

Image_Color_Quantization_Using_Kmeans_Clustering

January 10, 2025

1 K-means and PCA: Implementation and Applications

##Project Overview

This project implements the **K-means clustering** algorithm and **Principal Component Analysis (PCA)** for data clustering and dimensionality reduction. We also apply these techniques to image color quantization, where K-means is used to simplify the number of colors in an image. This process can be useful for compression and artistic rendering of images.

The notebook is structured into the following sections:

1. **Introduction and Setup:** Overview of concepts and importing libraries.
2. **K-means Algorithm Implementation:** Clustering using synthetic datasets.
3. **Evaluating K-means with SSE:** Investigating the impact of the number of clusters.
4. **Principal Component Analysis (PCA):** Dimensionality reduction with visualization.
5. **Image Color Quantization using K-means:** Simplifying image colors with clustering.
6. **Conclusion and Insights:** Summarizing findings and observations.

1.1 1. Introduction and Setup

K-means is an unsupervised learning algorithm that partitions data into `clusters` by minimizing the intra-cluster sum of squares (SSE). PCA is a dimensionality reduction technique that transforms data into a lower-dimensional space while preserving as much variance as possible.

```
[ ]: # Importing essential libraries
import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import make_blobs
from sklearn.decomposition import PCA
from sklearn.cluster import KMeans
from sklearn.metrics import silhouette_score
from skimage.io import imread
from skimage.util import img_as_float
import seaborn as sns
```

1.2 2. K-means Algorithm Implementation

Here, we generate a synthetic dataset using `make_blobs` and apply the K-means algorithm. The goal is to assign data points to `clusters`.

1.2.1 2.1 K-means Clustering Explication

In this project, we first implemented the K-means algorithm as a Python function that accepts the number of clusters (K) and a dataset $\mathbf{x}_1, \mathbf{x}_2, \dots, \mathbf{x}_N$, where each data vector $\mathbf{x}_i \in \mathbb{R}^d$. The function is designed for general (d), and later we apply it to a two-dimensional synthetic dataset for visualization.

1.2.2 General Algorithm Description

Given training examples $\mathbf{x}_1, \mathbf{x}_2, \dots, \mathbf{x}_N$, the K-means algorithm partitions the data into (K) clusters by iteratively updating the cluster assignments and centroids. The algorithm proceeds as follows:

- Initialize cluster centers $\mu_1, \dots, \mu_K \in \mathbb{R}^d$ at random
- Repeat until convergence
 - For every data point \mathbf{x}_i , update its label as

$$z_i = \operatorname{argmin}_j \|\mathbf{x}_i - \mu_j\|_2^2.$$

- For each cluster j , update its center μ_j as mean of all points assigned to cluster j :

$$\mu_j = \frac{\sum_{i=1}^N \delta\{z_i = j\} \mathbf{x}_i}{\sum_{i=1}^N \delta\{z_i = j\}}.$$

$\delta\{z_i = j\}$ denotes an indicator function that is equal to 1 if $z_i = j$ and zero otherwise.
 $\sum_{i=1}^N \delta\{z_i = j\}$ indicates the number of points in i th cluster.

We can define sum of squared errors (SSE) as

$$\text{SSE} = \sum_j \sum_i \delta\{z_i = j\} \|\mathbf{x}_i - \mu_j\|_2^2$$

The algorithm iterates until the cluster centroids stabilize or a predefined maximum number of iterations is reached.

1.2.3 Objective Function

The K-means algorithm minimizes the *Sum of Squared Errors (SSE)*, which is defined as: [SSE = $\sum_{j=1}^K \sum_{i=1}^N \delta\{z_i = j\} \|\mathbf{x}_i - \mu_j\|_2^2$.] The SSE measures the total intra-cluster variance, and a lower SSE indicates tighter clusters.

1.2.4 Implementation Details

We implemented the K-means algorithm in Python using the `KMeans` class from the Scikit-learn library. The function accepts the dataset, the desired number of clusters ((K)), and parameters for the maximum number of iterations and the number of initializations.

1.2.5 Synthetic Dataset Application

To illustrate the behavior of K-means, we applied the algorithm to a two-dimensional synthetic dataset. The dataset was generated using `make_blobs`, and we experimented with ($K = 2$) to ($K = 8$). The clustering results were visualized for each value of (K), showing how the algorithm partitions the data and updates the cluster centroids.

For each value of (K), the data points are colored according to their cluster assignments, and the centroids are marked with red crosses. This visualization helps in understanding how the clustering changes as (K) varies and the clusters evolve.

1.2.6 2.2 K-means clustering function

The function below implements K-means clustering using the Scikit-learn library.

```
[ ]: def k_means_clustering(data, K, max_iter=100, tol = pow(10,-3)):  
    # Inputs  
    #   data - N x d array  
    #   K - number of clusters  
    #   max_iter - maximum iterations for K-means  
    #   tol - stopping parameter that checks relative change in sum of squared  
    ↪errors  
    #  
    # Outputs:  
    #   labels - cluster assignment label for each data sample (N values)  
    #   centroid - centroids of each cluster (K vectors)  
    #   SSE_history - table of SSE record at every iteration  
    #   iter - total number of iterations at stopping/convergence  
  
    N, d = data.shape  
    centroids = data[np.random.choice(N, K, replace=False)]  # Randomly select K  
    ↪initial centroids  
    labels = np.zeros(N, dtype=int)  # Placeholder for cluster assignments  
    SSE_history = []  # To store SSE values at each iteration  
  
    for iteration in range(max_iter):  
        # Step 1: Assign each point to the nearest centroid  
        for i in range(N):  
            distances = np.linalg.norm(data[i] - centroids, axis=1)  # Compute  
        ↪distances to all centroids  
            labels[i] = np.argmin(distances)  # Assign to the nearest centroid  
  
        # Step 2: Update centroids based on current cluster assignments  
        new_centroids = np.zeros_like(centroids)  
        for k in range(K):  
            points_in_cluster = data[labels == k]  
            if len(points_in_cluster) > 0:  # If cluster is not empty  
                new_centroids[k] = np.mean(points_in_cluster, axis=0)  
            else:  # If cluster is empty, reinitialize its centroid randomly
```

```

    new_centroids[k] = data[np.random.choice(N)]

centroids = new_centroids

# Step 3: Compute the Sum of Squared Errors (SSE)
SSE = 0
for k in range(K):
    points_in_cluster = data[labels == k]
    SSE += np.sum((points_in_cluster - centroids[k])**2)
SSE_history.append(SSE)

# Step 4: Check for convergence based on SSE change
if iteration > 0 and abs(SSE_history[iteration] - SSE_history[iteration-1]) / SSE_history[iteration-1] <= tol:
    break

return labels, centroids, SSE_history, iteration + 1

```

1.2.7 2.3 Implement K-means Clustering

Here, we visualize the synthetic dataset and then apply K-means clustering for $K = 2, 3, 4, 5, 6, 7, 8$. Each result is visualized to show how the clustering changes as K increases.

```

[ ]: # Generate synthetic data
X, y_true = make_blobs(n_samples=400, centers=4, cluster_std=1.5, random_state=42)

plt.figure(figsize=(8, 8))
plt.scatter(X[:, 0], X[:, 1], c='gray', s=30, label="Data points")
plt.title("Synthetic Dataset")
plt.xlabel("Feature 1")
plt.ylabel("Feature 2")
plt.legend()
plt.grid()
plt.show()

# Apply K-means clustering for K = 2 to K = 8
k_values = range(2, 9)

fig, axs = plt.subplots(3, 3, figsize=(12, 12))
axs = axs.ravel()

for idx, k in enumerate(k_values):
    labels, centers, SSE_history, iters = k_means_clustering(X, k)

    axs[idx].scatter(X[:, 0], X[:, 1], c=labels, cmap='viridis', s=30)

