In [3]:
```
import os
from tqdm import tqdm
import pandas as pd
import urllib.request
from math import floor
import sys
from joblib import Parallel, delayed

class ImageDownloader:
    def __init__(self, loader_root):
        self.loader_root = loader_root
        self.csv_remote_path = 'https://raw.githubusercontent.com/Nationa

    def ensure_exists(self, path, image=False):
        if not os.path.exists(path):
            os.makedirs(path)
        elif os.listdir(path) and image:
            # Prevent downloading images in a non-empty folder
            raise OSError(f"The folder '{path}' is not empty.")

    def get_base_dir(self):
        self.ensure_exists(self.loader_root)
        self.ensure_exists(f"{self.loader_root}/annotations")
        self.ensure_exists(f"{self.loader_root}/images",True)
        return self.loader_root

    def thumbnail_to_local(self, base_path, object_id):
        image_path = f"{base_path}/images"
        ending = f"{object_id}.jpg"
        return f"{image_path}/{ending}"

    def get_file(self, remote_url, out, timeout_seconds=10):
        with urllib.request.urlopen(remote_url, timeout=timeout_seconds)
            with open(out, "wb") as out_file:
                data = response.read()  # a `bytes` object
                out_file.write(data)

    def check_csv_exists(self,csv_name,base_dir=None):
        base_dir = base_dir or self.get_base_dir()
        csv_path = f"{base_dir}/annotations/{csv_name}.csv"
        if not os.path.exists(csv_name):
                self.get_file(self.csv_remote_path+f'/{csv_name}.csv', ou
                print(f"{csv_name}.csv file download successful")
        return csv_path

    def download_painting(self, base_dir=None, percent=100):
        print("Downloading data...")
        base_dir = base_dir or self.get_base_dir()
        objects_csv = self.check_csv_exists('objects')
        objects_df = pd.read_csv(objects_csv)

        published_images_csv = self.check_csv_exists('published_images')
        images_df = pd.read_csv(published_images_csv)

        # Merge and filter DataFrames
        painted_df = self.merge_and_filter(objects_df, images_df,base_dir
        samples = floor(painted_df.shape[0] * (percent / 100))
        painted_df = painted_df.head(samples)
```

```
        def download_image(object_id,thumb):
            out = self.thumbnail_to_local(base_dir,object_id)
            if os.path.exists(out):
                 return
            try:
                self.get_file(thumb, out=out)
            except Exception as e:
                print(e)
                print(f"failed to get {thumb}")

        print(f"Found {painted_df['objectid'].nunique()} images.")

        Parallel(n_jobs=16)(delayed(download_image)(object_id, thumb) for

        existing_files = os.listdir( os.path.join(self.loader_root,'image
        existing_objectids = [int(filename.split('.')[0]) for filename in
        missing_objectids = set(painted_df['objectid']) - set(existing_ob
        painted_df = painted_df[~painted_df['objectid'].isin(missing_obje
        painted_df.to_csv('./data/merged.csv', index=False)
        print(f"{len(missing_objectids)} rows with URL error are dropped"
        print(f"{len(painted_df['objectid'])} images download completed")

    def merge_and_filter(self, objects_df, images_df, output_file):
        painted_df = pd.merge(
            objects_df[['objectid', 'title', 'attribution', 'classificati
            images_df[['depictstmsobjectid', 'iiifthumburl']],
            left_on='objectid', right_on='depictstmsobjectid',
            how='inner'
        )

        painted_df = painted_df.drop_duplicates().drop('depictstmsobjecti

        return painted_df
```

In [4]:

```
import os
from PIL import Image
from torchvision import transforms
from torch.utils.data import Dataset

class ImageDataset(Dataset):

    def __init__(self, dataFrame, image_dir="./data/images", transform=No
        self.dataFrame = dataFrame
        self.image_dir = image_dir
        self.transform = transforms.Compose([
                                    transforms.ToTensor(),
                                    transforms.Resize((200,200)),
                                    transforms.Normalize((0.5, 0.5, 0.5),
                                ])

    def __getitem__(self, idx):
        image_path = os.path.join(self.image_dir, str(self.dataFrame.iloc
        image = Image.open(image_path).convert("RGB")
        image = self.transform(image)
        return image

    def __len__(self):
        return len(self.dataFrame)
```

