

Inpainting The Colors

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Colorization Background

- ❖ **Colorization** is any process that adds color to black-and-white or monochrome still/moving images.
- ❖ Application:
 - Image Editing
 - Image compression
- ❖ Computerized colorization began in the 1970s with a process developed by Wilson Markle
- ❖ Problem: soft contrast and fairly pale, flat, washed out images

Colorization Background

❖ Colorization

- Based on Segmentation
 - Fuzzy edges segmentation
 - Object tracking (Foreground/Background Method)
- Base on scribble



Colorization Background

- ❖ Example-based methods
- ✓ Transferring color to grayscale images (Welsh et al. 2002)

Shortcoming: spatial coherence

Convert source image to decorrelated $l\alpha\beta$ color space

- l : luminance
- α, β : chromatic channels (yellow/blue and red/green)
 - Perform luminance remapping (histogram matching)
 - Take ~ 200 color samples from the source image
 - For each pixel in the target image (in scanline order):
 - Find best matching source pixel (compare luminance and std. dev. of luminance values in neighborhood)
 - Transfer color from source pixel to target pixel

Colorization Background

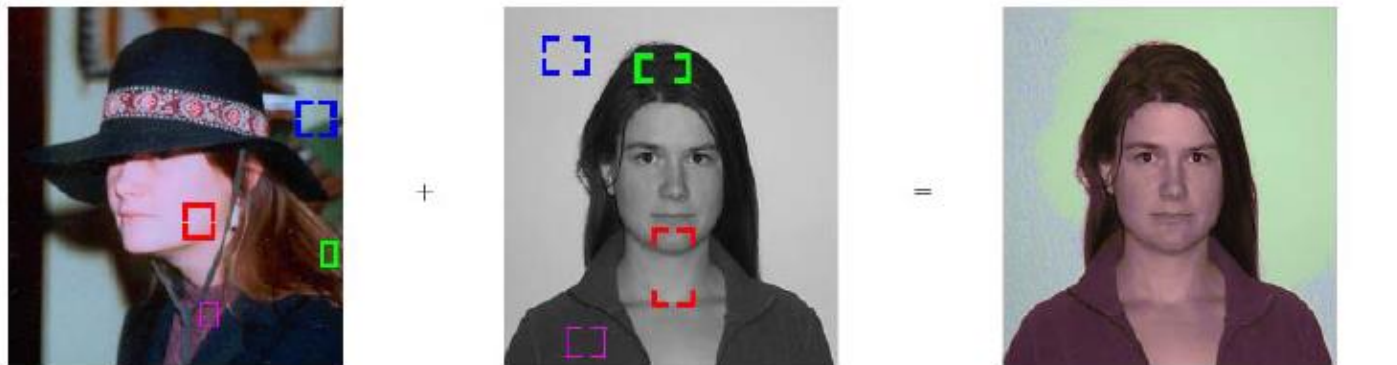
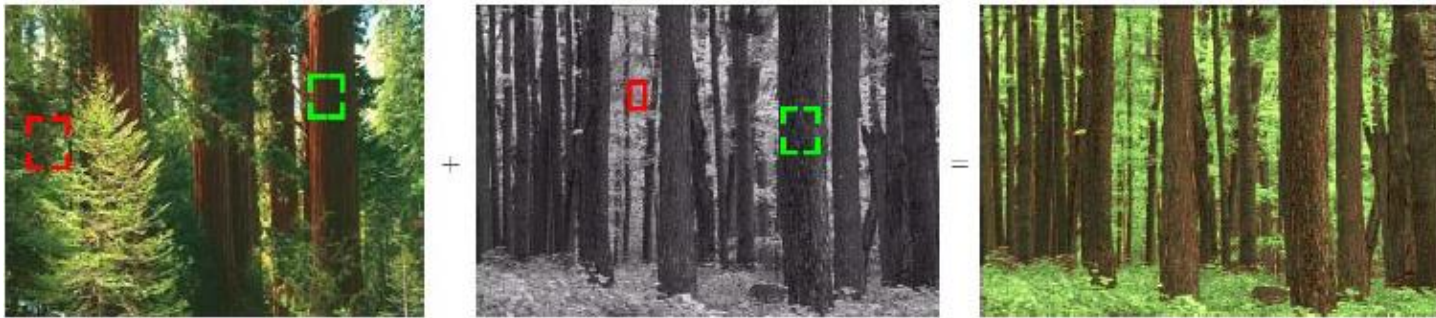