```

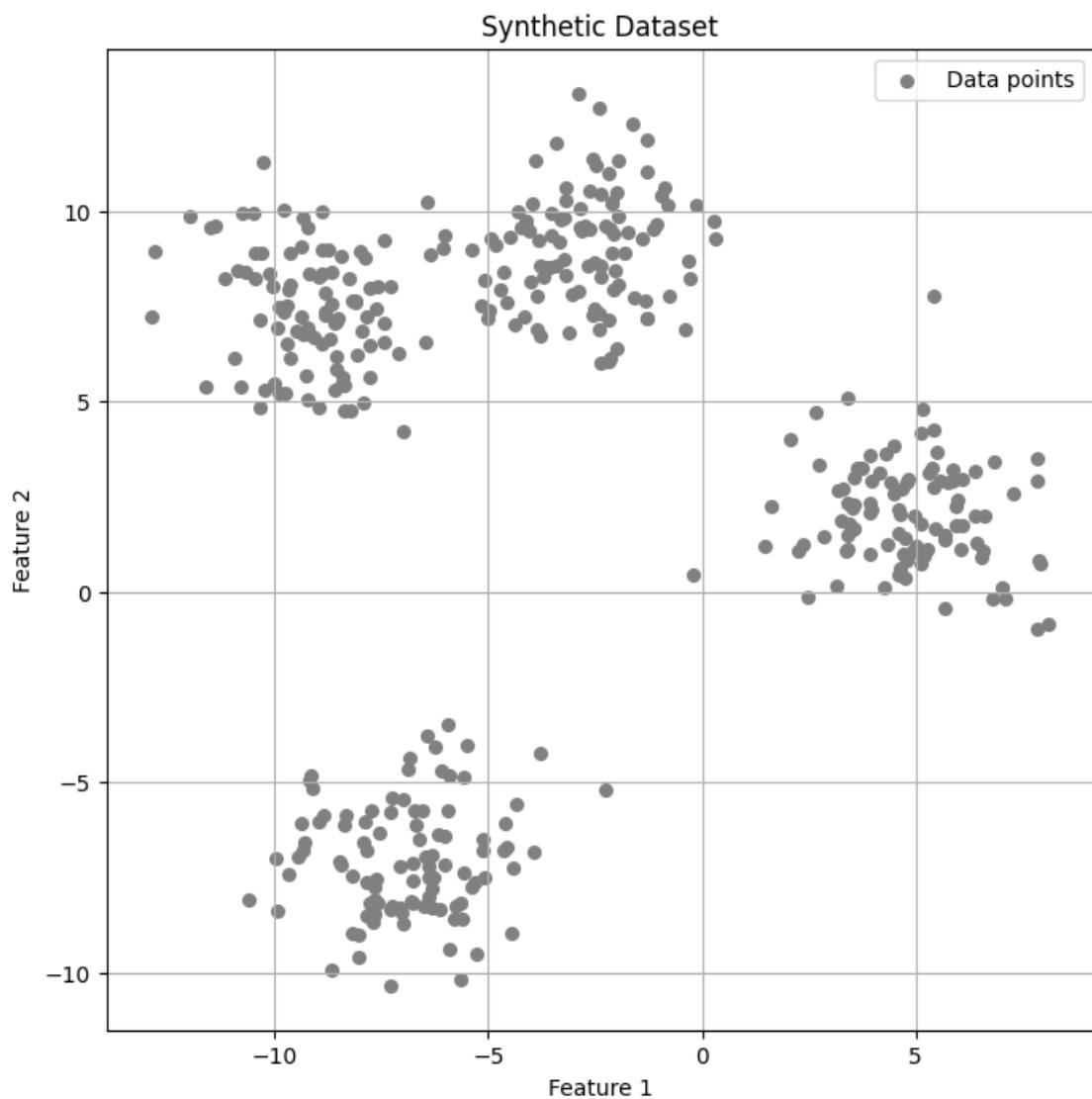
```

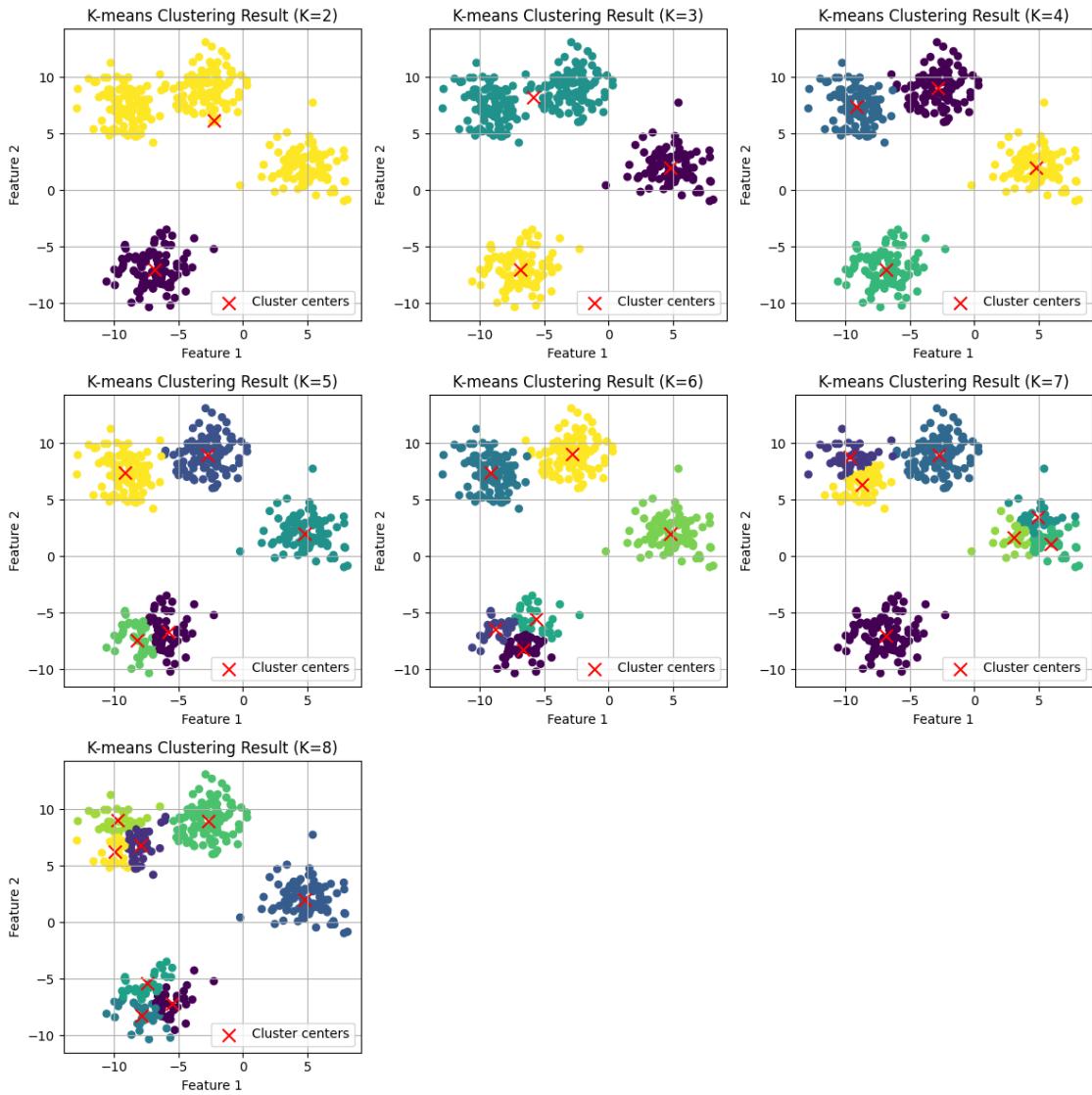
        axs[idx].scatter(centers[:, 0], centers[:, 1], c='red', marker='x', s=100, u
    ↵label="Cluster centers")
        axs[idx].set_title(f"K-means Clustering Result (K={k})")
        axs[idx].set_xlabel("Feature 1")
        axs[idx].set_ylabel("Feature 2")
        axs[idx].legend()
        axs[idx].grid()

for ax in axs[len(k_values):]:
    ax.axis('off')

plt.tight_layout()
plt.show()

```





1.3 3. Evaluating K-means with SSE

To understand the impact of the number of clusters, we evaluate the Sum of Squared Errors (SSE) for varying K . A plot of SSE against K can reveal the “elbow point,” which is the optimal number of clusters.

```
[ ]: # Generate synthetic dataset
X, _ = make_blobs(n_samples=400, centers=4, cluster_std=1.5, random_state=42)

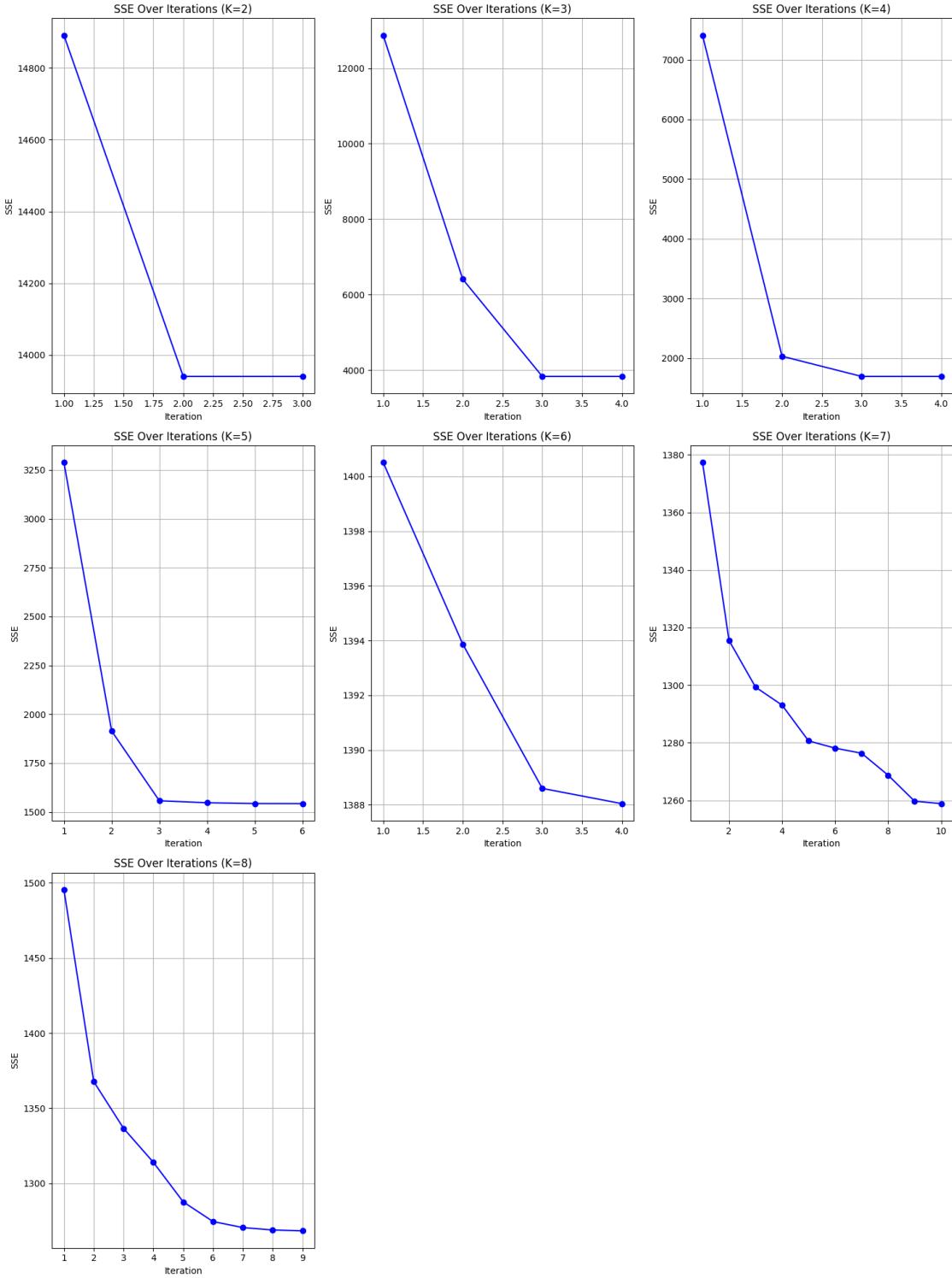
# Evaluate SSE for K = 2 to 8 and plot SSE over iterations for each K
k_values = range(2, 9)
```

```
plt.figure(figsize=(15, 20)) # Set up the figure size

for i, K in enumerate(k_values, start=1):
    _, _, SSE_history, total_iterations = k_means_clustering(X, K)

    # Plot SSE over iterations for the current K
    plt.subplot(3, 3, i)
    plt.plot(range(1, len(SSE_history) + 1), SSE_history, marker='o', color='b')
    plt.title(f"SSE Over Iterations (K={K})", fontsize=12)
    plt.xlabel("Iteration", fontsize=10)
    plt.ylabel("SSE", fontsize=10)
    plt.grid()

plt.tight_layout()
plt.show()
```



The **SSE** consistently decreases with every iteration of the K-means algorithm. This is because the algorithm optimizes the cluster centroids to minimize the sum of squared errors, and convergence occurs when SSE stops changing significantly or reaches a local minimum.