In [5]:
```
import torch
import numpy as np
from PIL import Image
from torchvision import transforms
from facenet_pytorch import MTCNN
from torchvision.transforms.functional import to_pil_image
from torchvision.models import VGG16_Weights, ResNet50_Weights

class ResNetCompressor():
    def __init__(self, device='cpu'):
        super().__init__()
        self.device = device
        self.model = torch.hub.load('pytorch/vision:v0.9.0', 'resnet50',
        self.extractor = torch.nn.Sequential(*list(self.model.children())

    def extract(self, image_tensor):
        with torch.no_grad():
            features = self.extractor(image_tensor.to(self.device))
        return features.view(features.size(0), -1)

class FaceCropper():
    def __init__(self, compressor, device='cpu'):
        self.compressor = compressor
        self.device = device
        self.face_detector = MTCNN(min_face_size=2,margin=10,thresholds =
        self.face_detector.eval()

    def crop_faces(self, image_tensor):
        cropped_images = []
        for img in image_tensor:
            pil_img = to_pil_image(img)
            boxes, _ = self.face_detector.detect(pil_img)

            if boxes is not None and len(boxes) > 0:
                valid_boxes = []
                for box in boxes:
                    x_min, y_min, x_max, y_max = map(int, box)
                    x_min, y_min, x_max, y_max = [max(0, val) for val in

                    if x_max > x_min and y_max > y_min:
                        valid_boxes.append((x_min, y_min, x_max, y_max))

                if len(valid_boxes) > 0:
                    x_min = min(box[0] for box in valid_boxes)
                    y_min = min(box[1] for box in valid_boxes)
                    x_max = max(box[2] for box in valid_boxes)
                    y_max = max(box[3] for box in valid_boxes)

                    cropped_img = img[:, y_min:y_max, x_min:x_max]

                    resized_img = torch.nn.functional.interpolate(cropped
                    cropped_images.append(resized_img.squeeze(0))
            else:
                x_min, y_min, x_max, y_max = 0, 0, 200, 200
                cropped_img = img[:, y_min:y_max, x_min:x_max]
                cropped_images.append(cropped_img)

        stacked_tensor = torch.stack(cropped_images).to(self.device)
```

```
        extracted_features = self.compressor.extract(stacked_tensor)

        return extracted_features
```

In [6]:

```
import os
import torch
import numpy as np
from PIL import Image
import pandas as pd
from tqdm import tqdm
import matplotlib.pyplot as plt
from torch.utils.data import DataLoader
from sklearn.neighbors import NearestNeighbors
from torchvision.transforms import transforms
import pickle

class ImageRetrieval:
    def __init__(self, compressor, img_path, k=5, face_crop=False, device
        self.compressor = compressor
        self.compressor.device = device
        self.merged_df = pd.read_csv('./data/merged.csv')
        self.img_path = img_path
        self.device = device
        self.k = k

        pickle_file = "features.pkl"
        if os.path.exists(pickle_file) and os.path.getsize(pickle_file) >
            with open(pickle_file, "rb") as f:
                self.features, self.image_paths = pickle.load(f)
            print(f"Loaded features from {pickle_file}")
        else:
            print(f"features.pkl is empty or does not exist. Extracting f
            self.features, self.image_paths = self.extract_features(face_

    def extract_features(self, face_crop=False, save_interval=100000):
      pickle_file = "features.pkl"
      if os.path.exists(pickle_file):
          with open(pickle_file, "rb") as f:
              features, image_paths = pickle.load(f)

          total_images = len(self.merged_df)

          if len(image_paths) == total_images:
              print(f"Loaded features from {pickle_file}. Feature extract
              return features, image_paths
          else:
              print(f"Loaded features for {len(image_paths)} images from
              start_index = len(image_paths)
      else:
          features = []
          image_paths = []
          start_index = 0

      image_dataset = ImageDataset(self.merged_df)
      data_loader = DataLoader(image_dataset, batch_size=32, shuffle=Fals

      if face_crop:
          face_cropper = FaceCropper(self.compressor, device=self.device)

      print('Building Feature Vector List')
```

```
        for i, image_tensors in enumerate(tqdm(data_loader, total=len(data_
            if i < start_index // data_loader.batch_size:
                continue

            if face_crop:
                extracted_features = face_cropper.crop_faces(image_tensors)
            else:
                extracted_features = self.compressor.extract(image_tensors.

            extracted_features = extracted_features.view(extracted_features
            features.extend(extracted_features)
            image_paths.extend(image_dataset.dataFrame.iloc[len(features) -

            if len(image_paths) % save_interval == 0:
                with open(pickle_file, "wb") as f:
                    pickle.dump((features, image_paths), f)
                print(f"Saved progress to {pickle_file}")

        return features, image_paths

    def retrieve_similar_images(self, query_image_path, metric='cosine',f
        self.transform = transforms.Compose([
                                    transforms.ToTensor(),
                                    transforms.Resize((200,200)),
                                    transforms.Normalize((0.5, 0.5, 0.5),
                                ])
        image = Image.open(query_image_path).convert("RGB")
        query_image_tensor = self.transform(image).unsqueeze(0).to(self.d

        if face_crop:
            face_cropper = FaceCropper(self.compressor,device=self.device
            query_features = face_cropper.crop_faces(query_image_tensor)
            if query_features is None:
                    query_features = self.compressor.extract(query_image_
        else:
            query_features = self.compressor.extract(query_image_tensor)

        query_object_id = os.path.basename(query_image_path).split(".")[0
        query_index = self.merged_df[self.merged_df['objectid'] == int(qu
        except_query = np.delete(self.features, query_index+1, axis=0)

        knn = NearestNeighbors(n_neighbors=self.k, metric=metric)
        knn.fit(except_query)

        query_features = query_features.cpu().numpy()
        distances, indices = knn.kneighbors(query_features)
        similar_images = [(self.image_paths[i], distances[0, j]) for j, i
        similar_images = similar_images[1:]  # Skip the first element (qu
        similar_images.sort(key=lambda x: x[1])  # Sort the similar image

        return similar_images
```

