A Fine-grained Artist Identification Method for Authentication and Attribution of Drawings using Hatching Lines

Supplementary Material

6. Data Collection

Since there is no previous computer vision research on hatching technique analysis, there are no available public art datasets with hatching annotations to be used for our investigations. Preparing hatching annotations is difficult since it is a tedious task and requires expertise.

For hatching detection, we collected a total of 702 images of artworks from different artists and various sources. Each of these artworks was annotated by marking the hatching areas at the pixel level. We used this dataset for training, optimization, and testing our hatching detector models.

For artist classification based on hatching we collected several datasets. Artist identification datasets sum to a total of 442 drawings and prints from various artists. Besides their image-level artist labels, we annotated 322 images with pixel-level hatching annotations. The collection included drawings and prints by Giovanni Battista Piazzetta (50), Giovanni Battista Tiepolo (50), Giovanni Domenico Tiepolo (50), Giovanni Battista Piranesi (85), Giovanni Antonio Canal (85), Rembrandt van Rijn (61), Followers of Rembrandts (61).

Hatching detection and artist identification data were collected from various online sources, predominantly from The Morgan Museum & Library [39], the Van Gogh Museum, the Metropolitan Museum, the Rijksmuseum, and the National Gallery of Art, with a small number of samples included from other sources.

7. Hatching Segmentation

To achieve pixel-level segmentation of hatching areas, hatching detection is applied at various locations of the image in a sliding window manner with a stride of 1 pixel, and the detection results are aggregated for each pixel. We used overlapping patches to predict hatching segmentation masks based on patch-level hatching detection results. Since the hatching detection model predicts a single hatching probability for the entire patch, relying only on this single value to assign segmentation mask values for every pixel in the patch can lead to incorrect predictions, especially for transitional pixels between hatching and non-hatching areas. To mitigate this, we used overlapping patches, allowing multiple patch predictions to collectively impact the final segmentation mask value for a pixel they all cover.

8. Drawing-level Artist Identification

We experimented with four aggregation strategies [10] to translate the patch-level artist classification outcomes into drawing-level predictions:

1. Majority Voting: In this straightforward strategy, all patches have an equal impact on the drawing-level outcome. We count the number of occurrences of each class in the pool of patches tested by the classifier and output the majority class as the drawing-level prediction for the image.
2. Posterior Aggregate Voting: Unlike majority voting, where all patch-level votes contribute equally to the drawing-level class prediction, posterior aggregate voting employs a weighted voting strategy. For each patch, we use the posterior probability of the predicted class on that patch as a weight for its vote toward the drawing-level outcome.
3. K-certain Voting: This method enhances the majority voting strategy by first filtering out the less certain patches and then performing a majority voting on patches with more certain class votes (i.e., those with higher posterior probability of predicted class) to determine drawing-level artist prediction. In this strategy we used a threshold of 0.85 on the posterior probability of the predicted class, as the minimum acceptable certainty for a patch to participate in voting.
4. Certainty Weighted Voting: In this weighted voting strategy, the weight of each patch-level vote is determined by the value of a gamma function applied to its posterior probability of the predicted class. Consequently, votes by patches with higher certainty outputs contribute more to the drawing-level prediction, while the influence of patches with low-certainty predictions is discounted.