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Empa
Materials Science and Technology

A Deep Active Learning Framework for Crack Detection in Digital Images of Paintings

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The Ghent Altarpiece

Closed

Opened

Hubert and Jan Van Eyck, completed in 1432.

closertovaneyck.kikirpa.be

Restoration of the Ghent Altarpiece

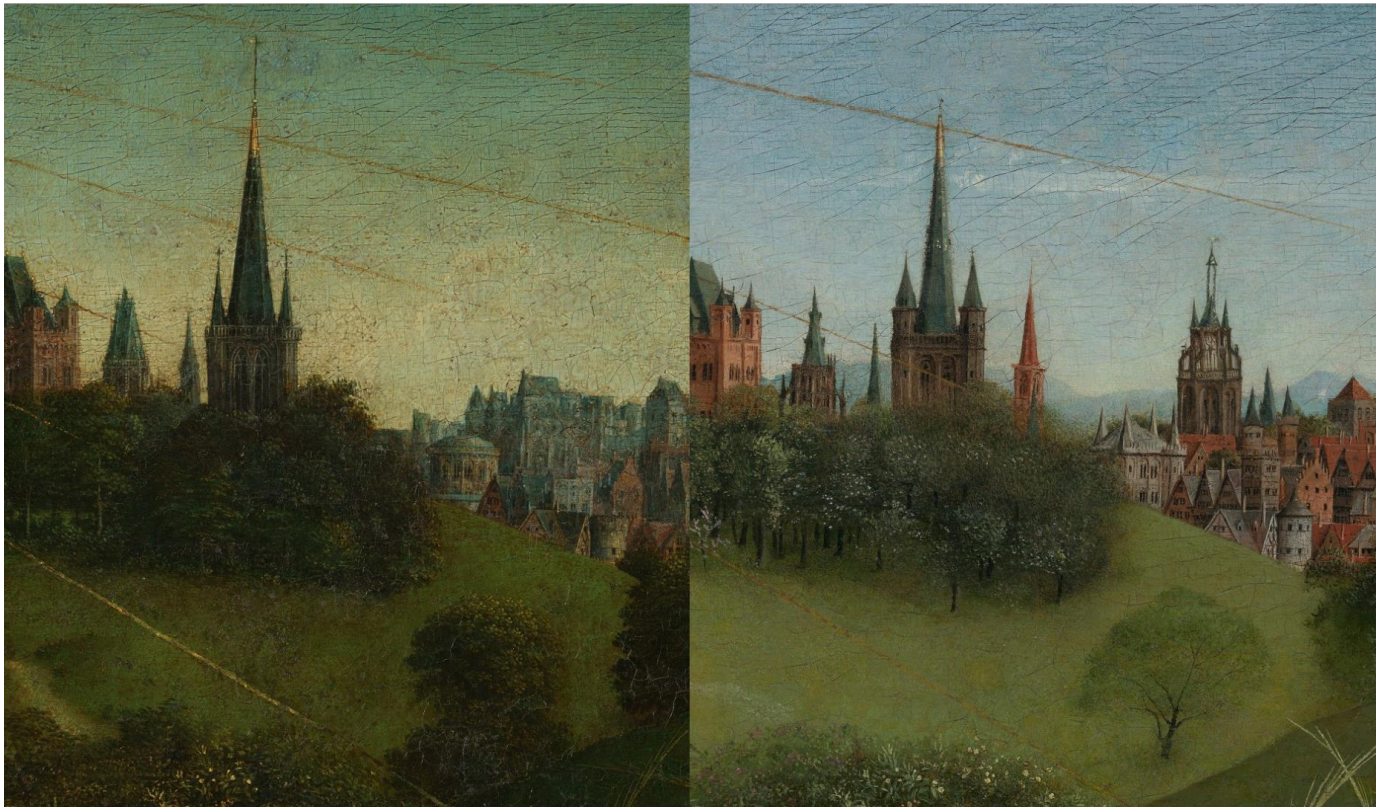
The restorers at work during the first phase of the restoration.
Museum of Fine Arts, Ghent.

Restoration of the Ghent Altarpiece

Comparison before (left) and after (right) restoration (Adoration of the Lamb).

closertovaneyck.kikirpa.be

Restoration of the Ghent Altarpiece



Comparison before (left) and after (right) restoration (Adoration of the Lamb).
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Why crack detection?

Paintings deteriorate over time, due to:

- aging of the underlying material
- oxidation of the varnish layer
- fluctuations of humidity and temperature

Cracks / craquelures are the most common kind of degradation

Example showing cracks and paint loss in a detail of the Angel Musicians painting.

Why crack detection?

Crack detection is crucial for

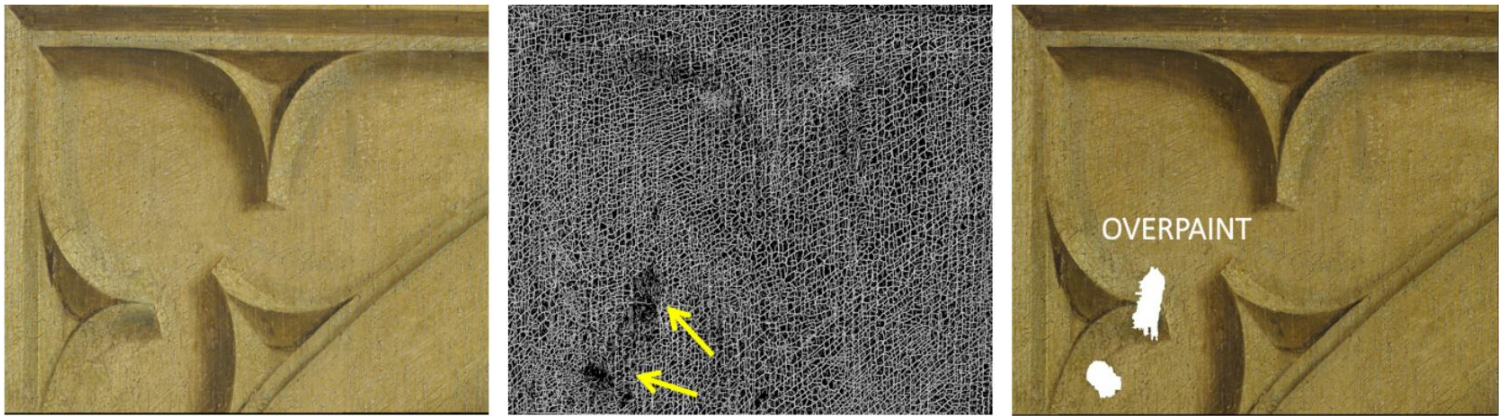
- documenting purpose
- virtual inpainting
- decision making in the actual restoration process