- ❖ Global procedure fails when corresponding colors don't have corresponding luminance values



Colorization Background

- ✓ Colorization by example (Irony et al. 2005)



Colorization Background

Stroke-based methods

- ✓ Colorization using optimization (Levin et al. 2004)



- Shortcomings: color leaking, too many strokes required for textured images

Colorization Background

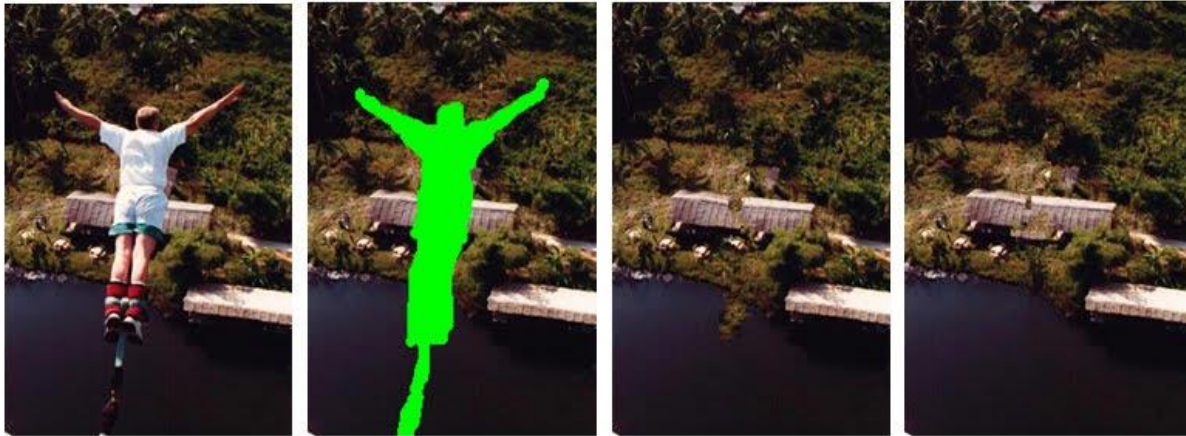
- ✓ Natural image colorization (Qing et al. 2007)
 - Handle images with non-contiguous textures
 - The user draws strokes indicating regions that (roughly) share the same color
 - Strokes are used for automatic texture segmentation
 - The user selects color for a few pixels in each region
 - Color is transferred automatically based on segmentation and selected colors

Colorization Background



Inpainting Background

- ❖ Inpainting is the process of reconstructing lost or deteriorated parts of images and videos.
 - ❖ Restoration
 - ❖ Editing/Image Blending



Inpainting Methods

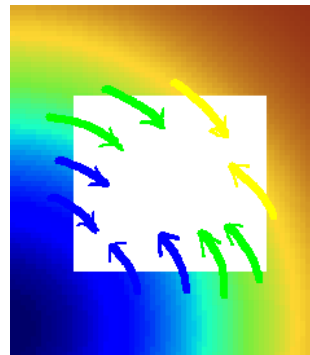
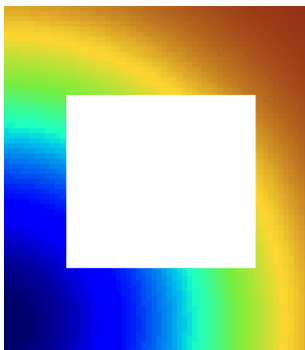
- ❖ Optimization base methods
 - Smooth propagation
- ❖ Propagation information
- ❖ Evolutionary form

θ = normalized gradient $\Rightarrow \theta \cdot \nabla I = \|\nabla I\|$

$$\min(I) \int_{\Omega Y Band} \|\nabla I\| - \theta \cdot \nabla I \, d\Omega$$

$$\nabla L \cdot \vec{N} = 0$$

$$\frac{\partial I}{\partial t} = \nabla L \cdot \vec{N}$$



Inpainting The Colors

- ❖ Main Idea is looking at colorization as an inpainting problem
- ❖ Chung and Sapiro have shown that the (scalar) luminance channel faithfully represents the geometry of the whole (vectorial) color image.(Edges)
- ❖ We work in Y Cb Cr
 - ❖ Y represented By intensity levels of grayscale image.
 - ❖ Changes in Cb and Cr will prepare the correct color.

