Smart-Phone Assisted Digital Rejuvenation of Medieval Paintings

Abstract

Researchers at Duke previously digitally rejuvenated a piece of medieval artwork. Even though the results were good, the process was mostly executed manually under expert's supervision. The goal was to streamline and automate the rejuvenation process with minimal user inputs by implementing the following:

- ❖A GUI-based crack detection for exporting crackmap
- ❖An automatic segmentation that supports layer-based image editing software
- ❖An accurate transformation of colorspace based on some groundtruth color maps
- ❖A user interactive punchmark detection algorithm
- ❖An automatic 3D gold model generation given the location and shape of punchmarks

The team explored the viability of satisfying all of the above requirements through open-source software. The team concluded that a rejuvenation workflow is feasible for a project with wider distribution in the form of a website, mobile app, or captcha.

Team Members

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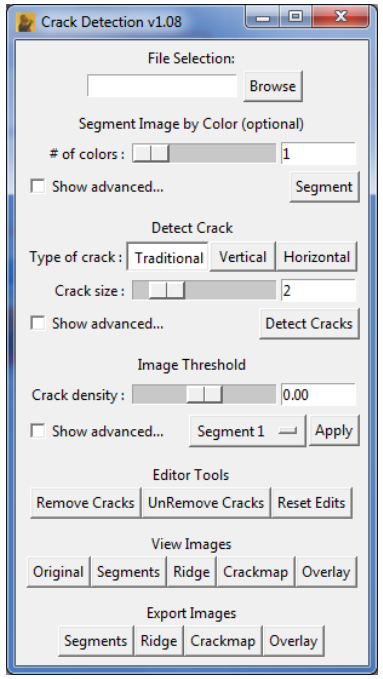
Ghissi Altarpiece

The altarpiece that served as an inspiration for this project was painted by Francescussio Ghissi in the fourteenth century. It is made up of nine panels (one of which is missing) of tempera on wood depicting scenes from Saint John the Apostle's life

App Prototype



The usefulness of crack analysis to art conservators led to the development of a stand-alone application for crack detection of an image. The software allows flexibility in specifying parameters A built-in color segmentation tool allows for independent assignment of thresholds for crack detection and the resulting binary crackmap can be used to mask the cracks for inpainting. The prototype was distributed to the conservators at North Carolina Museum of Art for testing.

Future Work

The development of the app is an ongoing process. Future steps that are being pursued are:

- Adding punchmark textures to the gilding render to recreate their original effect of reflecting light and appearing brighter than their background
- Creating an app or website where museum visitors can upload their own pictures and restore paintings themselves
- Using detailed inputs from museum visitors to crowdsource restoration process

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Project Workflow

Original Image

The following is a crop from the eighth panel of the Ghissi altarpiece depicting St. John the Apostle drinking from the poisoned cup. The artwork as seen in the 21st century does not accurately depict what the painting would have looked like at the time of its conception.

Color Segmentation

Natural pigments used in medieval paintings fade and crack distinctly over time. Differentiating each color segment is essential for accurate crack detection and color mapping in order to apply different parameters to different paints. A K-means clustering algorithm measures proximity in CIELAB color space to group pixels by color.

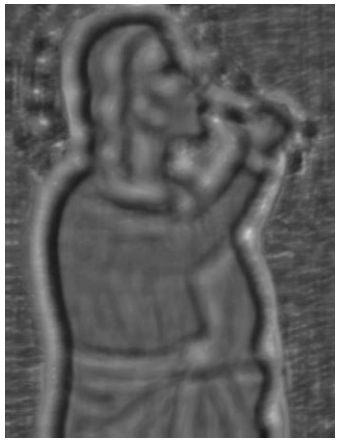
Crack Detection & Inpainting

Cracks form due to a combination of several factors, including moisture and wood distortion. The image is convolved with multiple edge detecting kernels to extract crack-like features. Hysteresis thresholding algorithm is applied to classify each pixel. Open-source image editing software (GIMP & G'Mic) inpaints the crack pixels

Color Mapping

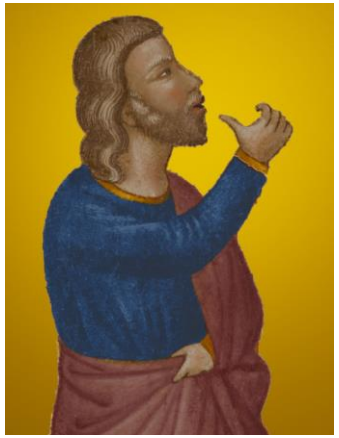
Original colors used in the paintings lose their vibrancy with age. Color mapping procedure restores an image to the artist's intended color choice. Principle Component Analysis (PCA) locates the central colors of each segment and transforms them across the entire image.

Punchmark Detection



Gold leaf on the background of the painting was indented with small ornaments. In order to render the gold foil, every indentation must be located. Punchmark-detecting filters return bright white marks where the best matches are found. Halos are automatically located and masked for more efficient punchmark detection

Gilding & 3D Rendering



Medieval paintings utilized thin layers of gold leaf to highlight the background. Gilded background fades with time and loses its luster. Open-source 3D rendering software (Blender) creates a gold texture and animates the light source for more authentic visualization