Currently involves

- machine learning and morphological filtering
- manual fine-tuning and correction
- prone to errors

Restoration of the Angel Musicians © Martin Corlazzoli. mskgent.be

Why crack detection?



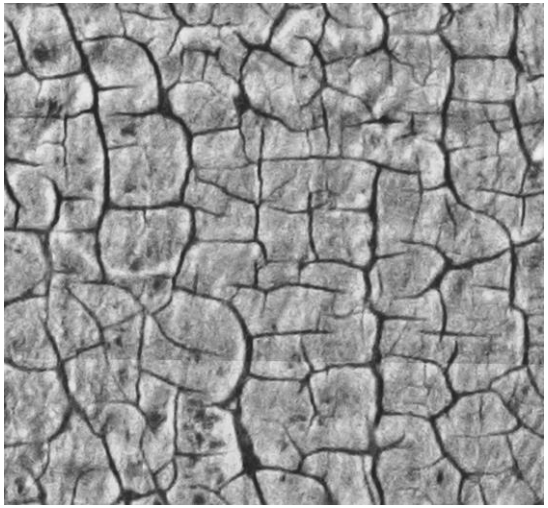
Diagnostics, overpaint detection.

Input for virtual crack filling. Improving readability of inscriptions.

Multimodal data

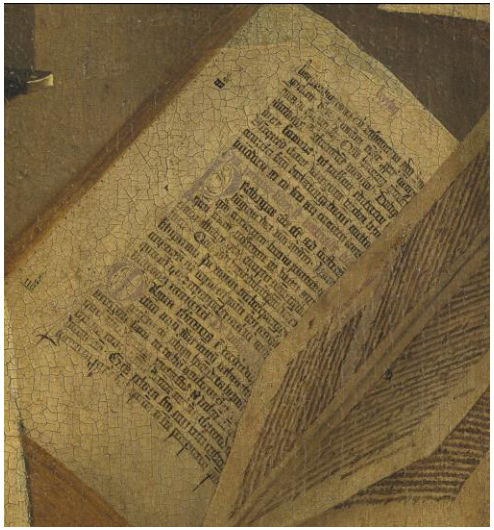
Macrophotography

Infrared reflectography

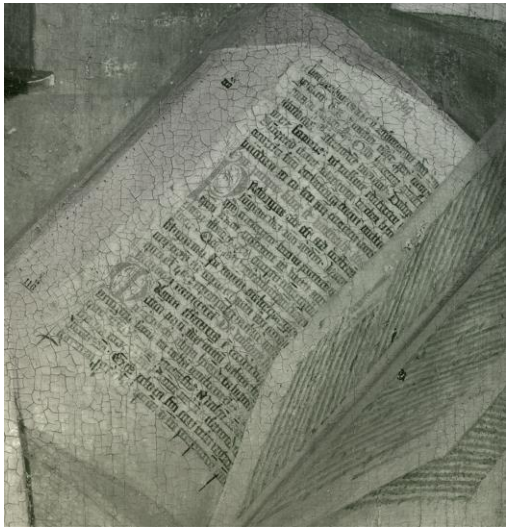


