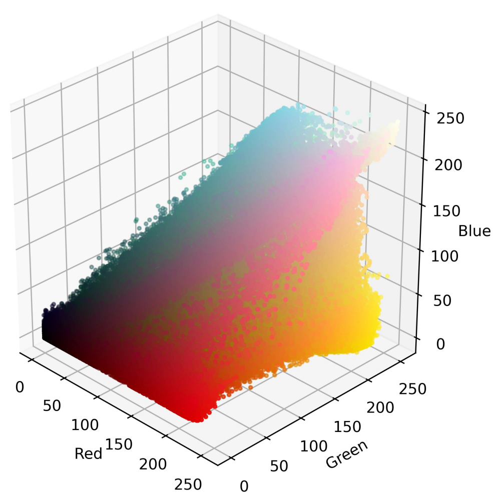
(a) Red Marilyn RGB Space - 30 °elevation, 45 °azimuth



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



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



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

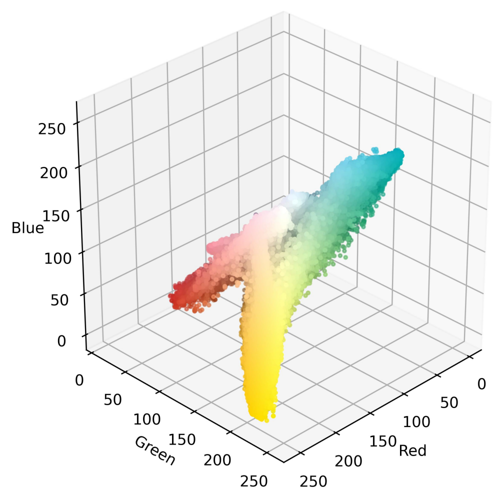
Figure 5: The RGB space occupied by the pixels for the entire image of Red Marilyn, showing different angles: (a) 30 °elevation, 45 °azimuth, (b) 30 °elevation, 135 °azimuth, (c) 30 °elevation, 225 °azimuth, (d) 30 °elevation, 315 °azimuth. These variations highlight the color distribution within the artwork.

Figure 5 displays the RGB space of "Red Marilyn" from four different angles. In (a), the density of pixels representing different parts of the image is shown, revealing a balanced mix of colors including a red background, yellow hair, pink cheeks, and blue eye shades. The shape of the 3D scatter plot in (a) indicates a broad, dispersed distribution of colors, showing the diverse color use in the background and facial features.

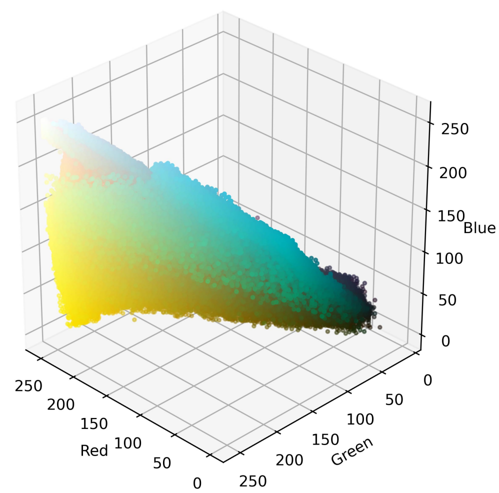
In (b), the plot illustrates how colors are distributed from darker pixels at the bottom to brighter pixels at the top, highlighting shading gradients. This gradient reflects the shading around Marilyn's clothes, eye shades, and hair, adding depth to the portrait. The darker pixels likely represent shadows in the hair and facial contours, while the brighter pixels correspond to highlights on her clothes and hair. The shape in (b) is elongated, showing a clear separation between the dark and bright areas.

In (c), the concentration of the brightest pixels is evident, showing specific groupings likely related to prominent features. This highlights the intense colors used in Marilyn's lips, eye shades, clothes, and other facial highlights. The plot suggests a focused clustering of bright colors, indicating areas where Warhol applied more vivid hues to draw attention. The shape in (c) suggests a dense clustering of bright colors.

