

BBM 415 - Fundamentals of Image Processing



HACETTEPE UNIVERSITY

Department of Computer Engineering

Problem Set 1

Fall '2016-2017

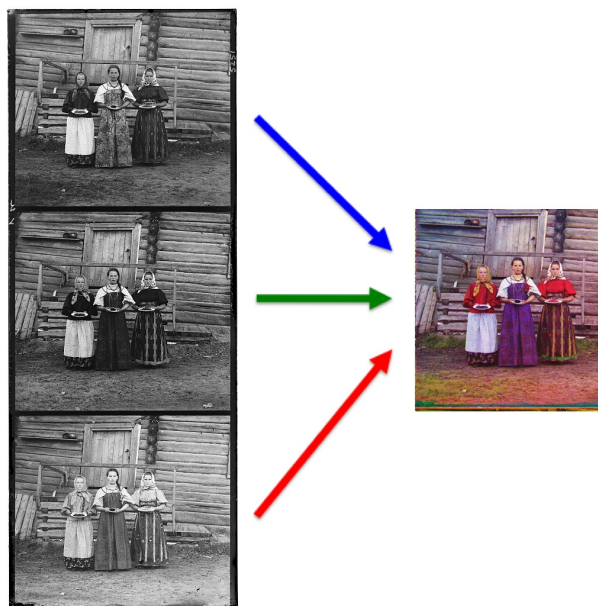
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Images of the Russian Empire: Colorizing the Prokudin-Gorskii photo collection¹

Due: 23:59 October 27, 2016



Background

Sergei Mikhailovich Prokudin-Gorskii (1863-1944) [1], a Russian chemist and photographer, is considered as a pioneer in color photography. With Tsar's special permission and funding, he traveled across the Russian Empire, and took color photographs of people, daily life, buildings, landscapes, etc., documenting the early 20th-century Russia. He produced these color photographs by using a simple but ingenious idea: recording three exposures of every scene onto a glass plate using a blue, a green, and a red filter. These negative plates is now in possession by the Library of Congress of U.S.A., and have been recently digitized. They are available on-line at [2].

Overview

The goal of this assignment is to automatically produce color images from the digitized Prokudin-Gorskii glass plate images by applying some simple image processing techniques. For that, you will need to extract the red/green/blue color channels from the digitized plate images, and find the best alignment so that they form an RGB color image with few visual artifacts. You can download a starter code and some sample plate images from the course webpage.

¹Credits: This assignment is a simplified version of the one that Alexei A. Efros developed for his Computational Photography class.

Details

Your program will take a glass plate image as input and produce a related color image as output. It should have the following structure:

1. Divide the input image into three equal parts corresponding to RGB channels.
2. Align the second and the third parts (G and R channels) to the first one (B channel).

The simplest strategy to align the parts is to perform an exhaustive search over a window of possible displacements (e.g. [-15,15] pixels), and take the displacement that gives the best matching score. Some possible matching metrics are as follows:

- Sum of squared differences (SSD) ($\text{sum}(\text{sum}((\text{image1}-\text{image2}).^2))$)
- Normalized cross-correlation (NCC) (see Matlab function `normxcorr2`)

3. Improve the quality of the aligned image.

Even if you've find a nearly correct alignment, the resulting color image may have a poor quality, *i.e.* it may suffer from low or high contrast, or the colors may not be so vivid. You can enhance the contrast of the images by applying Laplacian filtering, gamma correction, and histogram equalization, or a combination of those. Additionally, you can choose to work on a different color space, *e.g.* HSV color space (see Matlab function `rgb2hsv`), and accordingly manipulate the appropriate channels to obtain a more brighter image.

Some important remarks:

- Recall that the color filter order from top to bottom is BGR, not the typical RGB.
- Assume that the negatives are evenly divided into 3 plates (*i.e.*, each plate is in exactly 1/3 of the negative).
- Assume that a simple x,y translation model is sufficient for proper alignment.
- In Matlab, you can easily shift a matrix by using `circshift` function.
- For a better matching score, you may ignore the image borders and use only the internal pixels.
- You can devise and utilize an algorithm to automatically crop the borders in order to eliminate the artifacts in the boundaries and obtain a better quality result.

Grading

- The assignment will be graded out of 100 : Code + Report
- The following features will be taken into account while grading:
 - ★ Completeness - does your program implement the whole assignment?
 - ★ Correctness - does your program provide the right output?
 - ★ Programming style (including documentation and program organization) - is the program well designed and easy to understand?
 - ★ Your LATEX report should contain a brief overview of the problem, the details of your approach, and the results of your algorithm on at least 8 negative images with your comments. Show the results of all of the main steps (unaligned result, result after alignment, results of the enhancement). If your algorithm failed to give a satisfactory result on a particular image, provide a brief explanation of the reason(s).

What to Hand In

You are required to submit all your code along with a short report in *LATEX*. For that purpose, prepare a folder containing

- `README.txt` (*text file containing details about your project*)
- `code/` (*directory containing all your code*)
- `report.pdf` (*a report which is prepared with LATEX*)

Archive this folder as `pset1.zip` and submit via <https://submit.cs.hacettepe.edu.tr> .

References

- [1] <http://en.wikipedia.org/wiki/Prokudin-Gorskii>
- [2] <http://www.loc.gov/exhibits/empire/gorskii.html>