X-radiography

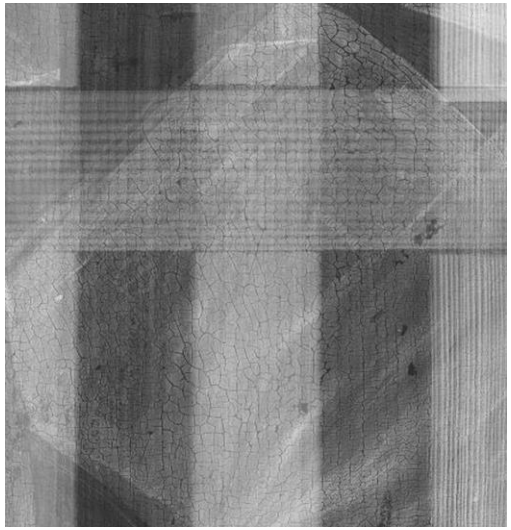
Multimodal data



Macrophotography

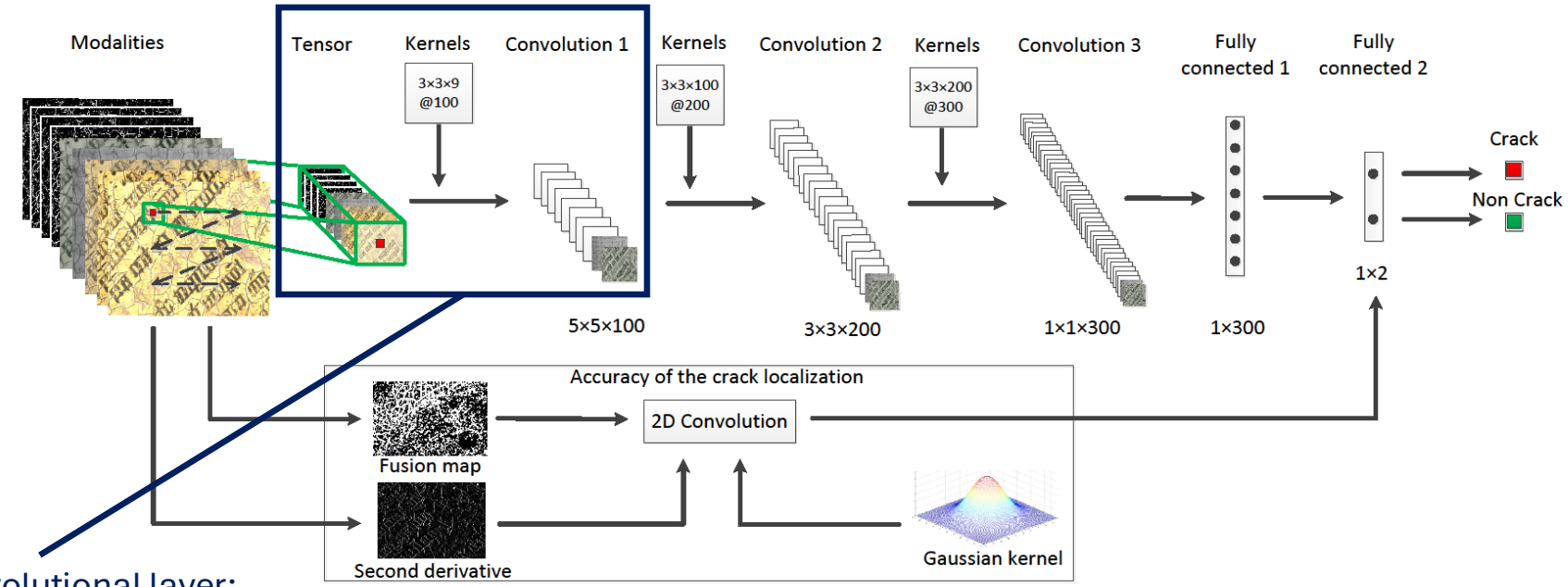


Infrared reflectography



X-radiography

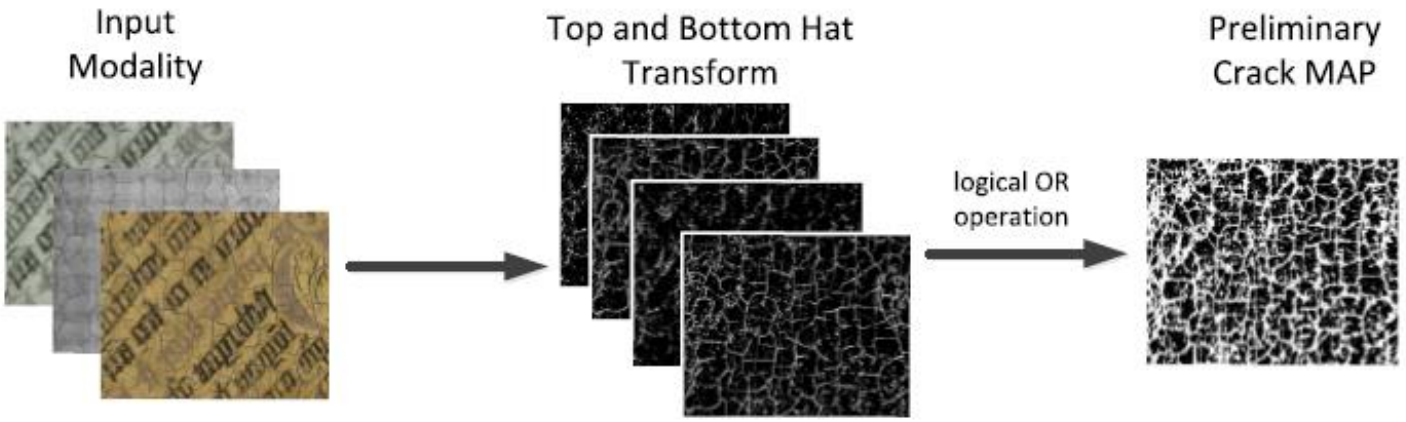
Crack detection based on deep learning



Convolutional layer:
Combining different modalities

R. Sizyakin, B. Cornelis, L. Meeus, H. Dubois, M. Martens, V. Voronin, and A. Pižurica. Crack Detection in Paintings Using Convolutional Neural Networks. IEEE Access, 2020.

