Exploring Pre-trained Models for Comparative Analysis of Scanned Historical Watermarks

Marin Alexandru Remus

Introduction and Problem Analysis

Traditional methods of watermark detection are very time-consuming and effortful. The manual scrutiny, although accurate, is not scalable when managing large data archives.

- Which automated techniques can be used?
- What is a pre-trained model?
- Why pre-trained models?
- Which is the research gap?

Figure 1. An untraced watermark

Figure 2. A traced watermark

Research Question

How effective are the pre-trained models - VGG16, ResNet50, EfficientNet, and InceptionV3 - in improving watermark recognition results?

Results and Discussion

Model	Traced Watermarks	Untraced Watermarks	Overall Dataset
VGG16	81,33	80,12	67,80
ResNet50	84,00	76,51	70,40
EfficientNetB0	80,00	71,99	64,60
InceptionV3	79,67	**81,02**	**71,20**
Harmonization + VGG16	89,33	53,61	64,13
Harmonization + ResNet50	86,67	54,82	62,90
Harmonization + EfficientNetB0	**94,66**	53,61	63,64
Harmonization + InceptionV3	84,00	46,08	58,72
Prior Art System	64,80	56,80	57,60

Table 1. Model Accuracy for Traced and Untraced Watermarks in Scenario 1 (first 4 rows) and Scenario 2 (next 4 rows) compared to the Prior Art System (last row). Numbers are in percentages. The best values for each case are highlighted. Values over 80% show that the models are very efficient, since it is almost impossible to achieve 100%.

Model	Traced Watermarks	Untraced Watermarks	Overall Dataset
VGG16	71,56	69,66	65,43
ResNet50	75,82	71,27	67,91
EfficientNetB0	73,50	**74,68**	70,05
InceptionV3	73,31	71,52	68,01
Harmonization + VGG16	75,94	66,76	63,92
Harmonization + ResNet50	**84,82**	71,49	**70,76**
Harmonization + EfficientNetB0	74,36	60,76	59,73
Harmonization + InceptionV3	78,97	64,27	63,27

Table 3. Model Similarity for Traced and Untraced Watermarks in Scenario 1 (first 4 rows) and Scenario 2 (next 4 rows). Numbers are in percentages. The best values for each case are highlighted. The decrease in accuracy by applying harmonization expresses the incapacity of the model to detect the watermark in the raw untraced images, due to the low quality of the watermarks.

Model	Traced Watermarks	Untraced Watermarks
VGG16	5,98	**17,95**
ResNet50	6,5	21,64
EfficientNetB0	6,08	27,54
InceptionV3	6,33	20,43
Harmonization + VGG16	3,57	44,92
Harmonization + ResNet50	5,4	43,46
Harmonization + EfficientNetB0	**2,89**	42,25
Harmonization + InceptionV3	6,12	54,43
Prior Art System	23,43	47,77

Table 2. Average Lowest Rank for Traced and Untraced Watermarks in Scenario 1 (first 4 rows) and Scenario 2 (next 4 rows) compared to the Prior Art System. The best values for each case are highlighted. A low rank means that a similar image is between the firsts in the ranking based on the cosine similarity.

Computation complexity

- The system built by Banta et al. [1] classify one watermark in approximately 4.5 seconds
- The pre-trained deep learning models outperform this system, delivering the results in approximately 0.2 seconds for one watermark.
- EfficientNet is the fastest network and delivers the result in 0.05 seconds.

Conclusion

- Pre-trained models prove to be slightly more effective than the prior art system
- Incorporating harmonization into the identified watermarks led to a noteworthy increase in accuracy across all models, achieving a 94.66% model accuracy for EfficientNetB0 with an average rank of 2.89.
- VGG16, ResNet50, EfficientNet, InceptionV3 exhibit promising advancements in both accuracy and time efficiency.
- For future work, besides only using the ImageNet weights, the pre-trained models can also be trained on watermarks.

Methodology

Dataset

- 500 images from the German Museum of Books and Writing
- Equally divided in traced and untraced
- Grouped into 125 classes with 4 images each, including 2 traced and 2 untraced watermarks

Algorithm

Images are tested in two different contexts using the weights from the ImageNet dateset:

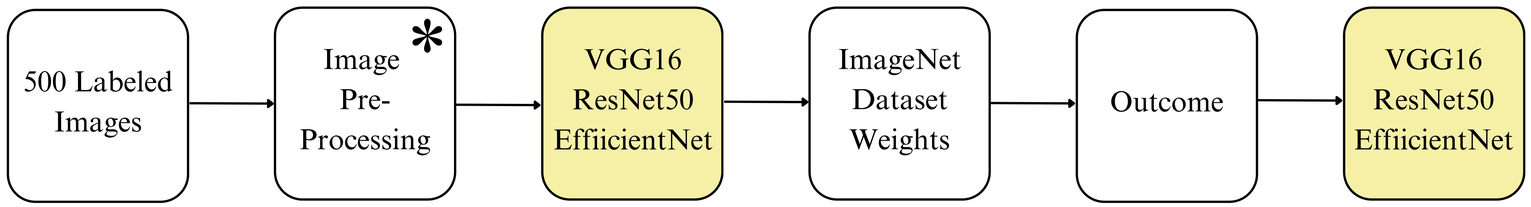
- first scenario uses raw images
- second scenario uses harmonized images

Evaluation

Each scenario is analysed in 3 different cases, to evaluate the traced watermarks, the untraced watermarks and the overall performance using the following evaluation metrics:

- Model Accuracy
- Average Lowest Rank
- Average Similarity

Process Flow Chart



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