In (d), the color distribution from dark to light is presented from a different angle, allowing us to observe the distribution of colors in areas such as hair and eye shades with dense red on the bottom from the background. The shapes in (b) through (d) all reflect a similar elongated form as seen in "Orange Marilyn," but with a more spread-out appearance, resembling a long and thick funnel. This shape shows a clear gradient from dark to light colors, indicating that the colors are brighter, bolder, and more impactful than in "Orange Marilyn." This consistent shape across different angles highlights the structured way Warhol applied color to create depth and contrast in the "Red Marilyn" painting.



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



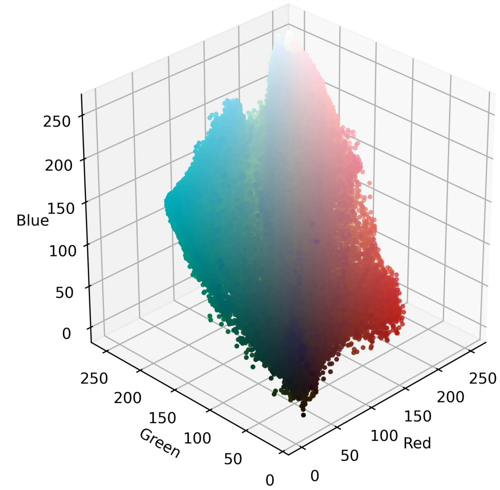
(b) Turquoise Marilyn RGB Space - 30 °elevation, 135 °azimuth

Figure 6 displays the RGB space of "Turquoise Marilyn" from four different angles.

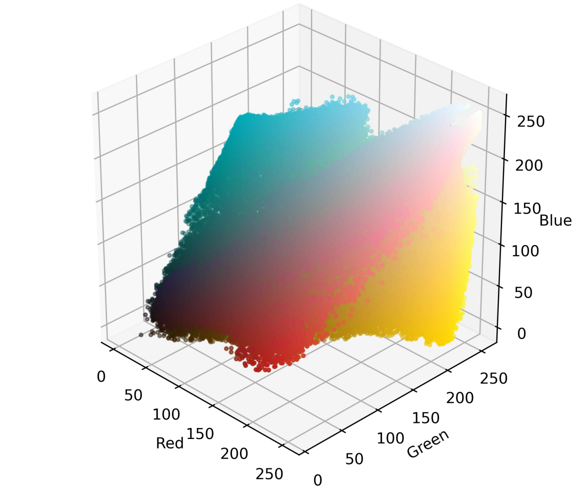
In (a), the density of pixels shows a broad mix of colors including turquoise, yellow, pink, and red, which correspond to the background, hair, face, and lips of the painting. The shape of the 3D scatter plot indicates a dispersed distribution of colors, reflecting the varied color use throughout the image. Most pixels cluster in the turquoise region, which is the background color of this painting, extending in three directions.

In (b), the distribution of colors transitions from darker pixels at the bottom to brighter pixels at the top, highlighting the gradient in shading. This transition illustrates the shading around Marilyn's facial features and hair, adding depth to the portrait. The shape shows a clear gradient from dark to bright areas, with darker pixels on the right side of the 3D space and brighter pixels on the left.

In (c), the plot emphasizes the concentration of the brightest pixels, showing specific groupings that likely correspond to Marilyn's lips, eyes, and other highlighted features. This suggests a focused clustering of bright colors where Warhol applied vivid hues to draw attention. The shape suggests a dense clustering of bright



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



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

Figure 6: The RGB space occupied by the pixels for the entire image of Turquoise 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.

colors. Viewing the backside of (a), it reaffirms that the painting contains a significant number of turquoise pixels.

In (d), the color distribution from dark to light is presented from a different angle, allowing us to observe how the colors in the hair and eye shades are distributed, with a notable presence of turquoise pixels from the background. The shape reflects the backside of (b), with darker pixels on the left and brighter pixels on the right.