Inpainting The Colors

$$Y(x, y) : \Omega \rightarrow \mathbb{R}^+$$

$$Cb(x, y) : \Omega \rightarrow \mathbb{R}^+$$

$$Cr(x, y) : \Omega \rightarrow \mathbb{R}^+$$

$$|\Omega_c| \ll |\Omega|$$

$$\min_{Cb} \int_{\Omega} \rho(\|\nabla Y - \nabla Cb\|) d\Omega$$

$$\Delta Cb = \Delta Y$$

$$\Delta := \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \right) \quad \nabla := \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y} \right)$$

Poisson Eq. Dif./Sol.

Poisson Equation:

$$\Delta\varphi = f$$

In Euclidean space:

$$\nabla^2\varphi = f$$

Cartesian space:

$$\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right)\varphi(x, y, z) = f(x, y, z)$$

Discrete Poisson: $(\nabla^2 u)_{ij} = \frac{1}{dx^2}(u_{i+1,j} + u_{i-1,j} + u_{i,j+1} + u_{i,j-1} - 4u_{ij}) = g_{ij}$

$$2 \leq i \leq m - 1 \text{ and } 2 \leq j \leq n - 1$$

Poisson Eq. Matrix:

$$[A][U] = [b]$$

$$[U] = [u_{11}, u_{21}, \dots, u_{m1}, u_{12}, u_{22}, \dots, u_{m2}, \dots, u_{mn}]^T$$

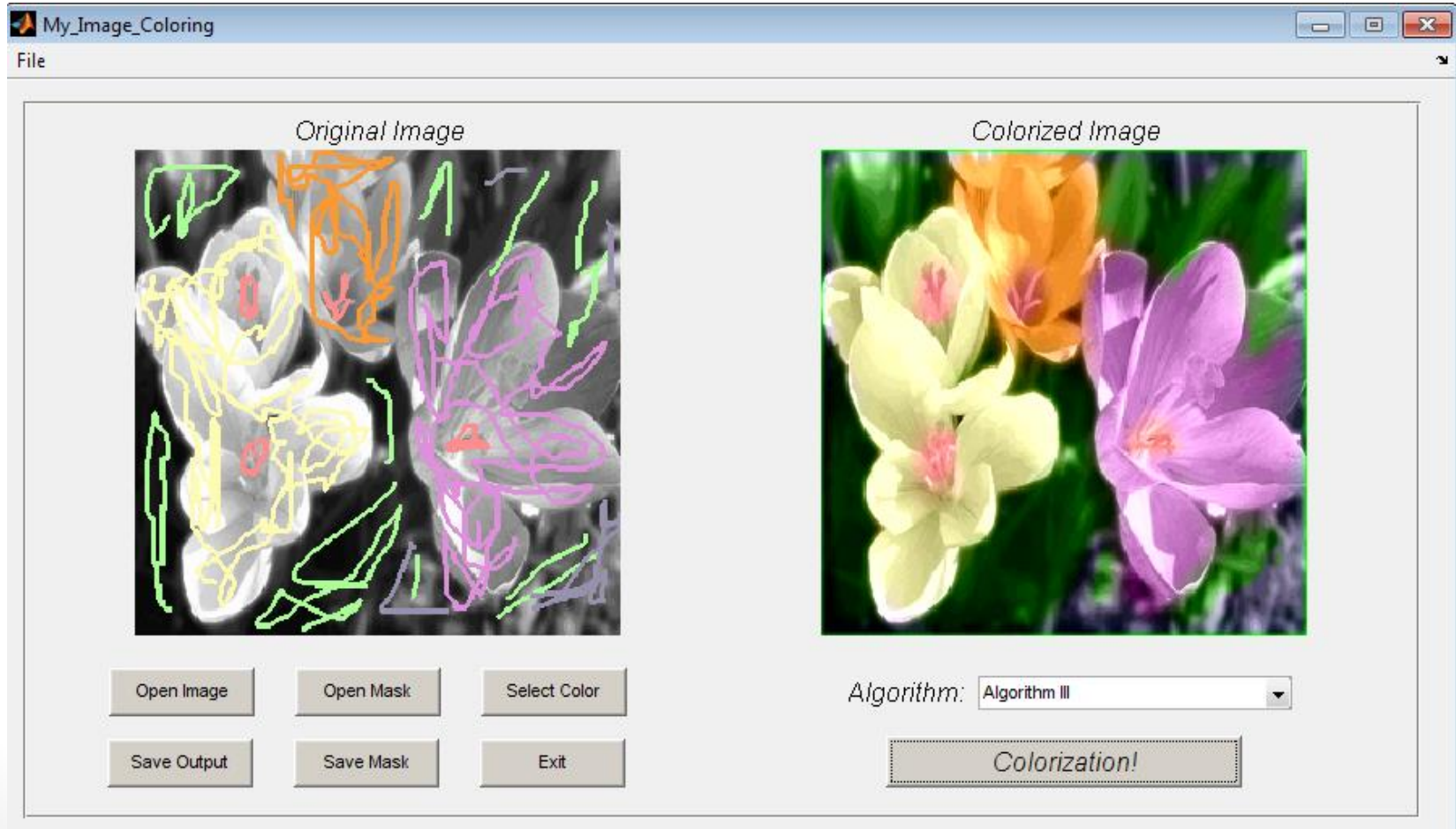
Poisson Eq. Dif./Sol.