As K increases, the SSE decreases. This is because more clusters allow for better fitting of the data, with each cluster representing fewer data points, which reduces the overall intra-cluster variance.

```
[ ]: X, _ = make_blobs(n_samples=400, centers=4, cluster_std=1.5, random_state=42)

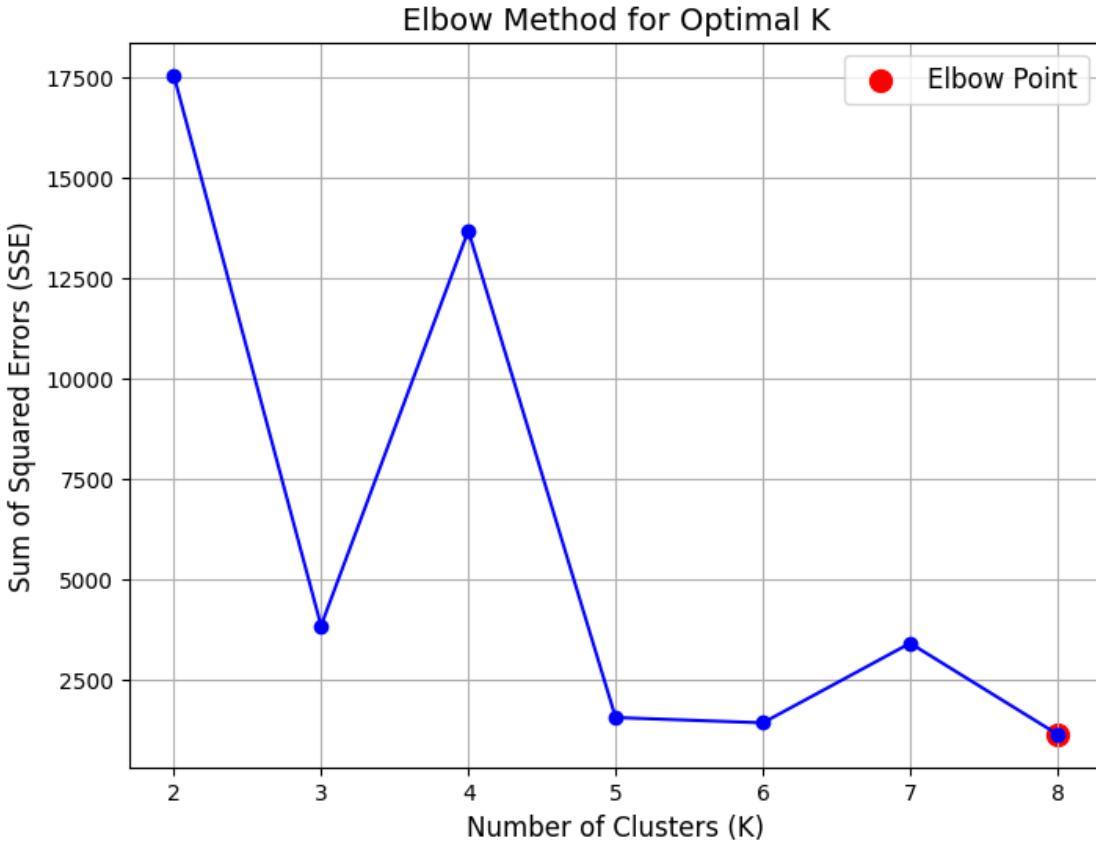
k_values = range(2, 9)
sse_values = []

for K in k_values:
    _, _, SSE_history, _ = k_means_clustering(X, K)
    sse_values.append(SSE_history[-1])

plt.figure(figsize=(8, 6))
plt.plot(k_values, sse_values, marker='o', linestyle='-', color='b')
plt.title("Elbow Method for Optimal K", fontsize=14)
plt.xlabel("Number of Clusters (K)", fontsize=12)
plt.ylabel("Sum of Squared Errors (SSE)", fontsize=12)
plt.xticks(k_values)
plt.grid()

elbow_index = np.argmin(np.gradient(np.gradient(sse_values))) + 2
plt.scatter(elbow_index, sse_values[elbow_index - 2], color='red', s=100, label="Elbow Point")
plt.legend(fontsize=12)

plt.show()
```



The elbow method graph shows a rapid decrease in SSE as the number of clusters K increases initially, followed by a plateau. This pattern indicates that the optimal number of clusters is at the “elbow” of the curve, where the rate of decrease in SSE becomes less significant. In this case, the elbow is observed around $K = 4$, suggesting that dividing the data into 4 clusters is a reasonable choice to achieve a good balance between model simplicity and clustering accuracy.

1.4 4. Image Color Quantization using K-means

Now we will use K-means to perform segmentation/quantization on a color image.

Each pixel in a given image will be a feature vector containing 3 color components (RGB). We will first group all colors into K clusters, which will provide us a color palatte. Then we will replace the color in every pixel with one of the colors in the color palatte (that is the centroid of the cluster in which RGB value of a pixel falls).

We will use K-means script from previous step to segment an image into K clusters. To create a “quantized” output image, we will replace every pixel in the image with the center of the cluster assigned to it. To see the differences we will report the results for $K = \{2, 4, 8, 16, 32, 64\}$ clusters.

In order to achieve a good result, I will use a colorful photo, in this case a photo of my dog, but if you want you could try with your photo uploading it to the files section of the right with the name of “photo.JPG”

```
[ ]: # load and display an image with Matplotlib
from matplotlib import image

# load image as pixel array
img = image.imread('photo.JPG')

print(img.dtype)
print(img.shape)

h, w, c = img.shape
unique_colors = np.unique(np.reshape(img, (h*w, c)), axis = 0)

plt.figure()
plt.clf()
ax = plt.axes([0, 0, 1, 1])
plt.grid(False)
plt.title('Original image with {0:d} unique colors.'.format(unique_colors.
    ↪shape[0]))
plt.imshow(img)
plt.show()
```

```
uint8
(1572, 1179, 3)
```



Before performing the clustering, we will process the image data.

1. We will crop or resize the image to a small size if the image is large. An image close to 100×100 pixels will be sufficient for this experiment.
2. We will convert 8 bit integers to floats by dividing every pixel by 255 so that we can perform floating point operations and plot the arrays as images using plt.imshow that works well on float data in the range [0-1].

```
[ ]: # Importing Image class from PIL module
from PIL import Image

img = Image.open('photo.JPG')
img_size = img.size
print(f"Original size: {img_size}")
```

```

new_size = np.asarray(img_size) // 4
img = img.resize(new_size.astype(int))
img = np.asarray(img)
print(f"Resized size: {img.shape}")

plt.figure(figsize=(5, 5))
plt.title(f"Resized image ({img.shape[0]}x{img.shape[1]} pixels)")
plt.imshow(img)
plt.grid(False)
plt.show()

```

Original size: (1179, 1572)
 Resized size: (393, 294, 3)



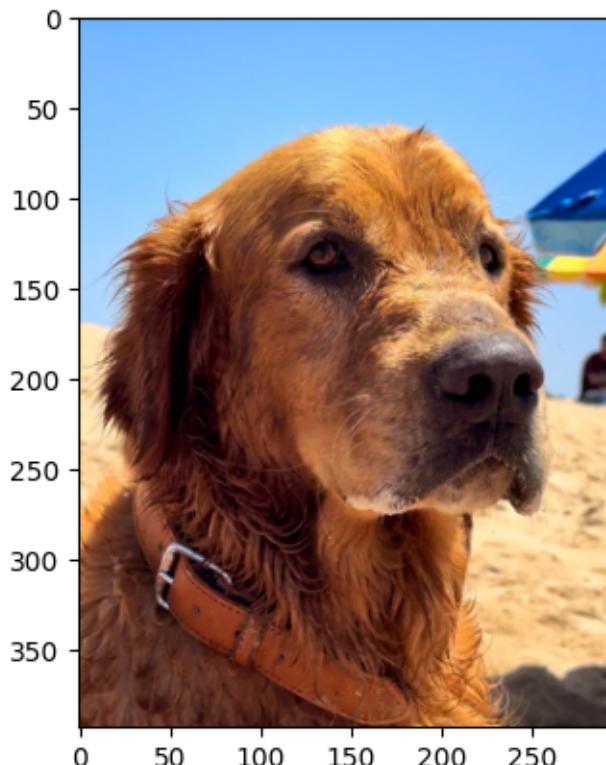
```

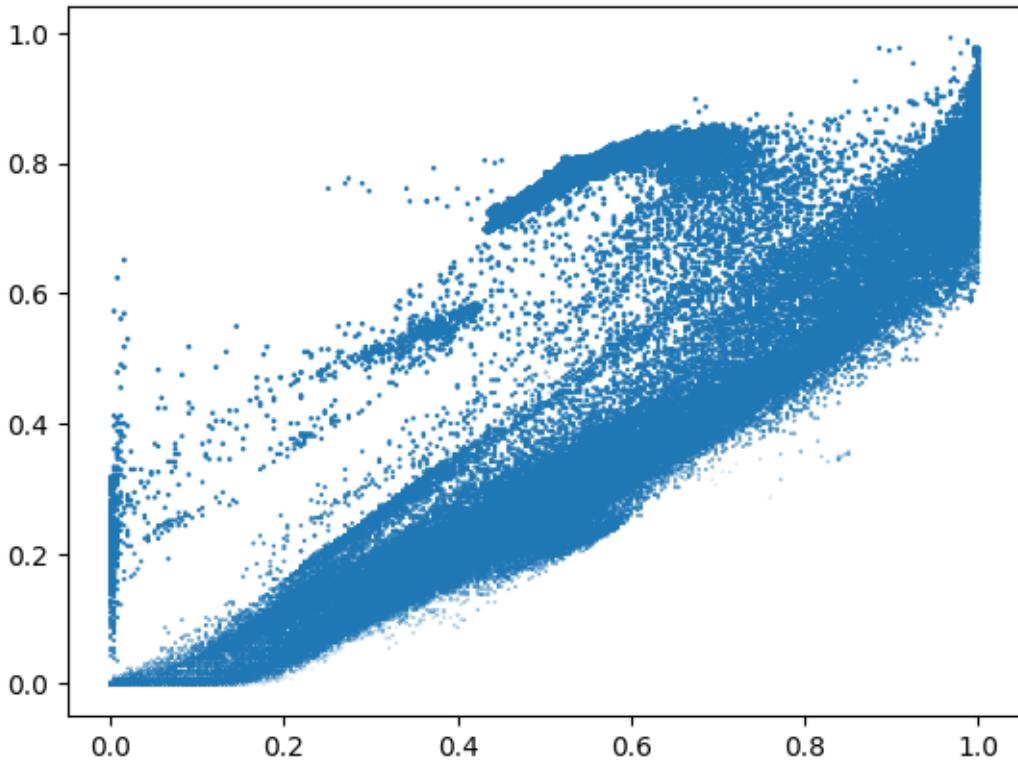
[ ]: # Preprocessing the data for clustering
# convert to float64 in range [0,1]
if np.max(img) > 1:
    img = np.array(img, dtype=np.float64) / 255
plt.imshow(img)
plt.grid(False)

```

```
# Load Image and transform to a 2D numpy array.  
h, w, c = original_shape = tuple(img.shape)  
assert c == 3  
data = np.reshape(img, (w * h, c))  
  
plt.figure()  
plt.scatter(data[:,0],data[:,1],data[:,2])
```

[]: <matplotlib.collections.PathCollection at 0x7f5ef3d1c100>





Now we will perform two steps.