The shapes in (a) through (d) reflect a similar elongated form, resembling a long and wide funnel, showing a clear gradient from dark to light colors. This highlights how the colors are brighter, bolder, and more impactful in “Turquoise Marilyn,” emphasizing the structured application of color by Warhol to create depth and contrast.

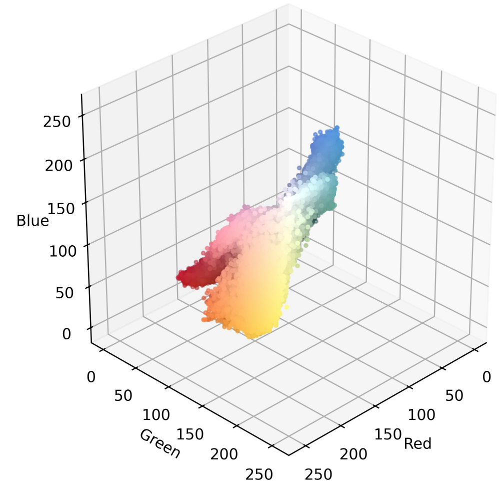
Figure 7 displays the RGB space of “Blue Marilyn” from four different angles.

In (a), the density of pixels shows a prominent mix of colors including blue, yellow, pink, and red, which correspond to the background, hair, face, and lips of the painting. The shape of the 3D scatter plot indicates a broad, dispersed distribution of colors, reflecting the varied color use throughout the image. Most pixels cluster in the blue region, which is the dominant background color. The yellow pixels representing Marilyn’s hair extend prominently, indicating a significant area covered by this hue.

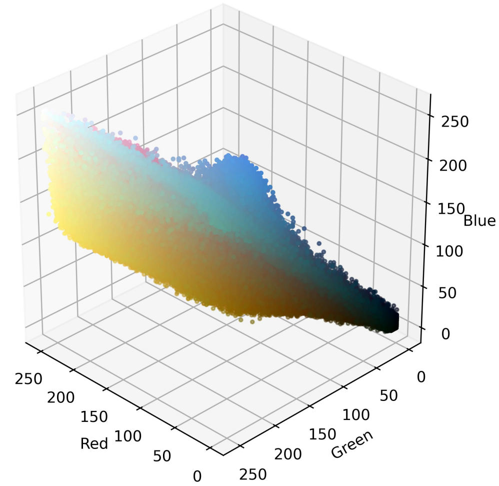
In (b), the distribution of colors transitions from darker pixels on the right side to brighter pixels on the left, highlighting a gradient. This gradient is evident in the shading of Marilyn’s facial features and hair, adding depth to the portrait. The shape shows a clear separation between dark and bright areas. The pink and red pixels, representing her facial skin and lips, are more noticeable on the brighter side, indicating the areas of the image where these colors are more concentrated.

In (c), the plot shows the backside of (a), reaffirming the significant presence of blue pixels. This view emphasizes the distribution of colors in the facial highlights and hair, showing focused clustering of bright colors where Warhol applied vivid hues. The shape indicates a dense clustering of these bright pixels. The blue and yellow pixels are prominently visible, showing the extensive use of these colors in the background and hair.

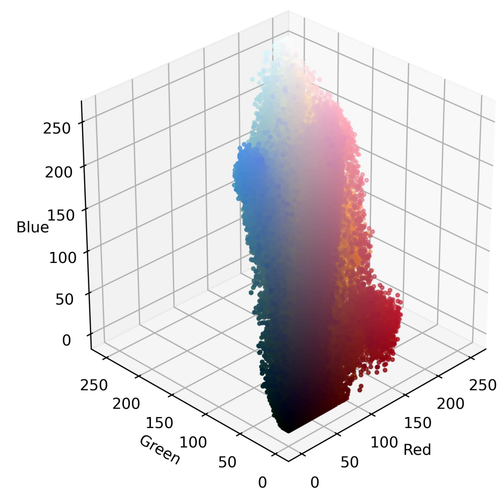
In (d), the color distribution from dark to light is presented from a different angle, allowing us to observe the spread of colors in areas such as the hair and facial features. The shape reflects the backside of (b), with