$$A = \begin{bmatrix} D & -I & 0 & 0 & 0 & \dots & 0 \\ -I & D & -I & 0 & 0 & \dots & 0 \\ 0 & -I & D & -I & 0 & \dots & 0 \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ 0 & \dots & 0 & -I & D & -I & 0 \\ 0 & \dots & \dots & 0 & -I & D & -I \\ 0 & \dots & \dots & \dots & 0 & -I & D \end{bmatrix}_{mn \times mn}$$
$$D = \begin{bmatrix} 4 & -1 & 0 & 0 & 0 & \dots & 0 \\ -1 & 4 & -1 & 0 & 0 & \dots & 0 \\ 0 & -1 & 4 & -1 & 0 & \dots & 0 \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ 0 & \dots & 0 & -1 & 4 & -1 & 0 \\ 0 & \dots & \dots & 0 & -1 & 4 & -1 \\ 0 & \dots & \dots & \dots & 0 & -1 & 4 \end{bmatrix}_{m \times m}$$

$$U = b/A$$

❖ Scribbles are our Dirichlet boundaries.

Results




Results


My_Image_Coloring

File

Original Image



Colorized Image



Open Image Open Mask Select Color

Save Output Save Mask Exit

Algorithm: Algorithm III

Colorization!

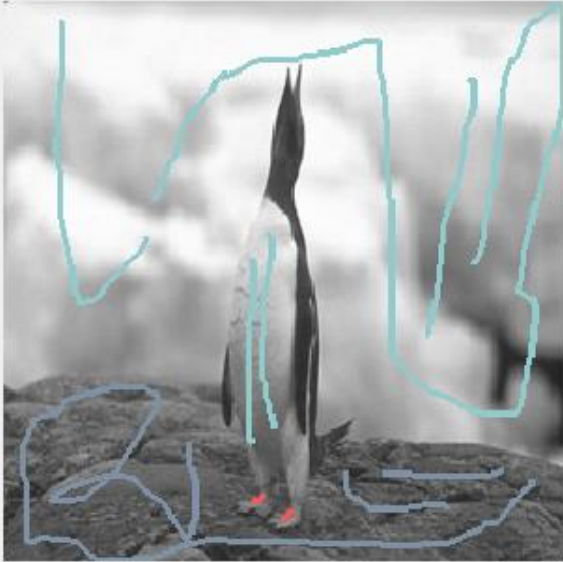
The image shows a software window titled "My_Image_Coloring" with a "File" menu. It displays two side-by-side images of Marilyn Monroe. The left image, labeled "Original Image", is a grayscale version with a yellow and orange mask overlay. The right image, labeled "Colorized Image", is the same image with color applied and a green border. Below the images are several control buttons: "Open Image", "Open Mask", "Select Color", "Save Output", "Save Mask", and "Exit". To the right of the "Colorized Image" is a dropdown menu for "Algorithm:" set to "Algorithm III" and a large "Colorization!" button.