1. K-means clustering for different values of K using the kmeans_clustering function above.
2. Replace all the colors in the original image with the centroids of the cluster each of them belong to. This will give us a “segmented/quantized image” for different values of K; let us denote each image as img_seg.

We will plot the original image and the img_seg for K = 2, 4, 8, 16, 32, 64.

```
[ ]: for K in [2, 4, 8, 16, 32, 64]:
    labels, centroids, SSE_history, iters =
    ↪k_means_clustering(data,K,max_iter=100,tol=pow(10,-3))

    img_seg = centroids[labels]

    img_seg = np.reshape(img_seg, (h, w, c))

    plt.figure(figsize=(12, 6))

    plt.subplot(1, 2, 1)
    plt.imshow(img)
    plt.title(f"Original Image")
    plt.axis('off')
```

```
plt.subplot(1, 2, 2)
plt.imshow(img_seg)
plt.title(f"Quantized Image (K={K})")
plt.axis('off')

plt.show()
```

Original Image



Quantized Image (K=2)



Original Image



Quantized Image (K=4)



Original Image



Quantized Image (K=8)



Original Image



Quantized Image (K=16)





1.5 5. Principal Component Analysis (PCA)

In this final section, we will apply **PCA** (Principal Component Analysis) to reduce the dimensionality of the RGB pixel values before performing K-means clustering. By reducing the color dimensions, we can explore how PCA affects the clustering results and the visual appearance of

the quantized images.

Dimensionality Reduction with PCA

Principal Component Analysis (PCA) is employed to reduce the dimensionality of the image data, specifically the RGB pixel values, which exist in a 3D space. Through PCA, this data is projected into a lower-dimensional (2D) space, enabling more efficient processing. This dimensionality reduction enhances the effectiveness of subsequent clustering algorithms, such as K-means, by concentrating on the most significant variations in the image's color distribution. By focusing on these principal components, K-means clustering is better equipped to capture the core color patterns of the image.

Reverting to the Original RGB Space

Once the image data has been clustered in the reduced 2D PCA space, the centroids corresponding to the clusters are mapped back to the original RGB space. This is achieved through the inverse transformation of the PCA-transformed data, which restores the pixel values to their original three-dimensional color representation. This step ensures that the quantized image retains its visual coherence with respect to its original color space.

Quantization Process

In this process, the pixels of the image are substituted with the nearest cluster centroids, similar to traditional image quantization methods. The difference lies in the application of PCA, which modifies the clustering process by operating in the reduced, lower-dimensional space. The quantized images are then visualized for different values of K, representing the number of clusters, to illustrate the effect that PCA has on color quantization. By varying K, the impact of dimensionality reduction on the overall image quality and clustering can be analyzed.

Visualization of Results

To better understand the outcomes of PCA integration, the reduced pixel data is represented in a scatter plot, showing its distribution in the 2D space after PCA transformation. Additionally, a side-by-side comparison is made between the original image and the quantized images produced using PCA, allowing for a direct visual assessment of how PCA influences the image's color representation and the effectiveness of the quantization process.

What are the Benefits of PCA Integration?

The integration of PCA in the quantization process offers several advantages. Firstly, dimensionality reduction simplifies the clustering task, particularly in large datasets like image pixels, thereby enhancing computational efficiency. Secondly, PCA prioritizes the most prominent color variations, which may lead to more meaningful and visually appealing quantization results. Finally, comparing the quantized images with and without PCA provides valuable insights into the role of PCA in improving visual quality and refining clustering outcomes, offering a deeper understanding of its impact on the image processing pipeline.

```
[ ]: from sklearn.decomposition import PCA
      from skimage.io import imread
      from skimage.util import img_as_float
      import matplotlib.pyplot as plt
      import numpy as np
```

```

image = img
rows, cols, channels = image.shape
X_image = image.reshape(-1, 3)

# Apply PCA to reduce dimensionality to 2 components
pca = PCA(n_components=2)
X_pca = pca.fit_transform(X_image)

# Visualize the PCA-transformed data
plt.figure(figsize=(8, 6))
plt.scatter(X_pca[:, 0], X_pca[:, 1], s=0.5, color='gray')
plt.title("Image Pixel Data in PCA Space", fontsize=14)
plt.xlabel("Principal Component 1", fontsize=12)
plt.ylabel("Principal Component 2", fontsize=12)
plt.grid()
plt.show()

# Apply K-means clustering to PCA-reduced data for K=2 to K=64
k_values = [2, 4, 8, 16, 32, 64]
quantized_images_pca = {}

for K in k_values:
    _, centroids, _, _ = k_means_clustering(X_pca, K)  # Use the custom K-means
    function
    centroids_rgb = pca.inverse_transform(centroids)  # Map centroids back to
    RGB space
    labels, _, _, _ = k_means_clustering(X_pca, K)

    # Reshape and clip pixel values to [0, 1]
    quantized_image = centroids_rgb[labels].reshape(rows, cols, channels)
    quantized_images_pca[K] = np.clip(quantized_image, 0, 1)  # Ensure valid
    RGB range

# Visualize the original image and PCA-based quantized images
fig, axs = plt.subplots(2, 4, figsize=(20, 12))  # Adjust layout for 6 images
    in a 2x4 grid

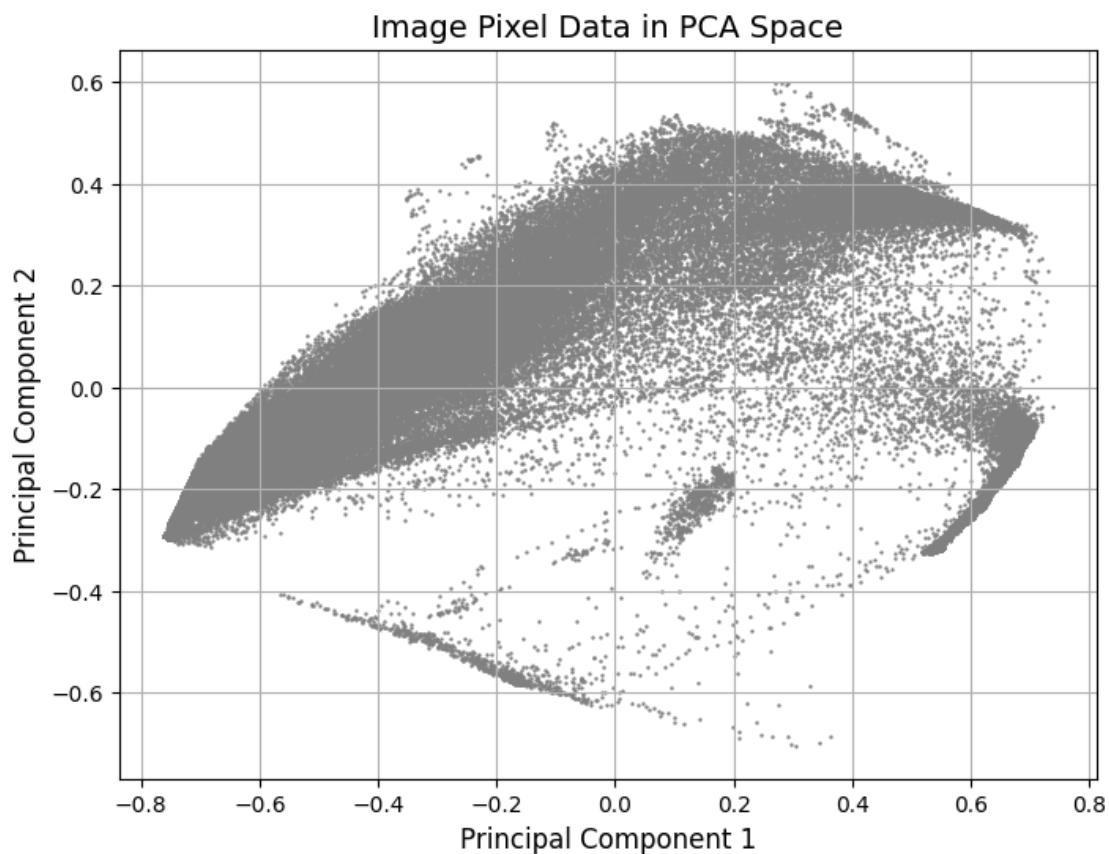
axs[0, 0].imshow(image)
axs[0, 0].set_title("Original Image", fontsize=12)
axs[0, 0].axis('off')

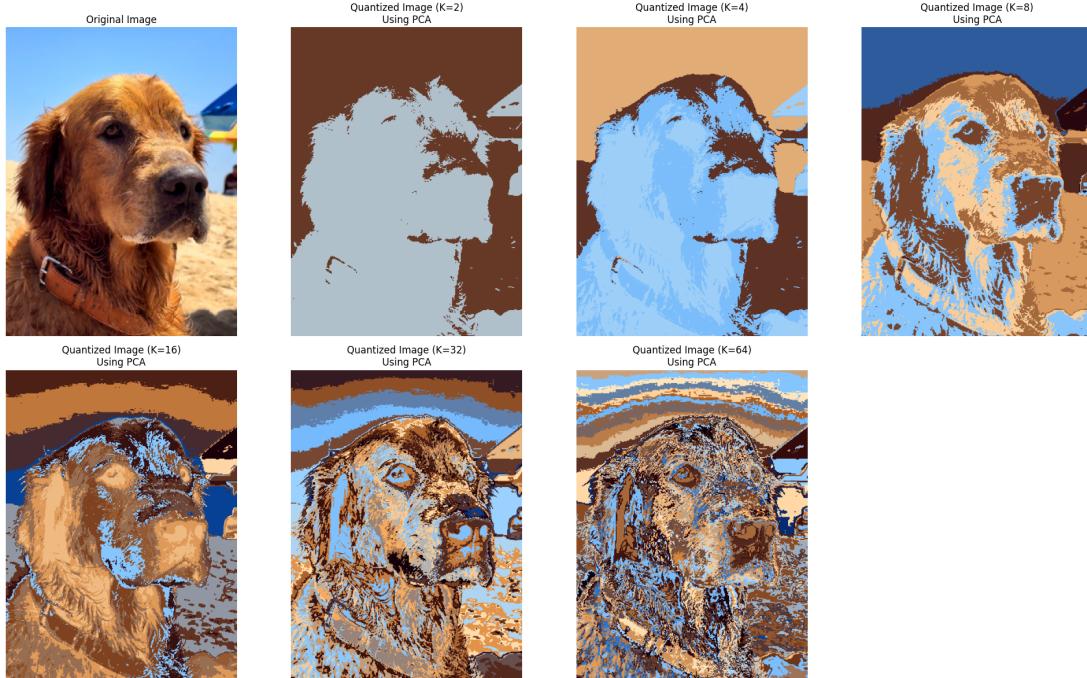
for i, K in enumerate(k_values):
    row, col = divmod(i + 1, 4)
    axs[row, col].imshow(quantized_images_pca[K])
    axs[row, col].set_title(f"Quantized Image (K={K})\nUsing PCA", fontsize=12)
    axs[row, col].axis('off')