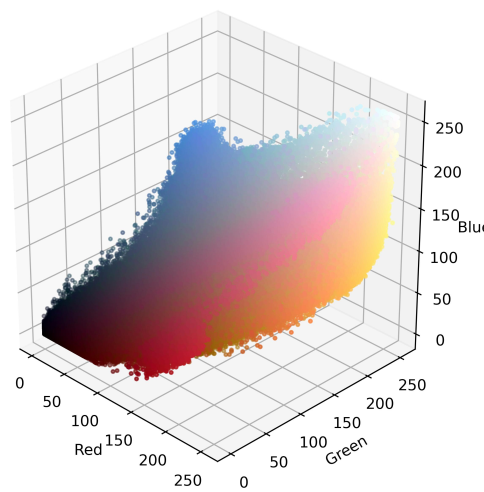
(a) Blue Marilyn RGB Space - 30 °elevation, 45 °azimuth



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



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

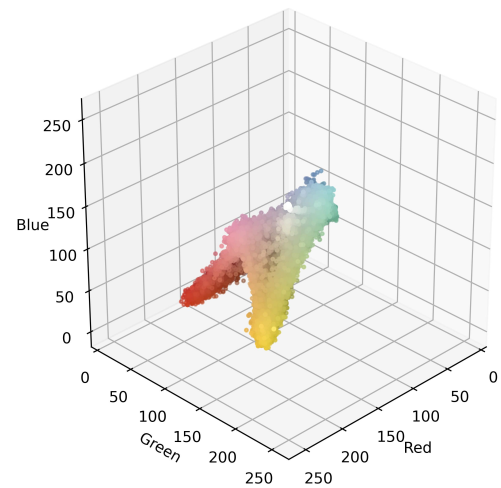


(d) Blue Marilyn RGB Space - 30 °elevation, 315 °azimuth

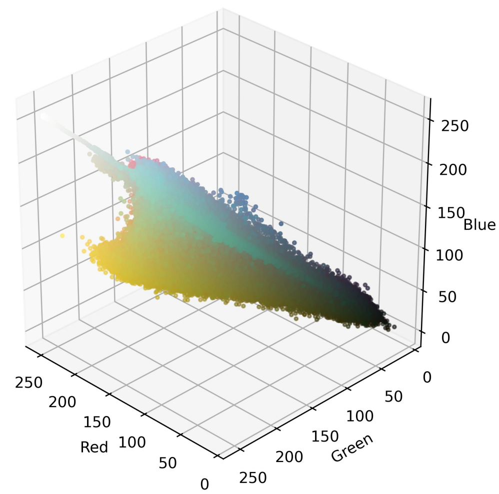
Figure 7: The RGB space occupied by the pixels for the entire image of Blue Marilyn, showing different angles: (a) 30 °elevation, 45 °azimuth, (b) 30 °elevation, 135 °azimuth, (c) 30 °elevation, 225 °azimuth, (d) 30 °elevation, 315 °azimuth. These variations highlight the color distribution within the artwork.

darker pixels on the left and brighter pixels on the right. The red pixels representing Marilyn's lips are more noticeable on the brighter side, highlighting their vibrant color in the image. The shapes in (b) through (d) reflect a similar elongated form, resembling a long funnel, showing a clear gradient from dark to light colors.

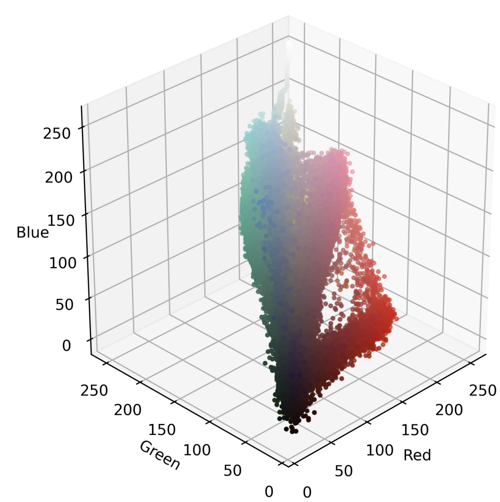
Overall, these shapes and color distributions highlight how Warhol used color to create depth and contrast in "Blue Marilyn," emphasizing the structured application of vivid and impactful colors to enhance the visual experience. The different angles reveal the prominence of blue in the background, yellow in the hair, pink in the facial skin, and red in the lips, showcasing Warhol's strategic use of color to define the features of Marilyn Monroe.