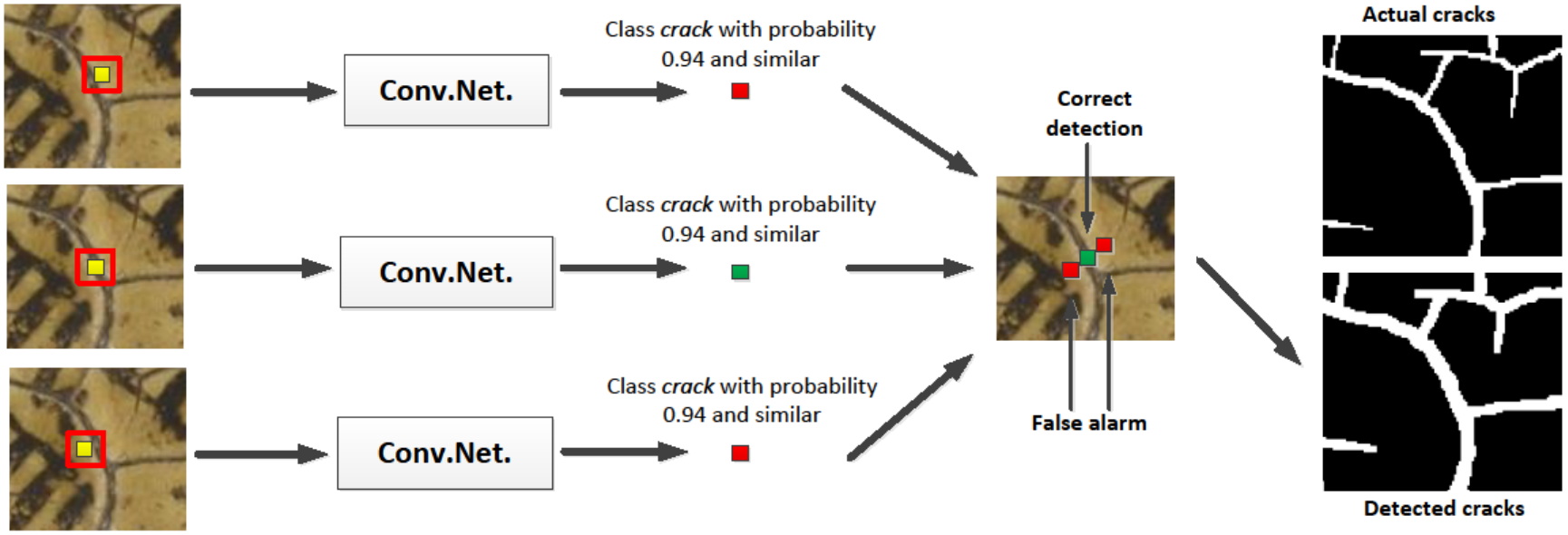
Morphological filtering



Morphological filtering is applied before the Conv.Net. to remove large portion of the non-cracks, reducing inference time of the model.

R. Sizyakin, B. Cornelis, L. Meeus, H. Dubois, M. Martens, V. Voronin, and A. Pižurica. Crack Detection in Paintings Using Convolutional Neural Networks. IEEE Access, 2020.

Excessive thickening



As a side effect, morphological filtering resolves excessive thickening of crack boundaries.

R. Sizyakin, B. Cornelis, L. Meeus, H. Dubois, M. Martens, V. Voronin, and A. Pižurica. Crack Detection in Paintings Using Convolutional Neural Networks. IEEE Access, 2020.

Deep Active Learning for Art Restoration

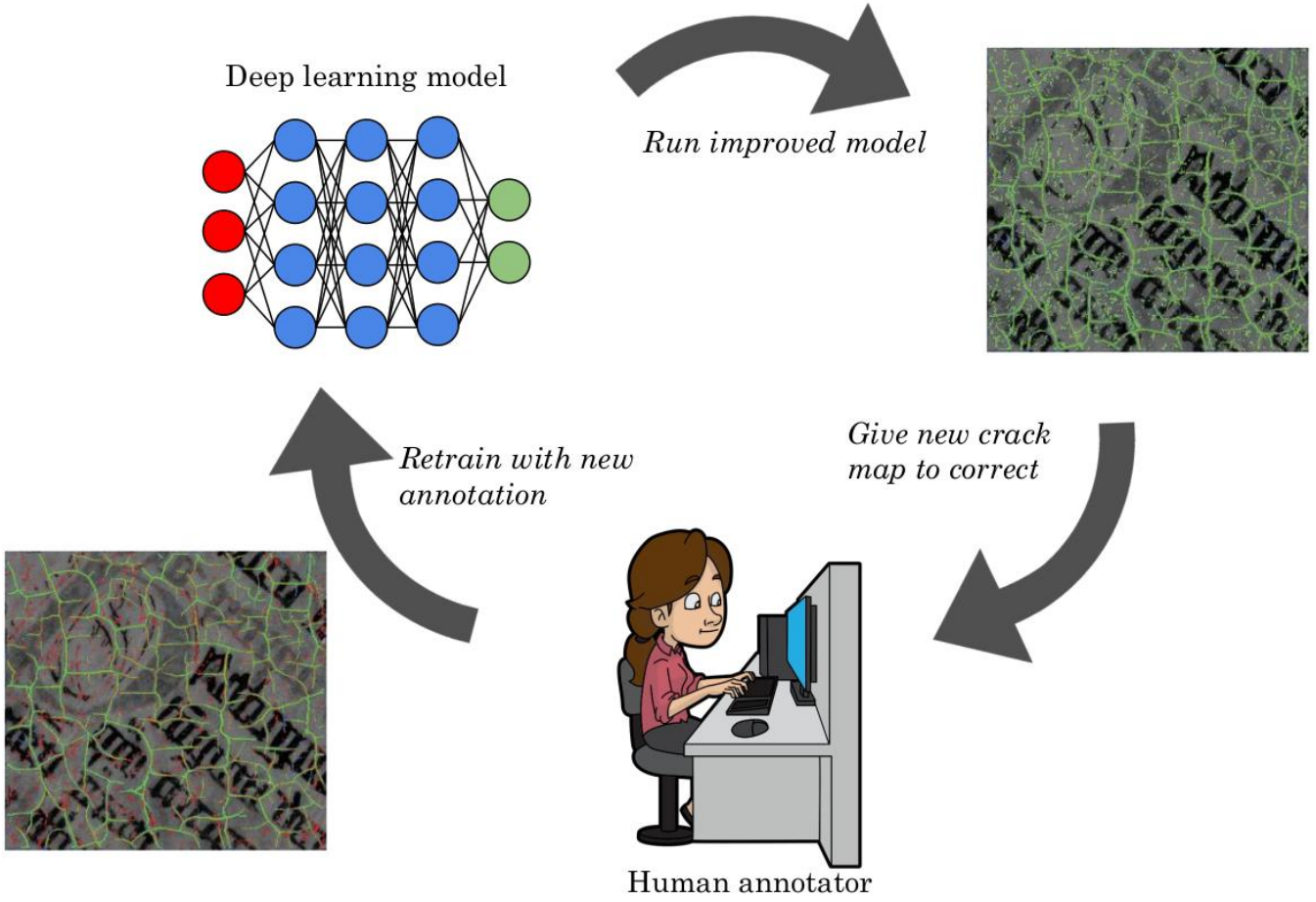
Existing crack detection models show good performance, but…