```

```
for i in range(len(k_values) + 1, 8):
    row, col = divmod(i, 4)
    axs[row, col].axis('off')

plt.tight_layout()
plt.show()
```





```
[ ]: !sudo apt-get update
!sudo apt-get install texlive-xetex texlive-fonts-recommended
texlive-plain-generic pandoc
!pip install pypandoc

0% [Working]          Get:1 http://security.ubuntu.com/ubuntu jammy-
security InRelease [129 kB]
0% [Connecting to archive.ubuntu.com (185.125.190.83)] [1 InRelease 5,484 B/129
0% [Connecting to archive.ubuntu.com (185.125.190.83)] [Connected to cloud.r-pr
Get:2 https://cloud.r-project.org/bin/linux/ubuntu jammy-cran40/ InRelease
[3,626 B]
0% [Waiting for headers] [Connected to r2u.stat.illinois.edu (192.17.190.167)]
Hit:3 http://archive.ubuntu.com/ubuntu jammy InRelease
0% [Waiting for headers] [Waiting for headers] [Waiting for headers] [Connectin
Get:4 https://developer.download.nvidia.com/compute/cuda/repos/ubuntu2204/x86_64
InRelease [1,581 B]
0% [Waiting for headers] [Waiting for headers] [4 InRelease 1,581 B/1,581 B 100
0% [Waiting for headers] [Waiting for headers] [Connected to ppa.launchpadconte
Get:5 https://r2u.stat.illinois.edu/ubuntu jammy InRelease [6,555 B]
Get:6 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [128 kB]
Get:7 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages
[2,560 kB]
Hit:8 https://ppa.launchpadcontent.net/deadsnakes/ppa/ubuntu jammy InRelease
Get:9 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 Packages
[45.2 kB]
```

```

Get:10 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages
[1,227 kB]
Get:11 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64
Packages [3,527 kB]
Get:12 http://archive.ubuntu.com/ubuntu jammy-backports InRelease [127 kB]
Get:13 https://ppa.launchpadcontent.net/graphics-drivers/ppa/ubuntu jammy
InRelease [24.3 kB]
Hit:14 https://ppa.launchpadcontent.net/ubuntugis/ppa/ubuntu jammy InRelease
Get:15 https://cloud.r-project.org/bin/linux/ubuntu jammy-cran40/ Packages [61.9
kB]
Get:16
https://developer.download.nvidia.com/compute/cuda/repos/ubuntu2204/x86_64
Packages [1,199 kB]
Get:17 https://r2u.stat.illinois.edu/ubuntu jammy/main amd64 Packages [2,639 kB]
Get:18 https://r2u.stat.illinois.edu/ubuntu jammy/main all Packages [8,588 kB]
Get:19 http://archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages
[3,663 kB]
Get:20 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages
[1,518 kB]
Get:21 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [2,859
kB]
Fetched 28.3 MB in 4s (6,928 kB/s)
Reading package lists... Done
W: Skipping acquire of configured file 'main/source/Sources' as repository
'https://r2u.stat.illinois.edu/ubuntu jammy InRelease' does not seem to provide
it (sources.list entry misspelt?)
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  dvisvgm fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono
  fonts-texgyre fonts-urw-base35 libapache-pom-java
  libcmark-gfm-extensions0.29.0.gfm.3 libcmark-gfm0.29.0.gfm.3
  libcommons-logging-java libcommons-parent-java libfontbox-java libfontenc1
  libgs9 libgs9-common libidn12 libijs-0.35 libjbig2dec0 libkpathsea6
  libpdfbox-java libptexenc1 libruby3.0 libsyntax2 libteckit0 libtexlua53
  libtexluajit2 libwoff1 libzzip-0-13 lmodern pandoc-data poppler-data
  preview-latex-style rake ruby ruby-net-telnet ruby-rubygems ruby-webrick
  ruby-xmlrpc ruby3.0 rubygems-integration t1utils teckit tex-common tex-gyre
  texlive-base texlive-binaries texlive-latex-base texlive-latex-extra
  texlive-latex-recommended texlive-pictures tipa xfonts-encodings
  xfonts-utils
Suggested packages:
  fonts-noto fonts-freefont-otf | fonts-freefont-ttf libavalon-framework-java
  libcommons-logging-java-doc libexcalibur-logkit-java liblog4j1.2-java
  texlive-luatex pandoc-citeproc context wkhtmltopdf librsvg2-bin groff ghc
  nodejs php python libjs-mathjax libjs-katex citation-style-language-styles
  poppler-utils ghostscript fonts-japanese-mincho | fonts-ipafont-mincho

```

```

fonts-japanese-gothic | fonts-ipafont-gothic fonts-aphic-ukai
fonts-aphic-uming fonts-nanum ri ruby-dev bundler debhelper gv
| postscript-viewer perl-tk xpdf | pdf-viewer xzdec
texlive-fonts-recommended-doc texlive-latex-base-doc python3-pygments
icc-profiles libfile-which-perl libspreadsheets-parseexcel-perl
texlive-latex-extra-doc texlive-latex-recommended-doc texlive-pstricks
dot2tex prerex texlive-pictures-doc vprerex default-jre-headless tipa-doc
The following NEW packages will be installed:
dvisvgm fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono
fonts-texgyre fonts-urw-base35 libapache-pom-java
libcmark-gfm-extensions0.29.0.gfm.3 libcmark-gfm0.29.0.gfm.3
libcommons-logging-java libcommons-parent-java libfontbox-java libfontenc1
libgs9 libgs9-common libidn12 libijs-0.35 libjbig2dec0 libkpathsea6
libpdfbox-java libptexenc1 libruby3.0 libsyntax2 libteckit0 libtexlua53
libtexluajit2 libwoff1 libzip-0-13 lmodern pandoc pandoc-data poppler-data
preview-latex-style rake ruby ruby-net-telnet ruby-rubygems ruby-webrick
ruby-xmlrpc ruby3.0 rubygems-integration t1utils teckit tex-common tex-gyre
texlive-base texlive-binaries texlive-fonts-recommended texlive-latex-base
texlive-latex-extra texlive-latex-recommended texlive-pictures
texlive-plain-generic texlive-xetex tipa xfonts-encodings xfonts-utils
0 upgraded, 58 newly installed, 0 to remove and 55 not upgraded.
Need to get 202 MB of archives.
After this operation, 728 MB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-droid-fallback all
1:6.0.1r16-1.1build1 [1,805 kB]
Get:2 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-lato all 2.0-2.1
[2,696 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy/main amd64 poppler-data all
0.4.11-1 [2,171 kB]
Get:4 http://archive.ubuntu.com/ubuntu jammy/universe amd64 tex-common all 6.17
[33.7 kB]
Get:5 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-urw-base35 all
20200910-1 [6,367 kB]
Get:6 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libgs9-common
all 9.55.0~dfsg1-0ubuntu5.10 [752 kB]
Get:7 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libidn12 amd64
1.38-4ubuntu1 [60.0 kB]
Get:8 http://archive.ubuntu.com/ubuntu jammy/main amd64 libijs-0.35 amd64
0.35-15build2 [16.5 kB]
Get:9 http://archive.ubuntu.com/ubuntu jammy/main amd64 libjbig2dec0 amd64
0.19-3build2 [64.7 kB]
Get:10 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libgs9 amd64
9.55.0~dfsg1-0ubuntu5.10 [5,031 kB]
Get:11 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libkpathsea6
amd64 2021.20210626.59705-1ubuntu0.2 [60.4 kB]
Get:12 http://archive.ubuntu.com/ubuntu jammy/main amd64 libwoff1 amd64
1.0.2-1build4 [45.2 kB]
Get:13 http://archive.ubuntu.com/ubuntu jammy/universe amd64 dvisvgm amd64