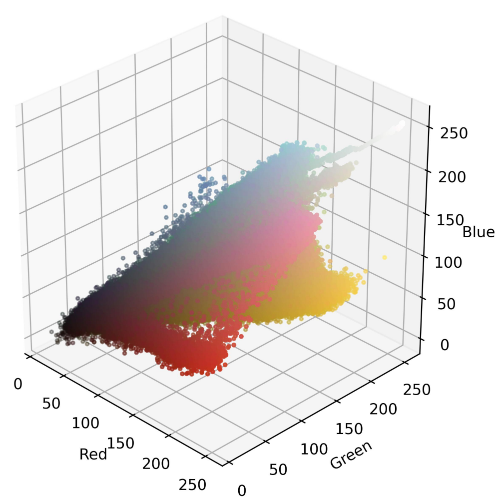
(a) Eggblue Marilyn RGB Space - 30 °elevation, 45 °azimuth



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



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



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

Figure 8: The RGB space occupied by the pixels for the entire image of Eggblue 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.

Figure 8 displays the RGB space of "Eggblue Marilyn" from four different angles.

In (a), the density of pixels shows a broad mix of colors including egg blue, yellow, pink, and red, corresponding to the background, hair, face, and lips of the painting. The shape of the 3D scatter plot indicates a dispersed distribution of colors, reflecting the varied use of hues throughout the image. Most pixels cluster in the egg blue region, which is the dominant background color. Yellow pixels representing Marilyn's hair extend prominently, indicating significant coverage by this hue. At this angle, the egg blue background and yellow hair colors are particularly noticeable.

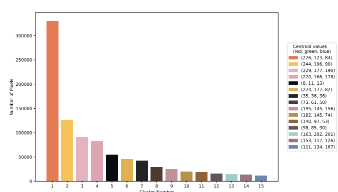
In (b), the distribution of colors transitions from darker pixels on the right side to brighter pixels on the left, highlighting a gradient. This gradient illustrates the shading around Marilyn's facial features and hair, adding depth to the portrait. The shape shows a clear separation between dark and bright areas. The pink pixels representing her facial skin and the red pixels of her lips are more noticeable on the brighter side, indicating the areas of the image where these colors are more concentrated. The egg blue and yellow pixels are also visible, but they are less prominent from this angle.

In (c), the plot emphasizes the concentration of the brightest pixels, showing specific groupings likely related to Marilyn's lips, eyes, and other highlighted features. This view, showing the backside of (a), reaffirms the significant presence of egg blue pixels. The yellow and pink pixels are prominently visible, highlighting the extensive use of these colors in the hair and facial features. The blue pixels in the eye shadow are also noticeable, clustered with the bright pixels of the face and hair.

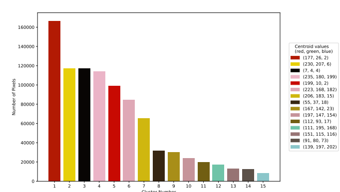
In (d), the color distribution from dark to light is presented from a different angle, allowing us to observe the spread of colors in areas such as the hair and facial features. The shape reflects the backside of (b), with darker pixels on the left and brighter pixels on the right. The red pixels representing Marilyn's lips are more noticeable on the brighter side, highlighting their vibrant color in the image. The yellow pixels of her hair and the egg blue background pixels are more spread out, showing a clear gradient from dark to light colors. The shapes in (b) through (d) reflect a similar elongated form, resembling a long funnel.