In [7]:

```
import os
import numpy as np
from PIL import Image
import skimage
from skimage.metrics import structural_similarity as ssim
from skimage.metrics import mean_squared_error as mse
import matplotlib.pyplot as plt
from skimage.transform import resize
```

```
class evaluation_metrics:
    def __init__(self,img_path):
        self.img_path = img_path

    def visualize_images(self, similar_images_paths, query_image_path):
        query_image = Image.open(query_image_path)

        fig, axes = plt.subplots(1, len(similar_images_paths) + 1, figsiz
        axes[0].imshow(query_image)
        axes[0].set_title("Query Image")
        axes[0].axis('off')

        for i, (file_name, distance) in enumerate(similar_images_paths, s
            image = Image.open(os.path.join(self.img_path, str(file_name)
            axes[i].imshow(image)
            axes[i].set_title(f'Similar Image {i} ({file_name})')
            axes[i].axis('off')

        plt.tight_layout()
        plt.show();


    def eval_results(self,query_image_path, similar_images_paths):
        query_image = np.array(Image.open(query_image_path).convert('RGB'
        query_image = resize(query_image, (200, 200, 3))

        ssim_scores = []
        rmse_scores = []
        psnr_scores = []
        uqi_scores = []

        for (file_name,_) in similar_images_paths:
            img_path = os.path.join(self.img_path, str(file_name)+'.jpg')
            similar_image = np.array(Image.open(img_path).convert('RGB'))
            similar_image = resize(similar_image, (200, 200, 3))

            ssim_score, _ = ssim(query_image, similar_image, channel_axis
            ssim_scores.append(ssim_score)

            rmse_score = np.sqrt(mse(query_image, similar_image))
            rmse_scores.append(rmse_score)

        avg_ssim = np.mean(ssim_scores)
        avg_rmse = np.mean(rmse_scores)

        return avg_ssim, avg_rmse
```

In [8]:

```
import os
import random
import torch
import warnings
import pandas as pd
from PIL import Image
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
from facenet_pytorch import MTCNN

warnings.filterwarnings("ignore")
```

```
device = 'cuda' if torch.cuda.is_available() else 'cpu'
print(device) #check the device status
```