Issues:

- Need lots of labeled data, but little is available
- Cracks are very diverse (shape, size, thickness, contrast)
- Hard to use for non-technical people, such as art restorers

Need for intuitive active learning tool, to apply these models and speed-up the (manual) crack labeling process

Deep active learning cycle

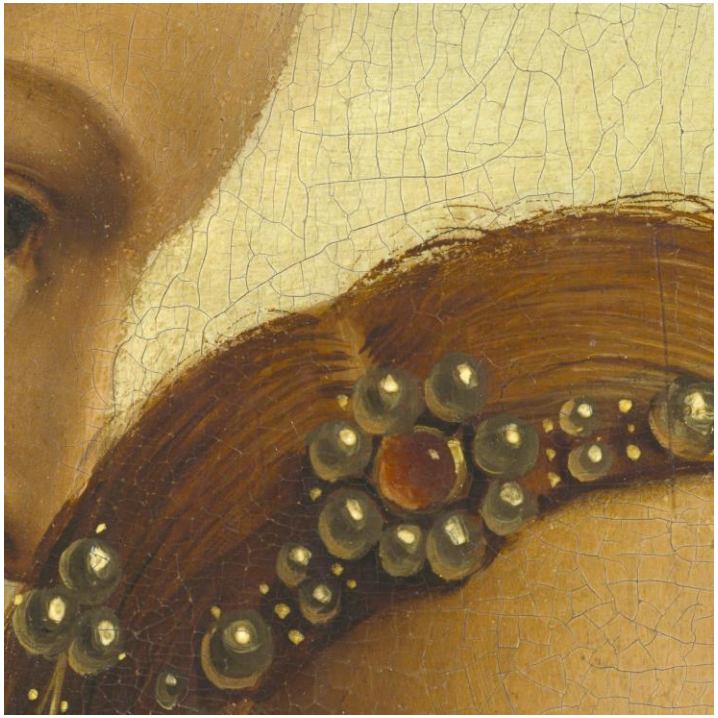


DAL4Art web interface

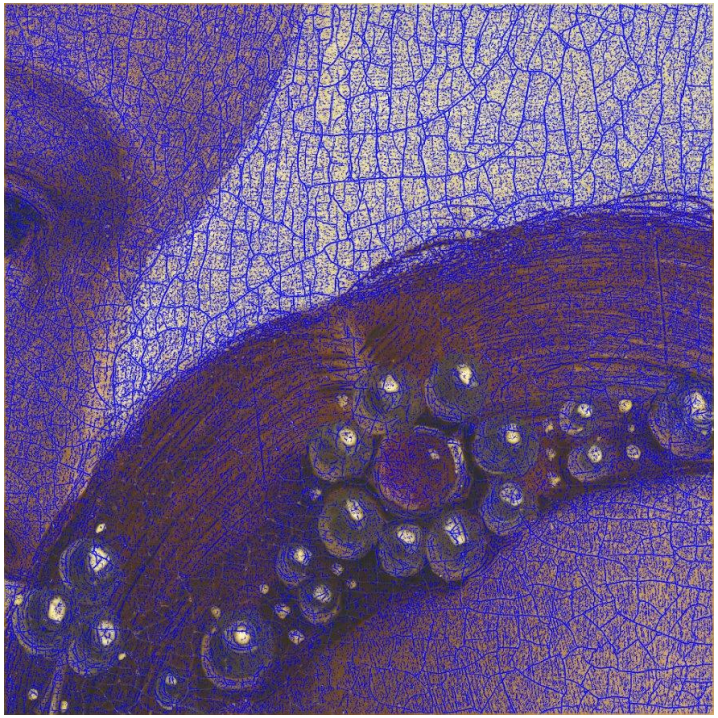
Illustration of the DAL4ART web interface. The red filter represents annotated cracks and the green filter represents annotated non-cracks.