Overall, these shapes and color distributions highlight how Warhol used color to create depth and contrast in "Eggblue Marilyn." The different angles reveal the prominence of egg blue in the background, yellow in the hair, pink in the facial skin, red in the lips, and blue in the eye shadow, showcasing Warhol's strategic use of color to define the features of Marilyn Monroe. The detailed analysis of each angle provides insights into how specific colors dominate different parts of the painting and contribute to its overall visual impact.

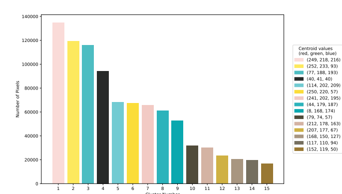
5 Clustering based on Whole Images



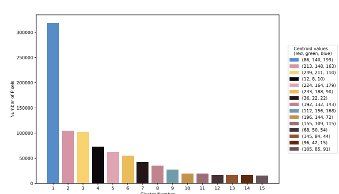
(a) Orange Marilyn Cluster Bar Plot



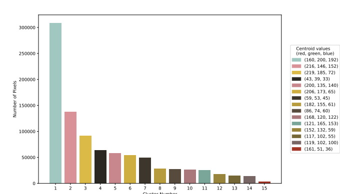
(b) Red Marilyn Cluster Bar Plot



(c) Turquoise Marilyn Cluster Bar Plot



(d) Blue Marilyn Cluster Bar Plot



(e) Eggblue Marilyn Cluster Bar Plot

Figure 9: xxx.

Figure 9 showcases the clustered bar representation of pixel distribution across various Marilyn paintings. The Orange, Blue, and Eggblue paintings each exhibit a prominent clustered bar, indicating a strong concentration of pixels within a specific color range for their respective backgrounds. This signifies a high degree of uniformity and consistency in the background hues of these paintings. In contrast, the Red Marilyn painting displays a dual-pronged approach with two distinct, yet prominent bars. These bars represent the pixels comprising both the background and the lips, underscoring the intentional use of red to emphasize both these elements. Meanwhile, the Turquoise Marilyn painting reveals a more complex picture, with four clustered bars grouped under the conceptual umbrella of "Turquoise." These bars encompass the colors of the background, eye shadows, and collar, suggesting a broader color palette within this designated category. However, upon closer inspection, it becomes evident that the actual color distribution within this "Turquoise" grouping is far from uniform, revealing inconsistencies that add depth and complexity to the painting.

An interesting pattern emerges in the clustering of colors, particularly with regards to yellow or golden hues, as the hair color pixels are segmented into 3 to 4 distinct clusters, reflecting variations in tone and shading. Similarly, the colors depicting the face are classified into three groups, highlighting the nuanced use of hues to capture the intricacies of facial features.

Examining the centroid values for the Orange, Blue, and Eggblue paintings, it becomes clear that the higher the prominence of one RGB color, the less evenly distributed the color becomes. For example, in the Orange painting, the centroid values for the first cluster are (226, 123, 84), indicating a strong emphasis on the red color. In contrast, the second and third clusters exhibit a more balanced distribution of RGB values, with no other clusters displaying a similar orange color as the first cluster. This suggests that the heavy emphasis on a single color in the first cluster results in a higher concentration of that color, leading to a greater number of pixels in that cluster.

In the Blue painting, the centroid values for the highest cluster are (86, 140, 199), with a notable emphasis on the blue color. The remaining clusters show a more even distribution of centroid values, with only cluster number nine having a similar color scheme to the first cluster. Similarly, in the Eggblue painting, the first cluster has centroid values of (160, 200, 192), with green being the dominant color. This concentration of a single color results in most pixels being concentrated in that cluster, with only cluster eleven displaying a similar color to the first cluster.

For the Red painting, the first cluster has centroid values of (177, 26, 2), with a higher concentration of red. Other clusters with a significant number of pixels also contain a substantial amount of red, leading to a more even distribution between clusters. The same pattern is observed in the Turquoise painting, where the cluster bars have either an even amount of red and green or green and blue, resulting in a more uniform distribution of the cluster bars.

6 Clustering based on Region of Interest (ROI)

7 Repair Gunshot of Image

8 Disuccsion

Conclusion and Future Work

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