

# Colorization Using Optimization

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## Abstract

Colorization is a computer-assisted process of adding color to a monochrome image or movie. The process typically involves segmenting images into regions and tracking these regions across image sequences. Neither of these tasks can be performed reliably in practice; consequently, colorization requires considerable user intervention and remains a tedious, time-consuming, and expensive task.

In this paper we present a simple colorization method that requires neither precise image segmentation, nor accurate region tracking. Our method is based on a simple premise: neighboring pixels in space-time that have similar intensities should have similar colors. We formalize this premise using a quadratic cost function and obtain an optimization problem that can be solved efficiently using standard techniques. In our approach an artist only needs to annotate the image with a few color scribbles, and the indicated colors are automatically propagated in both space and time to produce a fully colorized image or sequence. We demonstrate that high quality colorizations of stills and movie clips may be obtained from a relatively modest amount of user input.

- [Still image colorization examples](#)
- [Progressive colorization example](#)
- [Recoloring examples](#)
- [Video clip colorization examples](#)
- **Note:** The camera ready version of the paper can be downloaded [here](#).
- Matlab code of our algorithm can be downloaded [here](#).

## Still Image Colorization Examples:

Click the images for uncompressed bitmaps.



Marked B/W image



Result



Marked B/W image



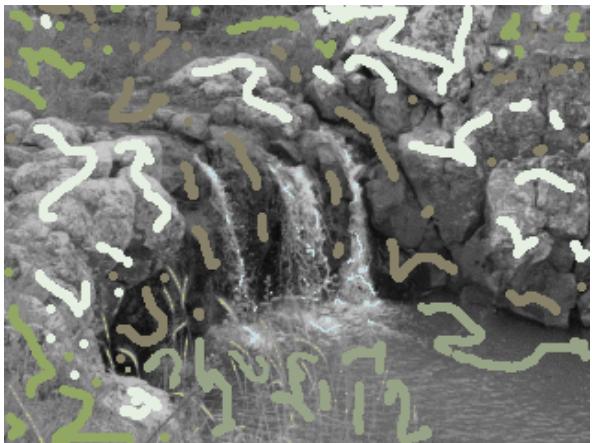
Result



Marked B/W image



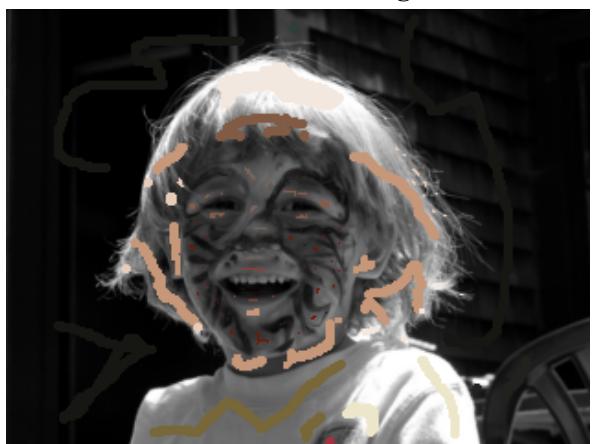
Result



Marked B/W image



Result



**Marked B/W image****Result**

## Progressive colorization:

**a1 - Initial set of scribbles****b1 - Scribbles have been added on the table cloth and the wall.****c1 - A few red pixels have been marked on the beads.****a2 - Initial result. Note that the table cloth gets the pink color of the girl's dress. Also, there is a cyan color spill from the pacifier on the wall behind.****b2 - Second result. Problems visible in a2 have been fixed.****c2 - Final result. We now have a string of red beads.**

## Recoloring Examples:

Click the images for uncompressed bitmaps.



Input image



Marked image



Result



Input image



Marked image



Result



Input image



Marked image



Result



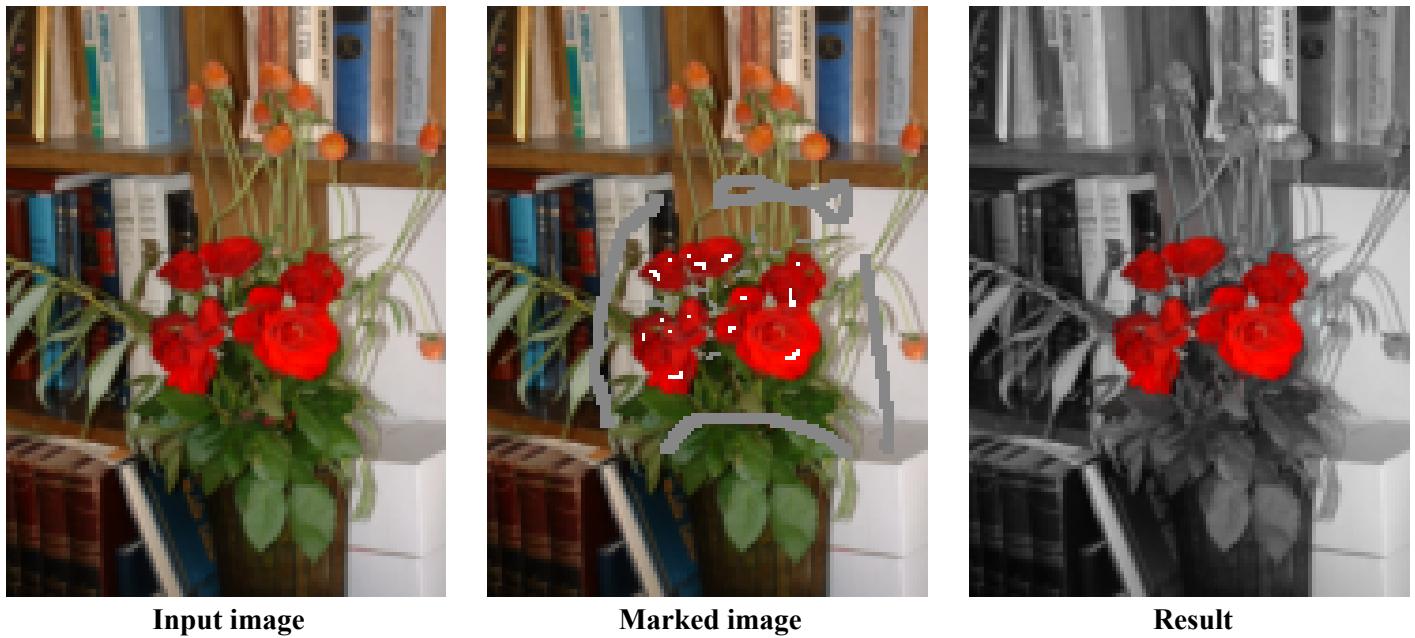
Input image



Marked image



Result



## Video Clip Colorization Examples:

The animated GIFs below use 8 bit color. For better color quality please play the QuickTime MPEG-4 movies.



**Clip 2: Toddler.**  
43 frames, 5 marked frames  
[Click here for a QuickTime MPEG-4 movie.](#)



Input grayscale clip



Marked frames



Colorized result

**Clip 3: Birthday.**  
62 frames, 10 marked frames  
[Click here for a QuickTime MPEG-4 movie.](#)



Input grayscale clip

**Marked frames****Colorized clip****Clip 4: Driving.****33 frames, 9 marked frames**[Click here for a QuickTime MPEG-4 movie.](#)**Input grayscale clip****Marked frames****Colorized clip**