```

2.13.1-1 [1,221 kB]
Get:14 http://archive.ubuntu.com/ubuntu jammy/universe amd64 fonts-lmodern all
2.004.5-6.1 [4,532 kB]
Get:15 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-noto-mono all
20201225-1build1 [397 kB]
Get:16 http://archive.ubuntu.com/ubuntu jammy/universe amd64 fonts-texgyre all
20180621-3.1 [10.2 MB]
Get:17 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libapache-pom-java
all 18-1 [4,720 B]
Get:18 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libcmark-
gfm0.29.0.gfm.3 amd64 0.29.0.gfm.3-3 [115 kB]
Get:19 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libcmark-gfm-
extensions0.29.0.gfm.3 amd64 0.29.0.gfm.3-3 [25.1 kB]
Get:20 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libcommons-parent-
java all 43-1 [10.8 kB]
Get:21 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libcommons-logging-
java all 1.2-2 [60.3 kB]
Get:22 http://archive.ubuntu.com/ubuntu jammy/main amd64 libfontenc1 amd64
1:1.1.4-1build3 [14.7 kB]
Get:23 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libptexenc1
amd64 2021.20210626.59705-1ubuntu0.2 [39.1 kB]
Get:24 http://archive.ubuntu.com/ubuntu jammy/main amd64 rubygems-integration
all 1.18 [5,336 B]
Get:25 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 ruby3.0 amd64
3.0.2-7ubuntu2.8 [50.1 kB]
Get:26 http://archive.ubuntu.com/ubuntu jammy/main amd64 ruby-rubygems all
3.3.5-2 [228 kB]
Get:27 http://archive.ubuntu.com/ubuntu jammy/main amd64 ruby amd64 1:3.0~exp1
[5,100 B]
Get:28 http://archive.ubuntu.com/ubuntu jammy/main amd64 rake all 13.0.6-2 [61.7
kB]
Get:29 http://archive.ubuntu.com/ubuntu jammy/main amd64 ruby-net-telnet all
0.1.1-2 [12.6 kB]
Get:30 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 ruby-webrick
all 1.7.0-3ubuntu0.1 [52.1 kB]
Get:31 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 ruby-xmlrpc all
0.3.2-1ubuntu0.1 [24.9 kB]
Get:32 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libruby3.0
amd64 3.0.2-7ubuntu2.8 [5,113 kB]
Get:33 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libsynctex2
amd64 2021.20210626.59705-1ubuntu0.2 [55.6 kB]
Get:34 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libteckit0 amd64
2.5.11+ds1-1 [421 kB]
Get:35 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libtexlua53
amd64 2021.20210626.59705-1ubuntu0.2 [120 kB]
Get:36 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libtexluajit2
amd64 2021.20210626.59705-1ubuntu0.2 [267 kB]
Get:37 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libzzip-0-13 amd64

```
0.13.72+dfsg.1-1.1 [27.0 kB]
Get:38 http://archive.ubuntu.com/ubuntu jammy/main amd64 xfonts-encodings all
1:1.0.5-0ubuntu2 [578 kB]
Get:39 http://archive.ubuntu.com/ubuntu jammy/main amd64 xfonts-utils amd64
1:7.7+6build2 [94.6 kB]
Get:40 http://archive.ubuntu.com/ubuntu jammy/universe amd64 lmodern all
2.004.5-6.1 [9,471 kB]
Get:41 http://archive.ubuntu.com/ubuntu jammy/universe amd64 pandoc-data all
2.9.2.1-3ubuntu2 [81.8 kB]
Get:42 http://archive.ubuntu.com/ubuntu jammy/universe amd64 pandoc amd64
2.9.2.1-3ubuntu2 [20.3 MB]
Get:43 http://archive.ubuntu.com/ubuntu jammy/universe amd64 preview-latex-style
all 12.2-1ubuntu1 [185 kB]
Get:44 http://archive.ubuntu.com/ubuntu jammy/main amd64 t1utils amd64
1.41-4build2 [61.3 kB]
Get:45 http://archive.ubuntu.com/ubuntu jammy/universe amd64 teckit amd64
2.5.11+ds1-1 [699 kB]
Get:46 http://archive.ubuntu.com/ubuntu jammy/universe amd64 tex-gyre all
20180621-3.1 [6,209 kB]
Get:47 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 texlive-
binaries amd64 2021.20210626.59705-1ubuntu0.2 [9,860 kB]
Get:48 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-base all
2021.20220204-1 [21.0 MB]
Get:49 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-fonts-
recommended all 2021.20220204-1 [4,972 kB]
Get:50 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-latex-base
all 2021.20220204-1 [1,128 kB]
Get:51 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libfontbox-java all
1:1.8.16-2 [207 kB]
Get:52 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libpdfbox-java all
1:1.8.16-2 [5,199 kB]
Get:53 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-latex-
recommended all 2021.20220204-1 [14.4 MB]
Get:54 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-pictures
all 2021.20220204-1 [8,720 kB]
Get:55 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-latex-extra
all 2021.20220204-1 [13.9 MB]
Get:56 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-plain-
generic all 2021.20220204-1 [27.5 MB]
Get:57 http://archive.ubuntu.com/ubuntu jammy/universe amd64 tipa all 2:1.3-21
[2,967 kB]
Get:58 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-xetex all
2021.20220204-1 [12.4 MB]
Fetched 202 MB in 3s (75.7 MB/s)
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based
frontend cannot be used. at /usr/share/perl5/Debconf/FrontEnd/Dialog.pm line 78,
<> line 58.)
```

```
debconf: falling back to frontend: Readline
debconf: unable to initialize frontend: Readline
debconf: (This frontend requires a controlling tty.)
debconf: falling back to frontend: Teletype
dpkg-preconfigure: unable to re-open stdin:
Selecting previously unselected package fonts-droid-fallback.
(Reading database ... 123632 files and directories currently installed.)
Preparing to unpack .../00-fonts-droid-fallback_1%3a6.0.1r16-1.1build1_all.deb
...
Unpacking fonts-droid-fallback (1:6.0.1r16-1.1build1) ...
Selecting previously unselected package fonts-lato.
Preparing to unpack .../01-fonts-lato_2.0-2.1_all.deb ...
Unpacking fonts-lato (2.0-2.1) ...
Selecting previously unselected package poppler-data.
Preparing to unpack .../02-poppler-data_0.4.11-1_all.deb ...
Unpacking poppler-data (0.4.11-1) ...
Selecting previously unselected package tex-common.
Preparing to unpack .../03-tex-common_6.17_all.deb ...
Unpacking tex-common (6.17) ...
Selecting previously unselected package fonts-urw-base35.
Preparing to unpack .../04-fonts-urw-base35_20200910-1_all.deb ...
Unpacking fonts-urw-base35 (20200910-1) ...
Selecting previously unselected package libgs9-common.
Preparing to unpack .../05-libgs9-common_9.55.0~dfsg1-0ubuntu5.10_all.deb ...
Unpacking libgs9-common (9.55.0~dfsg1-0ubuntu5.10) ...
Selecting previously unselected package libidn12:amd64.
Preparing to unpack .../06-libidn12_1.38-4ubuntu1_amd64.deb ...
Unpacking libidn12:amd64 (1.38-4ubuntu1) ...
Selecting previously unselected package libijs-0.35:amd64.
Preparing to unpack .../07-libijs-0.35_0.35-15build2_amd64.deb ...
Unpacking libijs-0.35:amd64 (0.35-15build2) ...
Selecting previously unselected package libjbig2dec0:amd64.
Preparing to unpack .../08-libjbig2dec0_0.19-3build2_amd64.deb ...
Unpacking libjbig2dec0:amd64 (0.19-3build2) ...
Selecting previously unselected package libgs9:amd64.
Preparing to unpack .../09-libgs9_9.55.0~dfsg1-0ubuntu5.10_amd64.deb ...
Unpacking libgs9:amd64 (9.55.0~dfsg1-0ubuntu5.10) ...
Selecting previously unselected package libkpathsea6:amd64.
Preparing to unpack .../10-libkpathsea6_2021.20210626.59705-1ubuntu0.2_amd64.deb
...
Unpacking libkpathsea6:amd64 (2021.20210626.59705-1ubuntu0.2) ...
Selecting previously unselected package libwoff1:amd64.
Preparing to unpack .../11-libwoff1_1.0.2-1build4_amd64.deb ...
Unpacking libwoff1:amd64 (1.0.2-1build4) ...
Selecting previously unselected package dvisvgm.
Preparing to unpack .../12-dvisvgm_2.13.1-1_amd64.deb ...
Unpacking dvisvgm (2.13.1-1) ...
Selecting previously unselected package fonts-lmodern.
```

```
Preparing to unpack .../13-fonts-lmodern_2.004.5-6.1_all.deb ...
Unpacking fonts-lmodern (2.004.5-6.1) ...
Selecting previously unselected package fonts-noto-mono.
Preparing to unpack .../14-fonts-noto-mono_20201225-1build1_all.deb ...
Unpacking fonts-noto-mono (20201225-1build1) ...
Selecting previously unselected package fonts-texgyre.
Preparing to unpack .../15-fonts-texgyre_20180621-3.1_all.deb ...
Unpacking fonts-texgyre (20180621-3.1) ...
Selecting previously unselected package libapache-pom-java.
Preparing to unpack .../16-libapache-pom-java_18-1_all.deb ...
Unpacking libapache-pom-java (18-1) ...
Selecting previously unselected package libcmark-gfm0.29.0.gfm.3:amd64.
Preparing to unpack .../17-libcmark-gfm0.29.0.gfm.3_0.29.0.gfm.3-3_amd64.deb ...
Unpacking libcmark-gfm0.29.0.gfm.3:amd64 (0.29.0.gfm.3-3) ...
Selecting previously unselected package libcmark-gfm-
extensions0.29.0.gfm.3:amd64.
Preparing to unpack .../18-libcmark-gfm-
extensions0.29.0.gfm.3_0.29.0.gfm.3-3_amd64.deb ...
Unpacking libcmark-gfm-extensions0.29.0.gfm.3:amd64 (0.29.0.gfm.3-3) ...
Selecting previously unselected package libcommons-parent-java.
Preparing to unpack .../19-libcommons-parent-java_43-1_all.deb ...
Unpacking libcommons-parent-java (43-1) ...
Selecting previously unselected package libcommons-logging-java.
Preparing to unpack .../20-libcommons-logging-java_1.2-2_all.deb ...
Unpacking libcommons-logging-java (1.2-2) ...
Selecting previously unselected package libfontenc1:amd64.
Preparing to unpack .../21-libfontenc1_1%3a1.1.4-1build3_amd64.deb ...
Unpacking libfontenc1:amd64 (1:1.1.4-1build3) ...
Selecting previously unselected package libptexenc1:amd64.
Preparing to unpack .../22-libptexenc1_2021.20210626.59705-1ubuntu0.2_amd64.deb
...
Unpacking libptexenc1:amd64 (2021.20210626.59705-1ubuntu0.2) ...
Selecting previously unselected package rubygems-integration.
Preparing to unpack .../23-rubygems-integration_1.18_all.deb ...
Unpacking rubygems-integration (1.18) ...
Selecting previously unselected package ruby3.0.
Preparing to unpack .../24-ruby3.0_3.0.2-7ubuntu2.8_amd64.deb ...
Unpacking ruby3.0 (3.0.2-7ubuntu2.8) ...
Selecting previously unselected package ruby-rubygems.
Preparing to unpack .../25-ruby-rubygems_3.3.5-2_all.deb ...
Unpacking ruby-rubygems (3.3.5-2) ...
Selecting previously unselected package ruby.
Preparing to unpack .../26-ruby_1%3a3.0~exp1_amd64.deb ...
Unpacking ruby (1:3.0~exp1) ...
Selecting previously unselected package rake.
Preparing to unpack .../27-rake_13.0.6-2_all.deb ...
Unpacking rake (13.0.6-2) ...
Selecting previously unselected package ruby-net-telnet.
```