Active learning example

Patch size: 2000 by 2000 pixels



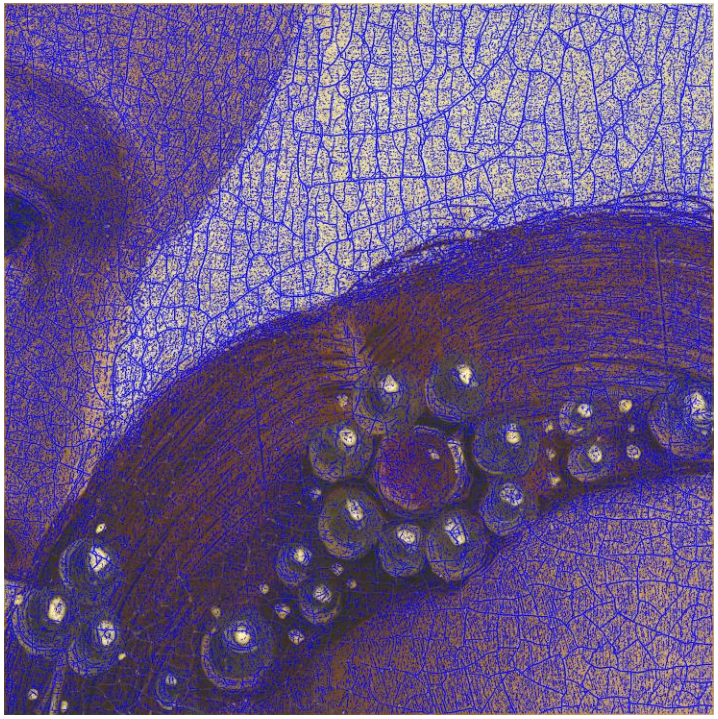
Original image



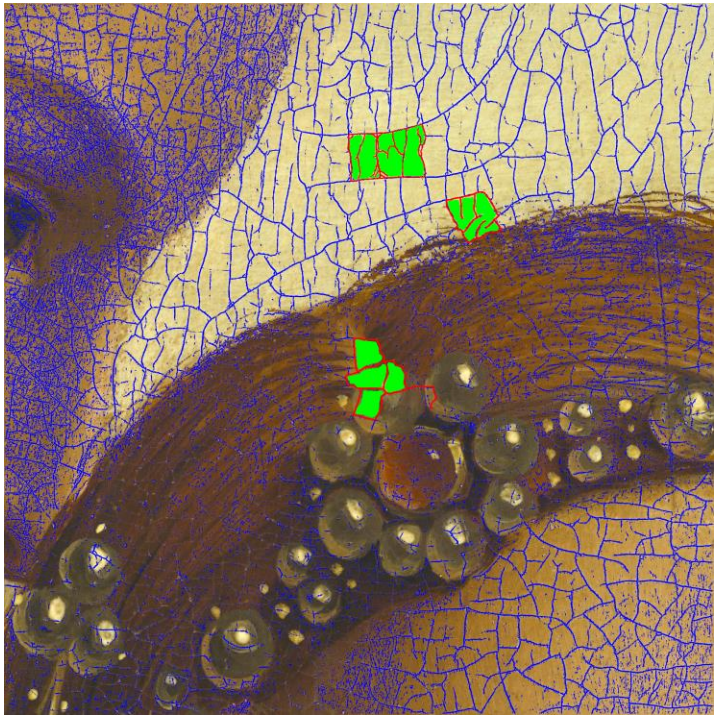
Morphological filtering

Active learning example

Patch size: 2000 by 2000 pixels



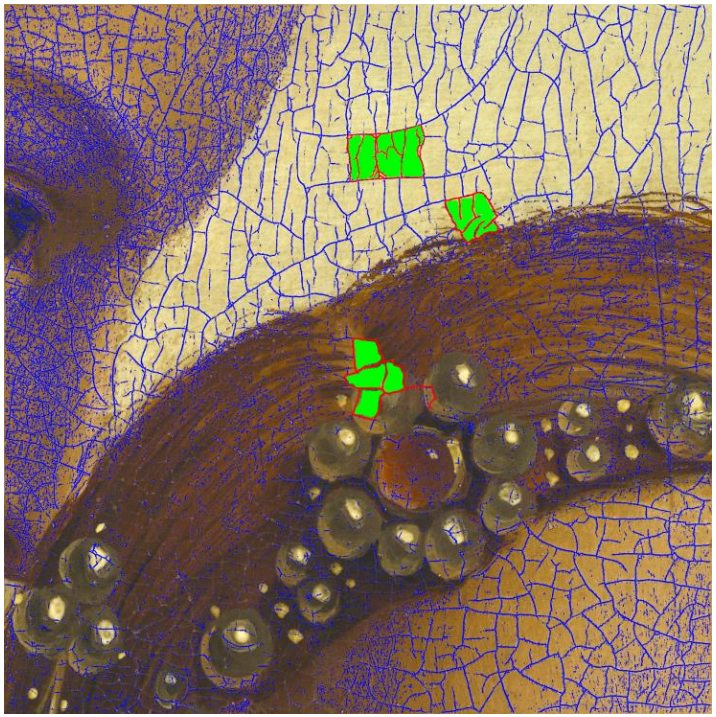
Morphological filtering



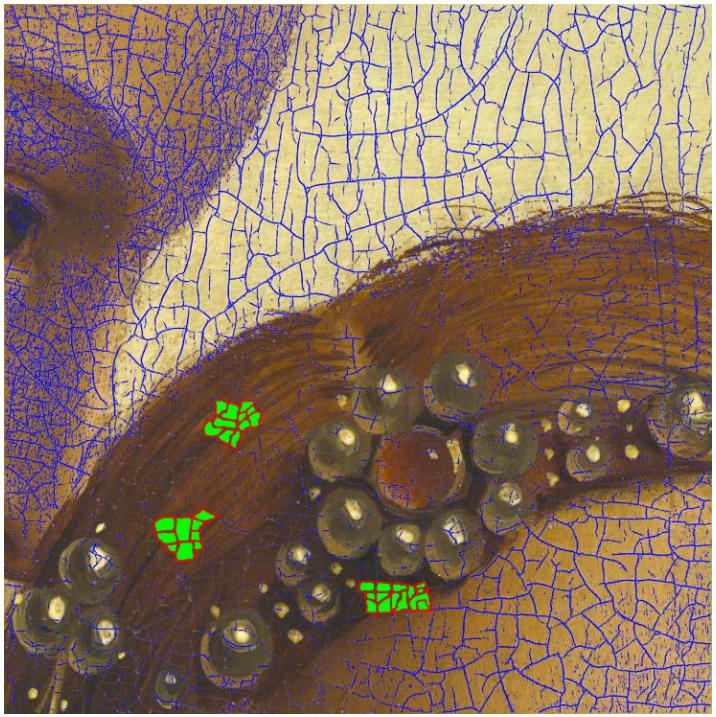
Active learning iteration 1

Active learning example

Patch size: 2000 by 2000 pixels



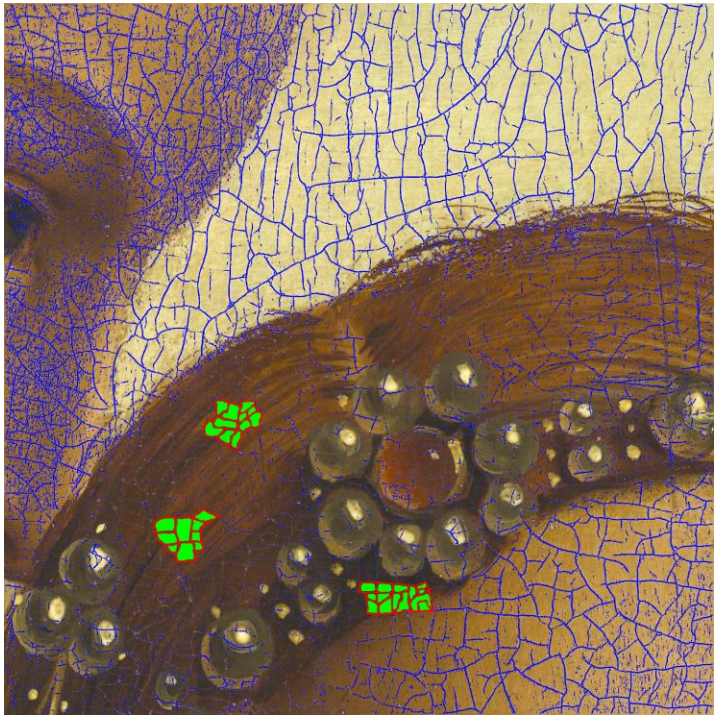
Active learning iteration 1



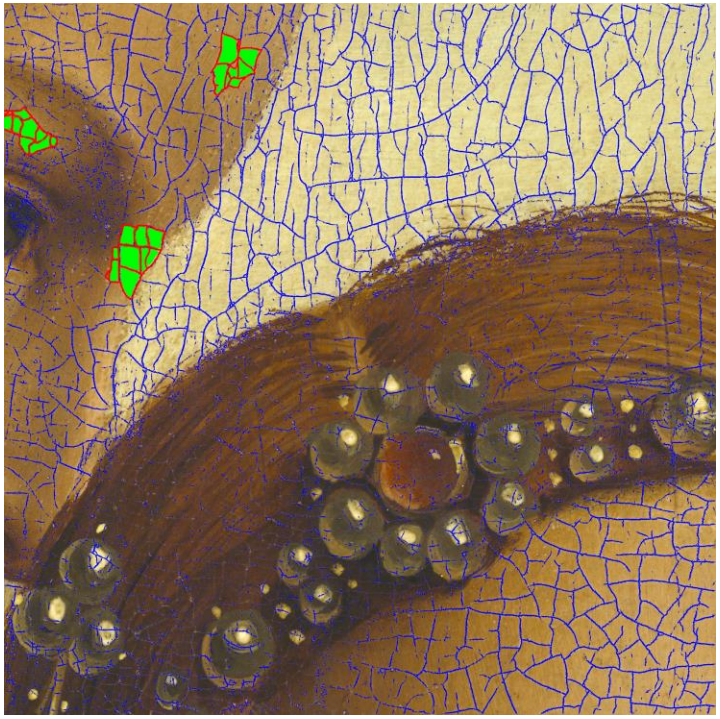
Active learning iteration 2

Active learning example

