Image Source Separation with Multi-Modal Side Information

Reconstruction of Concealed Content in Artworks

Graduate

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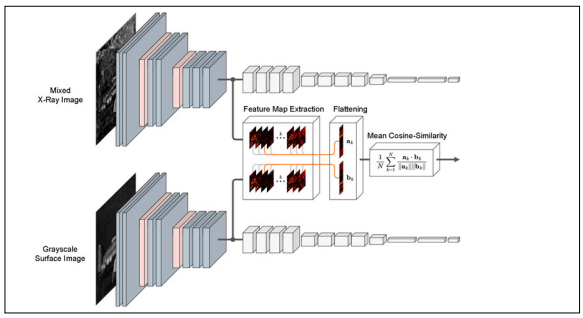
Introduction: Uncovering hidden designs in paintings offers valuable insights into artists' creative processes, material choices, and historical contexts. This thesis focuses on Paul Cézanne's Still Life with Bread and Eggs (1865), where X-ray imaging in 2022 revealed a concealed portrait beneath the visible layers. By employing advanced image separation techniques, the goal is to separate the underlayer composition from the upper painting, potentially uncovering whether the portrait depicts Cézanne himself or another individual, shedding light on its significance and context of the hidden composition.

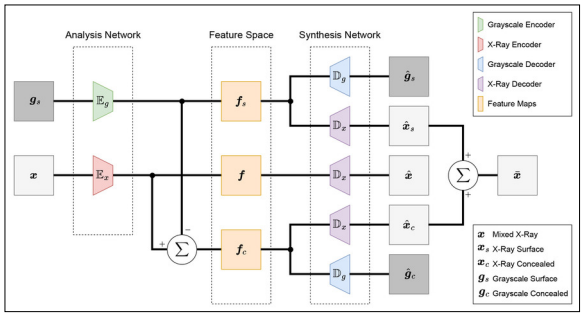
Approach: The X-ray image can be modeled as a linear superposition of two components: the visible surface painting and the concealed hidden design. The objective is to develop methods to separate these components, revealing the hidden design while preserving surface information. This problem falls under Blind Source Separation, where the original sources are recovered without direct access. The colored (RGB) surface image serves as side information, leveraging its correlation with the X-ray image to guide the separation process. Preprocessing involves removing the wooden frame from the mixed X-ray image using classical image processing techniques. Three methods are developed and evaluated: a linear filter as a baseline, an optimization-based iterative approach, and a coupled dictionary learning method inspired by state-of-the-art research. The coupled dictionary learning approach utilizes a self-supervised separation network with a novel image similarity measure. VGG16, a deep convolutional neural network pretrained on image recognition tasks, is used to extract feature maps from both image domains. These feature maps are then compared using cosine similarity to guide the separation process.

Result: The mixed X-ray image was successfully separated, providing improved visualization of the concealed parts. The novel feature space similarity measure greatly improved output sharpness over the edge-map correlation used in previous studies. This work lays a foundation for further research, including potential recolorization of the hidden image.

Feature Space Similarity Measure Based on VGG16 Architecture
Own presentment

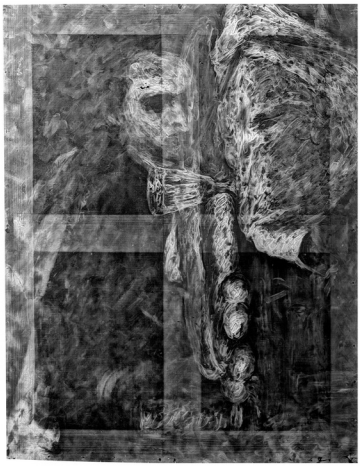


Coupled Dictionary Learning-Based Image Separation Network
Own presentment

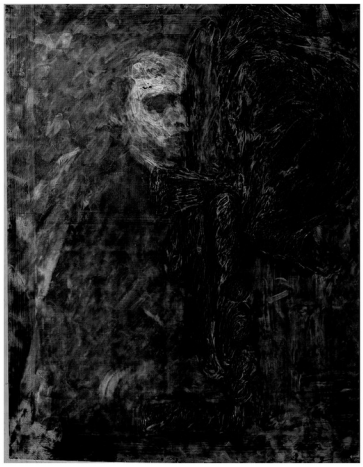


Still Life with Bread and Eggs (1865), Paul Cézanne: RGB Surface Image, Mixed X-Ray Image, and Separated Concealed Image
Own presentment

RGB Surface Image



Mixed X-Ray Image



Separated Concealed Image

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