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Preparing to unpack .../28-ruby-net-telnet_0.1.1-2_all.deb ...
Unpacking ruby-net-telnet (0.1.1-2) ...
Selecting previously unselected package ruby-webrick.
Preparing to unpack .../29-ruby-webrick_1.7.0-3ubuntu0.1_all.deb ...
Unpacking ruby-webrick (1.7.0-3ubuntu0.1) ...
Selecting previously unselected package ruby-xmlrpc.
Preparing to unpack .../30-ruby-xmlrpc_0.3.2-1ubuntu0.1_all.deb ...
Unpacking ruby-xmlrpc (0.3.2-1ubuntu0.1) ...
Selecting previously unselected package libruby3.0:amd64.
Preparing to unpack .../31-libruby3.0_3.0.2-7ubuntu2.8_amd64.deb ...
Unpacking libruby3.0:amd64 (3.0.2-7ubuntu2.8) ...
Selecting previously unselected package libsynctex2:amd64.
Preparing to unpack .../32-libsynctex2_2021.20210626.59705-1ubuntu0.2_amd64.deb
...
Unpacking libsynctex2:amd64 (2021.20210626.59705-1ubuntu0.2) ...
Selecting previously unselected package libteckit0:amd64.
Preparing to unpack .../33-libteckit0_2.5.11+ds1-1_amd64.deb ...
Unpacking libteckit0:amd64 (2.5.11+ds1-1) ...
Selecting previously unselected package libtexlua53:amd64.
Preparing to unpack .../34-libtexlua53_2021.20210626.59705-1ubuntu0.2_amd64.deb
...
Unpacking libtexlua53:amd64 (2021.20210626.59705-1ubuntu0.2) ...
Selecting previously unselected package libtexluajit2:amd64.
Preparing to unpack
.../35-libtexluajit2_2021.20210626.59705-1ubuntu0.2_amd64.deb ...
Unpacking libtexluajit2:amd64 (2021.20210626.59705-1ubuntu0.2) ...
Selecting previously unselected package libzzip-0-13:amd64.
Preparing to unpack .../36-libzzip-0-13_0.13.72+dfsg.1-1.1_amd64.deb ...
Unpacking libzzip-0-13:amd64 (0.13.72+dfsg.1-1.1) ...
Selecting previously unselected package xfonts-encodings.
Preparing to unpack .../37-xfonts-encodings_1%3a1.0.5-0ubuntu2_all.deb ...
Unpacking xfonts-encodings (1:1.0.5-0ubuntu2) ...
Selecting previously unselected package xfonts-utils.
Preparing to unpack .../38-xfonts-utils_1%3a7.7+6build2_amd64.deb ...
Unpacking xfonts-utils (1:7.7+6build2) ...
Selecting previously unselected package lmodern.
Preparing to unpack .../39-lmodern_2.004.5-6.1_all.deb ...
Unpacking lmodern (2.004.5-6.1) ...
Selecting previously unselected package pandoc-data.
Preparing to unpack .../40-pandoc-data_2.9.2.1-3ubuntu2_all.deb ...
Unpacking pandoc-data (2.9.2.1-3ubuntu2) ...
Selecting previously unselected package pandoc.
Preparing to unpack .../41-pandoc_2.9.2.1-3ubuntu2_amd64.deb ...
Unpacking pandoc (2.9.2.1-3ubuntu2) ...
Selecting previously unselected package preview-latex-style.
Preparing to unpack .../42-preview-latex-style_12.2-1ubuntu1_all.deb ...
Unpacking preview-latex-style (12.2-1ubuntu1) ...
Selecting previously unselected package t1utils.
```

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Preparing to unpack .../43-t1utils_1.41-4build2_amd64.deb ...
Unpacking t1utils (1.41-4build2) ...
Selecting previously unselected package teckit.
Preparing to unpack .../44-teckit_2.5.11+ds1-1_amd64.deb ...
Unpacking teckit (2.5.11+ds1-1) ...
Selecting previously unselected package tex-gyre.
Preparing to unpack .../45-tex-gyre_20180621-3.1_all.deb ...
Unpacking tex-gyre (20180621-3.1) ...
Selecting previously unselected package texlive-binaries.
Preparing to unpack .../46-texlive-
binaries_2021.20210626.59705-1ubuntu0.2_amd64.deb ...
Unpacking texlive-binaries (2021.20210626.59705-1ubuntu0.2) ...
Selecting previously unselected package texlive-base.
Preparing to unpack .../47-texlive-base_2021.20220204-1_all.deb ...
Unpacking texlive-base (2021.20220204-1) ...
Selecting previously unselected package texlive-fonts-recommended.
Preparing to unpack .../48-texlive-fonts-recommended_2021.20220204-1_all.deb ...
Unpacking texlive-fonts-recommended (2021.20220204-1) ...
Selecting previously unselected package texlive-latex-base.
Preparing to unpack .../49-texlive-latex-base_2021.20220204-1_all.deb ...
Unpacking texlive-latex-base (2021.20220204-1) ...
Selecting previously unselected package libfontbox-java.
Preparing to unpack .../50-libfontbox-java_1%3a1.8.16-2_all.deb ...
Unpacking libfontbox-java (1:1.8.16-2) ...
Selecting previously unselected package libpdfbox-java.
Preparing to unpack .../51-libpdfbox-java_1%3a1.8.16-2_all.deb ...
Unpacking libpdfbox-java (1:1.8.16-2) ...
Selecting previously unselected package texlive-latex-recommended.
Preparing to unpack .../52-texlive-latex-recommended_2021.20220204-1_all.deb ...
Unpacking texlive-latex-recommended (2021.20220204-1) ...
Selecting previously unselected package texlive-pictures.
Preparing to unpack .../53-texlive-pictures_2021.20220204-1_all.deb ...
Unpacking texlive-pictures (2021.20220204-1) ...
Selecting previously unselected package texlive-latex-extra.
Preparing to unpack .../54-texlive-latex-extra_2021.20220204-1_all.deb ...
Unpacking texlive-latex-extra (2021.20220204-1) ...
Selecting previously unselected package texlive-plain-generic.
Preparing to unpack .../55-texlive-plain-generic_2021.20220204-1_all.deb ...
Unpacking texlive-plain-generic (2021.20220204-1) ...
Selecting previously unselected package tipa.
Preparing to unpack .../56-tipa_2%3a1.3-21_all.deb ...
Unpacking tipa (2:1.3-21) ...
Selecting previously unselected package texlive-xetex.
Preparing to unpack .../57-texlive-xetex_2021.20220204-1_all.deb ...
Unpacking texlive-xetex (2021.20220204-1) ...
Setting up fonts-lato (2.0-2.1) ...
Setting up fonts-noto-mono (20201225-1build1) ...
Setting up libwoff1:amd64 (1.0.2-1build4) ...
```

```
Setting up libtexlua53:amd64 (2021.20210626.59705-1ubuntu0.2) ...
Setting up libijs-0.35:amd64 (0.35-15build2) ...
Setting up libtexluajit2:amd64 (2021.20210626.59705-1ubuntu0.2) ...
Setting up libfontbox-java (1:1.8.16-2) ...
Setting up rubygems-integration (1.18) ...
Setting up libzip-0-13:amd64 (0.13.72+dfsg.1-1.1) ...
Setting up fonts-urw-base35 (20200910-1) ...
Setting up poppler-data (0.4.11-1) ...
Setting up tex-common (6.17) ...
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based
frontend cannot be used. at /usr/share/perl5/Debconf/FrontEnd/Dialog.pm line
78.)
debconf: falling back to frontend: Readline
update-language: texlive-base not installed and configured, doing nothing!
Setting up libfontenc1:amd64 (1:1.1.4-1build3) ...
Setting up libjbig2dec0:amd64 (0.19-3build2) ...
Setting up libteckit0:amd64 (2.5.11+ds1-1) ...
Setting up libapache-pom-java (18-1) ...
Setting up ruby-net-telnet (0.1.1-2) ...
Setting up xfonts-encodings (1:1.0.5-0ubuntu2) ...
Setting up t1utils (1.41-4build2) ...
Setting up libidn12:amd64 (1.38-4ubuntu1) ...
Setting up fonts-texgyre (20180621-3.1) ...
Setting up libkpathsea6:amd64 (2021.20210626.59705-1ubuntu0.2) ...
Setting up ruby-webrick (1.7.0-3ubuntu0.1) ...
Setting up libcmark-gfm0.29.0.gfm.3:amd64 (0.29.0.gfm.3-3) ...
Setting up fonts-lmodern (2.004.5-6.1) ...
Setting up libcmark-gfm-extensions0.29.0.gfm.3:amd64 (0.29.0.gfm.3-3) ...
Setting up fonts-droid-fallback (1:6.0.1r16-1.1build1) ...
Setting up pandoc-data (2.9.2.1-3ubuntu2) ...
Setting up ruby-xmlrpc (0.3.2-1ubuntu0.1) ...
Setting up libsynctex2:amd64 (2021.20210626.59705-1ubuntu0.2) ...
Setting up libgs9-common (9.55.0~dfsg1-0ubuntu5.10) ...
Setting up teckit (2.5.11+ds1-1) ...
Setting up libpdfbox-java (1:1.8.16-2) ...
Setting up libgs9:amd64 (9.55.0~dfsg1-0ubuntu5.10) ...
Setting up preview-latex-style (12.2-1ubuntu1) ...
Setting up libcommons-parent-java (43-1) ...
Setting up dvisvgm (2.13.1-1) ...
Setting up libcommons-logging-java (1.2-2) ...
Setting up xfonts-utils (1:7.7+6build2) ...
Setting up libptexenc1:amd64 (2021.20210626.59705-1ubuntu0.2) ...
Setting up pandoc (2.9.2.1-3ubuntu2) ...
Setting up texlive-binaries (2021.20210626.59705-1ubuntu0.2) ...
update-alternatives: using /usr/bin/xdvi-xaw to provide /usr/bin/xdvi.bin
(xdvi.bin) in auto mode
update-alternatives: using /usr/bin/bibtex.original to provide /usr/bin/bibtex
```

```
(bibtex) in auto mode
Setting up lmodern (2.004.5-6.1) ...
Setting up texlive-base (2021.20220204-1) ...
/usr/bin/ucfr
/usr/bin/ucfr
/usr/bin/ucfr
/usr/bin/ucfr
mktexlsr: Updating /var/lib/texmf/ls-R-TEXLIVEDIST...
mktexlsr: Updating /var/lib/texmf/ls-R-TEXMFMAIN...
mktexlsr: Updating /var/lib/texmf/ls-R...
mktexlsr: Done.
tl-paper: setting paper size for dvips to a4:
/var/lib/texmf/dvips/config/config-paper.ps
tl-paper: setting paper size for dvipdfmx to a4:
/var/lib/texmf/dvipdfmx/dvipdfmx-paper.cfg
tl-paper: setting paper size for xdvi to a4: /var/lib/texmf/xdvi/XDvi-paper
tl-paper: setting paper size for pdftex to a4: /var/lib/texmf/tex/generic/tex-
ini-files/pdftexconfig.tex
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based
frontend cannot be used. at /usr/share/perl5/Debconf/FrontEnd/Dialog.pm line
78.)
debconf: falling back to frontend: Readline
Setting up tex-gyre (20180621-3.1) ...
Setting up texlive-plain-generic (2021.20220204-1) ...
Setting up texlive-latex-base (2021.20220204-1) ...
Setting up texlive-latex-recommended (2021.20220204-1) ...
Setting up texlive-pictures (2021.20220204-1) ...
Setting up texlive-fonts-recommended (2021.20220204-1) ...
Setting up tipa (2:1.3-21) ...
Setting up texlive-latex-extra (2021.20220204-1) ...
Setting up texlive-xetex (2021.20220204-1) ...
Setting up rake (13.0.6-2) ...
Setting up libruby3.0:amd64 (3.0.2-7ubuntu2.8) ...
Setting up ruby3.0 (3.0.2-7ubuntu2.8) ...
Setting up ruby (1:3.0~exp1) ...
Setting up ruby-rubygems (3.3.5-2) ...
Processing triggers for man-db (2.10.2-1) ...
Processing triggers for fontconfig (2.13.1-4.2ubuntu5) ...
Processing triggers for libc-bin (2.35-0ubuntu3.4) ...
/sbin/ldconfig.real: /usr/local/lib/libtbbmalloc_proxy.so.2 is not a symbolic
link

/sbin/ldconfig.real: /usr/local/lib/libur_adapter_level_zero.so.0 is not a
symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtcm.so.1 is not a symbolic link
```