Results


My_Image_Coloring

File

Original Image



Colorized Image



Open Image Open Mask Select Color

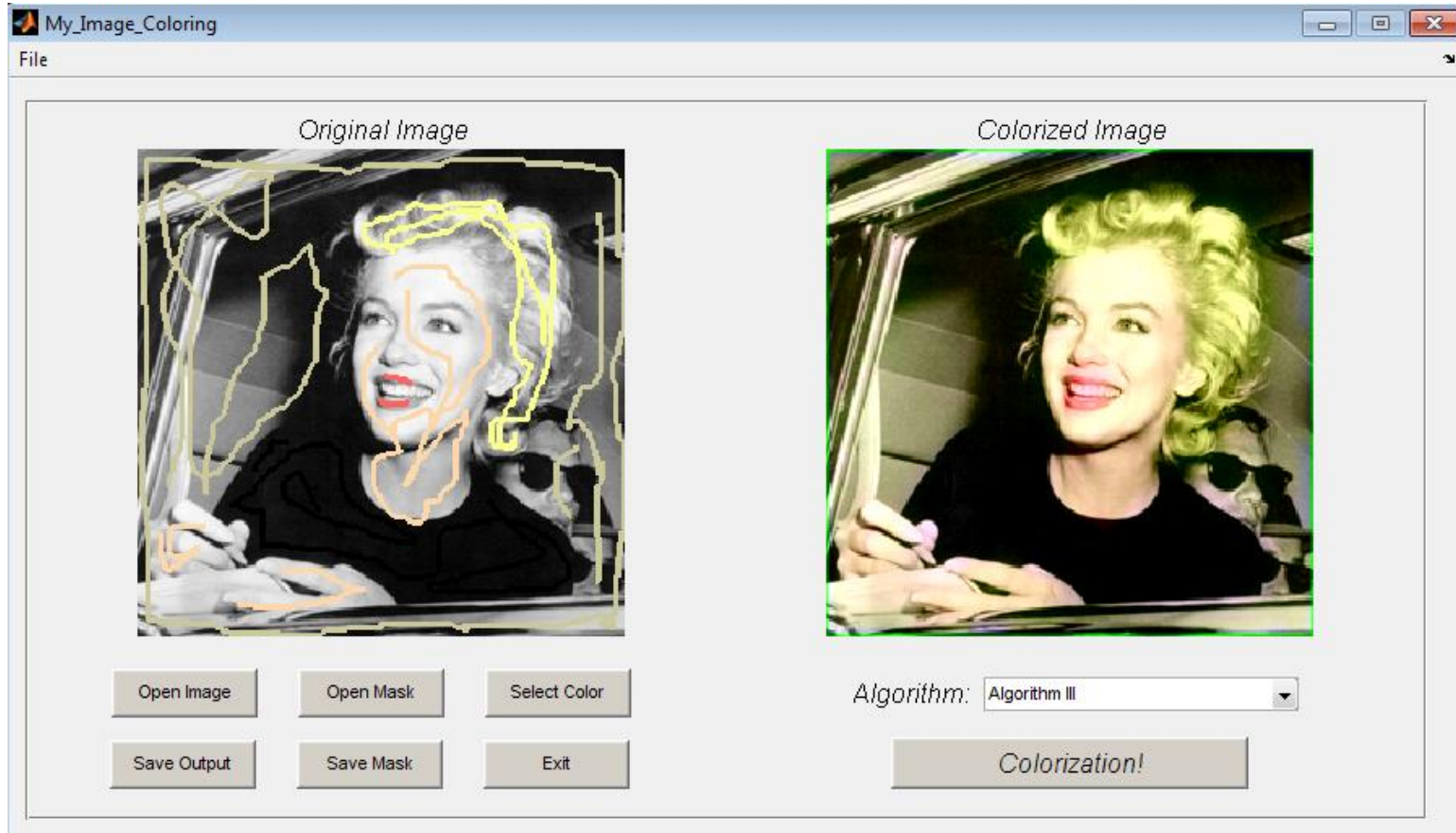
Save Output Save Mask Exit

Algorithm: Algorithm III

Colorization!

The image shows a software interface for image coloring. It features two main panels: 'Original Image' and 'Colorized Image'. The 'Original Image' panel displays a grayscale photograph of a penguin standing on a rock, with cyan-colored outlines indicating segmentation masks. The 'Colorized Image' panel shows the same penguin, but with the segmentation masks colored in green and red. Below the 'Original Image' panel are six buttons: 'Open Image', 'Open Mask', 'Select Color', 'Save Output', 'Save Mask', and 'Exit'. To the right of the 'Colorized Image' panel is a dropdown menu labeled 'Algorithm:' with 'Algorithm III' selected, and a button labeled 'Colorization!'.

Results



Results

My_Image_Coloring

File

Original Image

Colorized Image

Open Image

Open Mask

Select Color

Save Output

Save Mask

Exit

Algorithm: Algorithm III

Colorization!