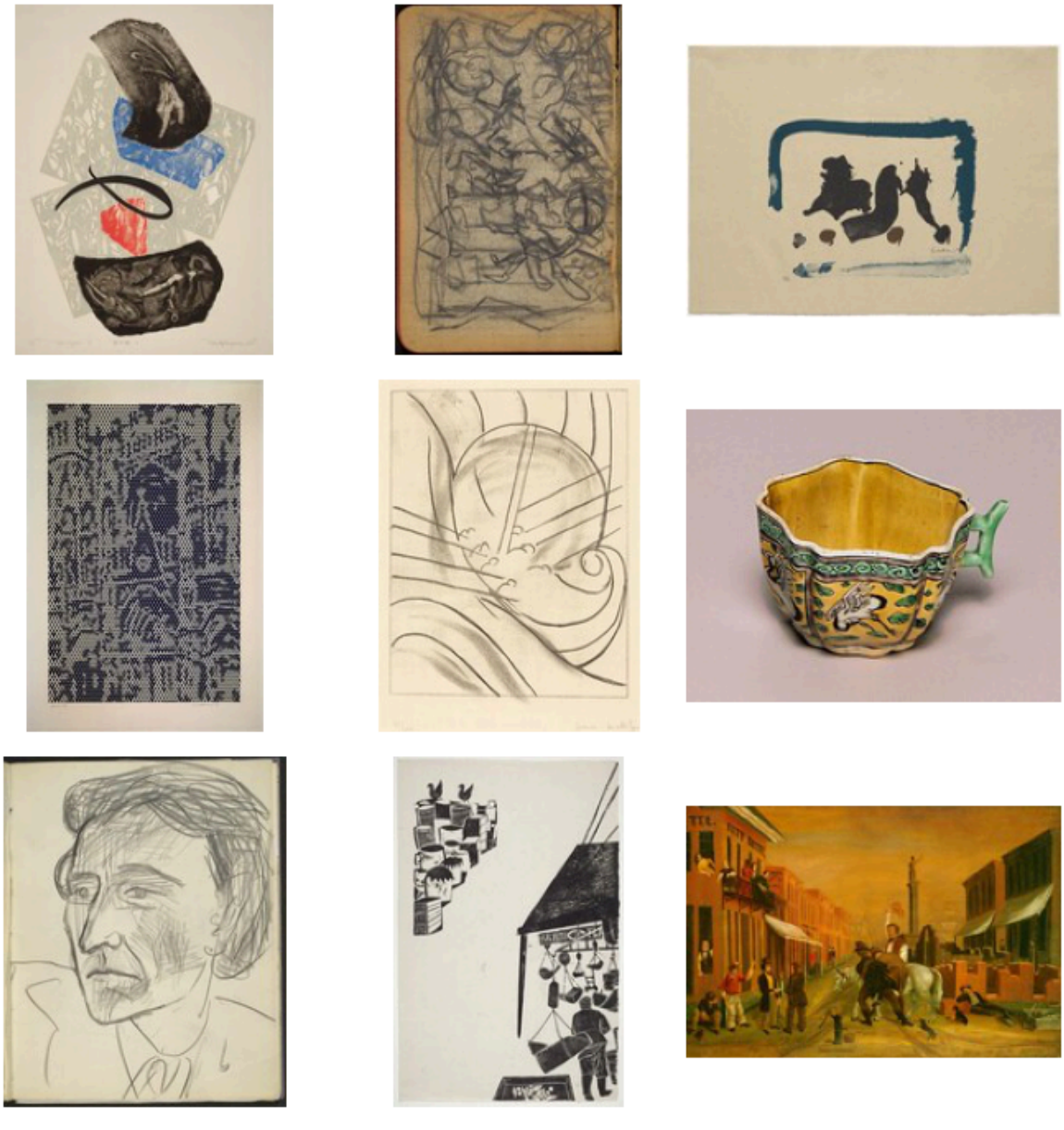
```
cpu
```

In [9]:
```
curr_path = os.getcwd()
loader_root = curr_path + "/data"
folder_path = './data/images'
percent = 15
```