Patch size: 2000 by 2000 pixels



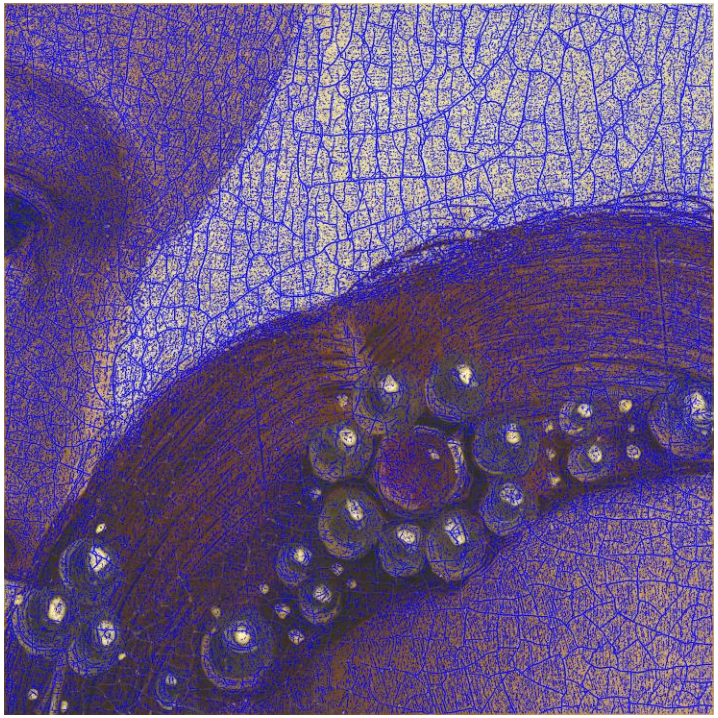
Active learning iteration 2



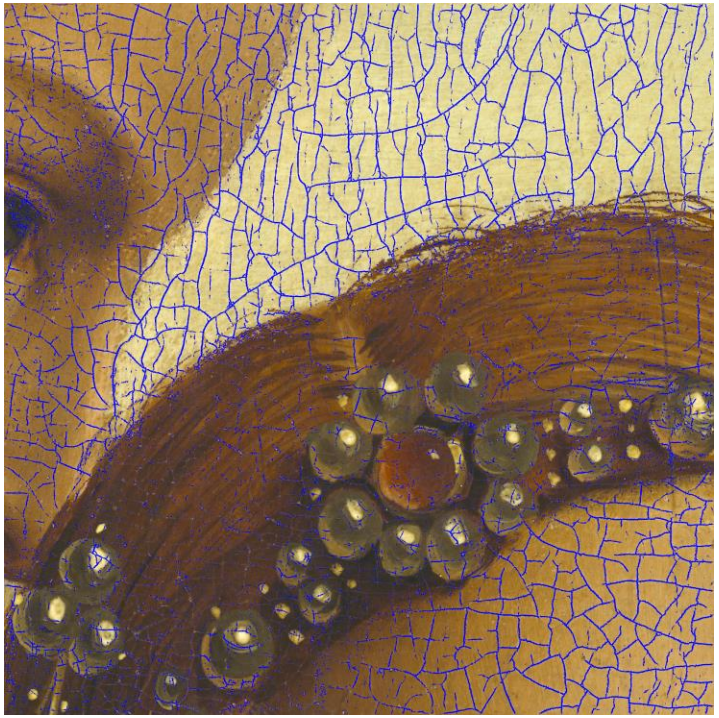
Active learning iteration 3

Active learning example

Patch size: 2000 by 2000 pixels



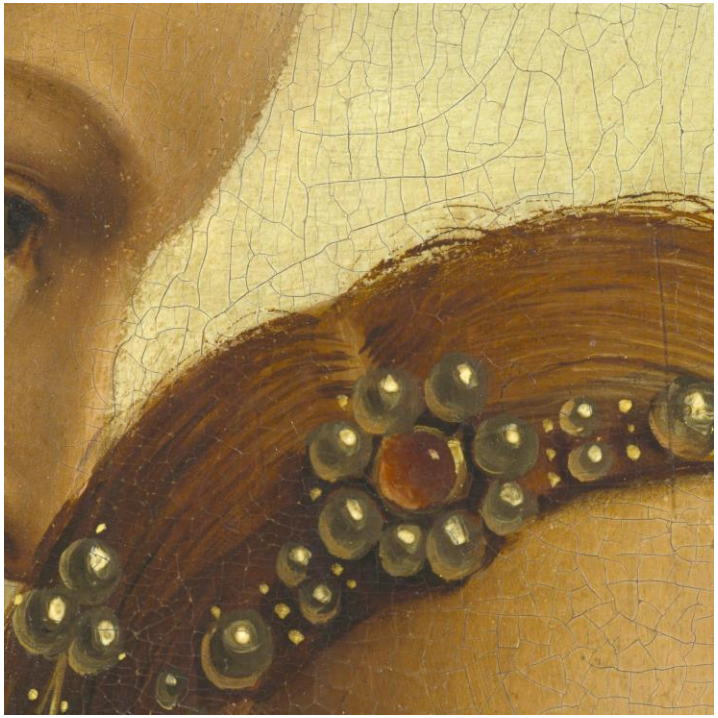
Morphological filtering



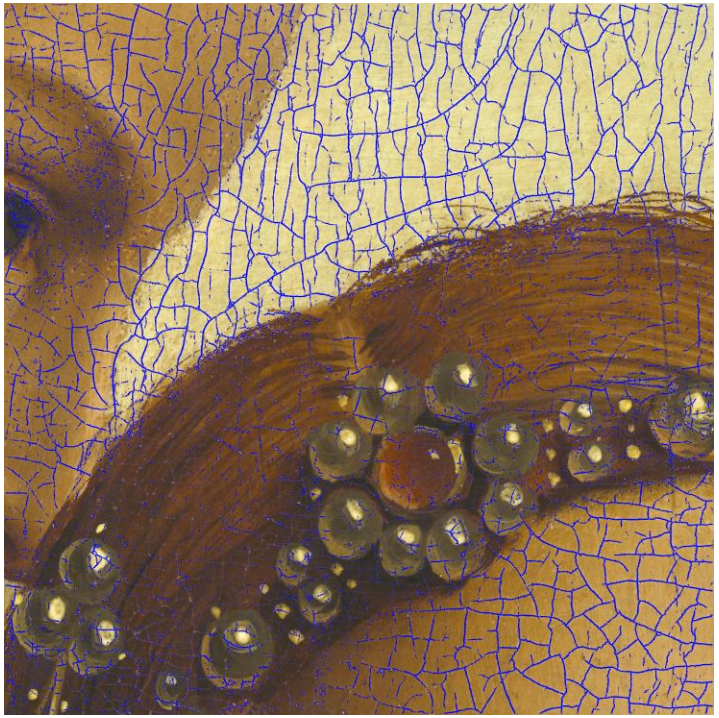
Final result after 3 iterations

Active learning example

Patch size: 2000 by 2000 pixels



Original image



Final result after 3 iterations

Reduction of annotation time

	Patch 1	Patch 2	Patch 3	Average
Manual annotation	16min 20s	18min 31s	20min 15s	18min 22s
DAL4ART	6min 41s	8min 55s	7min 9s	7min 35s
Time reduction	59%	52%	65%	59%

Measured annotation times for three patches of 256×256 pixels of the Ghent Altarpiece.

Conclusion

DAL4ART

- Interactive tool for (non-technical) art restorers
- Efficient detection of cracks in paintings
- Reduces time / improves accuracy

dal4art.ugent.be

Future work?

Also useful for other crack detection applications (such as roads)

Z. Fan, C. Li, Y. Chen, J. Wei, G. Loprencipe, X. Chen, P. Di Mascio. Automatic Crack Detection on Road Pavements Using Encoder-Decoder Architecture. Materials, 2020.