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/sbin/ldconfig.real: /usr/local/lib/libtcm_debug.so.1 is not a symbolic link
/sbin/ldconfig.real: /usr/local/lib/libur_loader.so.0 is not a symbolic link
/sbin/ldconfig.real: /usr/local/lib/libhwloc.so.15 is not a symbolic link
/sbin/ldconfig.real: /usr/local/lib/libumf.so.0 is not a symbolic link
/sbin/ldconfig.real: /usr/local/lib/libtbb.so.12 is not a symbolic link
/sbin/ldconfig.real: /usr/local/lib/libtbbbind_2_0.so.3 is not a symbolic link
/sbin/ldconfig.real: /usr/local/lib/libur_adapter_opencl.so.0 is not a symbolic link
/sbin/ldconfig.real: /usr/local/lib/libtbbmalloc.so.2 is not a symbolic link
/sbin/ldconfig.real: /usr/local/lib/libtbbbind_2_5.so.3 is not a symbolic link
/sbin/ldconfig.real: /usr/local/lib/libtbbbind.so.3 is not a symbolic link

Processing triggers for tex-common (6.17) ...
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based
frontend cannot be used. at /usr/share/perl5/Debconf/FrontEnd/Dialog.pm line
78.)
debconf: falling back to frontend: Readline
Running updmap-sys. This may take some time... done.
Running mktexlsr /var/lib/texmf ... done.
Building format(s) --all.
      This may take some time... done.
Collecting pypandoc
  Downloading pypandoc-1.15-py3-none-any.whl.metadata (16 kB)
  Downloading pypandoc-1.15-py3-none-any.whl (21 kB)
Installing collected packages: pypandoc
Successfully installed pypandoc-1.15

```

```
[ ]: !jupyter nbconvert --log-level DEBUG --to pdf
↳ "Image_Color_Quatization_Using_Kmeans_Clustering.ipynb"
```

```

[NbConvertApp] Searching ['/root/.jupyter', '/root/.local/etc/jupyter',
'/usr/etc/jupyter', '/usr/local/etc/jupyter', '/etc/jupyter'] for config files
[NbConvertApp] Looking for jupyter_config in /etc/jupyter
[NbConvertApp] Looking for jupyter_config in /usr/local/etc/jupyter
[NbConvertApp] Looking for jupyter_config in /usr/etc/jupyter
[NbConvertApp] Looking for jupyter_config in /root/.local/etc/jupyter
[NbConvertApp] Looking for jupyter_config in /root/.jupyter
[NbConvertApp] Looking for jupyter_nbconvert_config in /etc/jupyter

```

```

[NbConvertApp] Looking for jupyter_nbconvert_config in /usr/local/etc/jupyter
[NbConvertApp] Looking for jupyter_nbconvert_config in /usr/etc/jupyter
[NbConvertApp] Looking for jupyter_nbconvert_config in /root/.local/etc/jupyter
[NbConvertApp] Looking for jupyter_nbconvert_config in /root/.jupyter
[NbConvertApp] Converting notebook
Image_Color_Quatization_Using_Kmeans_Clustering.ipynb to pdf
[NbConvertApp] Notebook name is
'Image_Color_Quatization_Using_Kmeans_Clustering'
[NbConvertApp] Template paths:
    /usr/local/share/jupyter/nbconvert/templates/latex
    /usr/local/share/jupyter/nbconvert/templates/base
    /root/.local/share/jupyter
    /root/.local/share/jupyter/nbconvert/templates
    /root/.local/share/jupyter/nbconvert/templates/compatibility
    /usr/local/share/jupyter
    /usr/local/share/jupyter/nbconvert/templates
    /usr/local/share/jupyter/nbconvert/templates/compatibility
    /usr/share/jupyter
    /usr/share/jupyter/nbconvert/templates
    /usr/share/jupyter/nbconvert/templates/compatibility
    /usr/local/share/jupyter/nbconvert/templates

[NbConvertApp] Applying preprocessor: TagRemovePreprocessor
[NbConvertApp] Applying preprocessor: RegexRemovePreprocessor
[NbConvertApp] Applying preprocessor: SVG2PDFPreprocessor
[NbConvertApp] Applying preprocessor: LatexPreprocessor
[NbConvertApp] Applying preprocessor: HighlightMagicsPreprocessor
[NbConvertApp] Applying preprocessor: ExtractOutputPreprocessor
[NbConvertApp] Applying preprocessor: ExtractAttachmentsPreprocessor
[NbConvertApp] Attempting to load template index.tex.j2
[NbConvertApp]     template_paths: /usr/local/share/jupyter/nbconvert/templates/
latex:/usr/local/share/jupyter/nbconvert/templates/base:/root/.local/share/jupyter:
/root/.local/share/jupyter/nbconvert/templates:/root/.local/share/jupyter/nbconvert/
templates/compatibility:/usr/local/share/jupyter:/usr/local/share/jupyter/nbconvert/
templates:/usr/local/share/jupyter/nbconvert/templates/compatibility:
/usr/share/jupyter:/usr/share/jupyter/nbconvert/templates:/usr/share/jupyter/nbconvert/
templates/compatibility:/usr/local/share/jupyter/nbconvert/templates

[NbConvertApp] Support files will be in
Image_Color_Quatization_Using_Kmeans_Clustering_files/
[NbConvertApp] Making directory
./Image_Color_Quatization_Using_Kmeans_Clustering_files
[NbConvertApp] Writing 35772 bytes to ./Image_Color_Quatization_Using_Kmeans_Clustering_
files/Image_Color_Quatization_Using_Kmeans_Clustering_8_0.png
[NbConvertApp] Writing 244756 bytes to ./Image_Color_Quatization_Using_Kmeans_Clusteri
ng_files/Image_Color_Quatization_Using_Kmeans_Clustering_8_1.png
[NbConvertApp] Writing 150762 bytes to ./Image_Color_Quatization_Using_Kmeans_Clusteri
ng_files/Image_Color_Quatization_Using_Kmeans_Clustering_10_0.png
[NbConvertApp] Writing 326838 bytes to ./Image_Color_Quatization_Using_Kmeans_Clusteri
ng_files/Image_Color_Quatization_Using_Kmeans_Clustering_13_1.png

```

```
[NbConvertApp] Writing 213499 bytes to ./Image_Color_Quatization_Using_Kmeans_Clustering_files/Image_Color_Quatization_Using_Kmeans_Clustering_15_1.png
[NbConvertApp] Writing 195611 bytes to ./Image_Color_Quatization_Using_Kmeans_Clustering_files/Image_Color_Quatization_Using_Kmeans_Clustering_16_1.png
[NbConvertApp] Writing 115888 bytes to ./Image_Color_Quatization_Using_Kmeans_Clustering_files/Image_Color_Quatization_Using_Kmeans_Clustering_16_2.png
[NbConvertApp] Writing 322366 bytes to ./Image_Color_Quatization_Using_Kmeans_Clustering_files/Image_Color_Quatization_Using_Kmeans_Clustering_18_0.png
[NbConvertApp] Writing 372287 bytes to ./Image_Color_Quatization_Using_Kmeans_Clustering_files/Image_Color_Quatization_Using_Kmeans_Clustering_18_1.png
[NbConvertApp] Writing 426361 bytes to ./Image_Color_Quatization_Using_Kmeans_Clustering_files/Image_Color_Quatization_Using_Kmeans_Clustering_18_2.png
[NbConvertApp] Writing 453511 bytes to ./Image_Color_Quatization_Using_Kmeans_Clustering_files/Image_Color_Quatization_Using_Kmeans_Clustering_18_3.png
[NbConvertApp] Writing 482520 bytes to ./Image_Color_Quatization_Using_Kmeans_Clustering_files/Image_Color_Quatization_Using_Kmeans_Clustering_18_4.png
[NbConvertApp] Writing 507933 bytes to ./Image_Color_Quatization_Using_Kmeans_Clustering_files/Image_Color_Quatization_Using_Kmeans_Clustering_18_5.png
[NbConvertApp] Writing 120862 bytes to ./Image_Color_Quatization_Using_Kmeans_Clustering_files/Image_Color_Quatization_Using_Kmeans_Clustering_22_0.png
[NbConvertApp] Writing 1705096 bytes to ./Image_Color_Quatization_Using_Kmeans_Clustering_files/Image_Color_Quatization_Using_Kmeans_Clustering_22_1.png
[NbConvertApp] Writing 64651 bytes to notebook.tex
[NbConvertApp] Building PDF
[NbConvertApp] Running xelatex 3 times: ['xelatex', 'notebook.tex', '-quiet']
[NbConvertApp] Running bibtex 1 time: ['bibtex', 'notebook']
[NbConvertApp] WARNING | bibtex had problems, most likely because there were no citations
[NbConvertApp] bibtex output: ['bibtex', 'notebook']
b'This is BibTeX, Version 0.99d (TeX Live 2022/dev/Debian)\nThe top-level auxiliary file: notebook.aux\nI found no \\citation commands---while reading file notebook.aux\nI found no \\bibdata command---while reading file notebook.aux\nI found no \\bibstyle command---while reading file notebook.aux\n(There were 3 error messages)\n'
[NbConvertApp] PDF successfully created
[NbConvertApp] Writing 5199956 bytes to Image_Color_Quatization_Using_Kmeans_Clustering.pdf
```