In [10]:
```
image_files = [f for f in os.listdir(folder_path) if os.path.isfile(os.pa
selected_images = random.sample(image_files, 9)

fig, axes = plt.subplots(3, 3, figsize=(7, 7))
for i, image_file in enumerate(selected_images):
    img_path = os.path.join(folder_path, image_file)
    img = Image.open(img_path)
    axes[i // 3, i % 3].imshow(img)
    axes[i // 3, i % 3].axis('off')

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

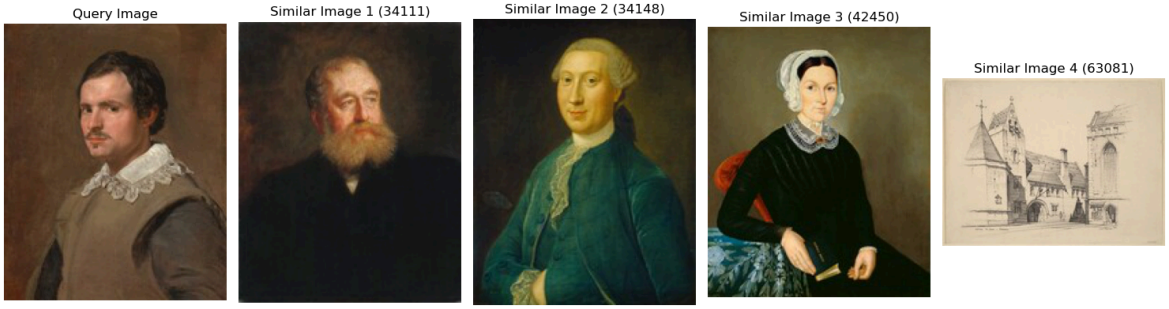


In [11]:
```
resnet = ResNetCompressor(device=device)
resnet_img_general = ImageRetrieval(resnet,folder_path,device=device)
# resnet_img_face = ImageRetrieval(resnet,folder_path,face_crop = True,de
```

```
Using cache found in /Users/rushi_jani/.cache/torch/hub/pytorch_vision_v0.
9.0
features.pkl is empty or does not exist. Extracting features...
Building Feature Vector List
100%|| 570/570 [44:06<00:00,  4.6
4s/it]
```

In [14]:
```
eval = evaluation_metrics(folder_path)
metric = 'cosine' # You can change to other distance metrics
```

In [26]:
```
query_image1 = "./data/images/89.jpg"
similar_images1 = resnet_img_general.retrieve_similar_images(query_image1
eval.visualize_images(similar_images1,query_image1)
```



In [20]:
```
from tqdm import tqdm
image_files = os.listdir(folder_path)

results = []

for query_image in tqdm(image_files[:30], desc="Processing images"):
    query_image_path = os.path.join(folder_path, query_image)

    similar_images = {
        "resnet_general": resnet_img_general.retrieve_similar_images(quer
    }

    for compressor, similar_images_set in similar_images.items():
        avg_ssim, avg_rmse = eval.eval_results(query_image_path, similar_
        results.append((compressor, avg_ssim, avg_rmse))

res = pd.DataFrame(results, columns=['Compressor', 'Average SSIM Score',
print(res)
```

```
Processing images: 100%| 30/30 [58:53<00:00, 117.8
0s/it]
```

	Compressor	Average SSIM Score	Average RMSE Score
0	resnet_general	0.368535	0.236226
1	resnet_general	0.127036	0.278058
2	resnet_general	0.207195	0.275650
3	resnet_general	0.453209	0.160430
4	resnet_general	0.526355	0.187666
5	resnet_general	0.109614	0.317456
6	resnet_general	0.222711	0.342105
7	resnet_general	0.184229	0.248418
8	resnet_general	0.164941	0.257645
9	resnet_general	0.422728	0.156201
10	resnet_general	0.090472	0.261566
11	resnet_general	0.440599	0.348840
12	resnet_general	0.167166	0.330780
13	resnet_general	0.397552	0.250146
14	resnet_general	0.260656	0.251840
15	resnet_general	0.292993	0.287530
16	resnet_general	0.131704	0.544100
17	resnet_general	0.161333	0.381897
18	resnet_general	0.268736	0.255736
19	resnet_general	0.050125	0.353396
20	resnet_general	0.232365	0.427994
21	resnet_general	0.055824	0.508918
22	resnet_general	0.216560	0.314035
23	resnet_general	0.654939	0.124623
24	resnet_general	0.104168	0.323184
25	resnet_general	0.238153	0.283720
26	resnet_general	0.122147	0.440054
27	resnet_general	0.380277	0.186870
28	resnet_general	0.075311	0.321867
29	resnet_general	0.216738	0.215626

In [21]:
```
average_scores = res.groupby('Compressor').agg({'Average SSIM Score': 'me

print(average_scores)
```

Compressor	Average SSIM Score	Average RMSE Score
resnet_general	0.244812	0.295753

In [ ]:
```

```