Due on 28 January 2024

Computer vision - Assignment 1

In this assignment, the goal is to get started with basic image operations in OpenCV.

Additionally, we will have some fun finding the blind spots in our eyes and look at some optical illusions to increase our general knowledge about how the human visual system works.

1. Download the image CinqueTerre.jpg. Read it using OpenCV and perform the following operations.
   (a) Find and store the size and number of channels of the image.
   (b) For many computer vision and image processing tasks, you should be comfortable with accessing sub-regions of an image. Your task is to extract 50×50 image sub-regions from the **top-right** as well as the **bottom left** and store them in the variables subimg1 and subimg2 respectively. After you successfully extract subimg1 and subimg2 images, compute the SSD (Sum of Squared Differences) of the intensities between them and store in the variable SSD.

2. Aligning the 3 channels of the Prokudin-Gorskii Photo Collection:
   Sergei Mikhailovich Prokudin-Gorskii (1863-1944) was a man well ahead of his time. Convinced, as early as 1907, that color photography was the wave of the future, he won Tzar's special permission to travel across the vast Russian Empire and take color photographs of everything he saw. And he really photographed everything: people, buildings, landscapes, railroads, bridges... thousands of color pictures! His idea was simple: record three exposures of every scene onto a glass plate using a red, a green, and a blue filter. Never mind that there was no way to print color photographs until much later — he envisioned special projectors to be installed in "multimedia" classrooms all across Russia where the children would be able to learn about their vast country. Alas, his plans never materialized: he left Russia in 1918, right after the revolution, never to return again. Luckily, his RGB glass plate negatives, capturing the last years of the Russian Empire, survived and were purchased in 1948 by the Library of Congress. The LoC has digitized the negatives and made them available online. The glass plate negatives contain three color channel images.

   For this assignment we have chosen one of his images, monastery.jpg. Download this image, split the image into three parts to extract the channels. The first channel is the blue channel, followed by the green channel, and the red channel. Keep the blue channel fixed and align the green and red channels to the blue channel in the following way:

   (a) To compute the best alignment between two channels, "slide" one image over the other i.e. search over a window of possible displacements say $[-10, 10]$ pixels, score each one using an image matching metric such as SSD, and take the displacement with the best score.
   (b) What is your best SSD value and displacement vector for each channel?
   (c) Once you find the best alignment between the channels, merge the 3 channels to get a coloured image.
   (d) Display the coloured image.

3. Prove geometrically that the projections of two parallel lines lying in some plane Φ appear to converge on a horizon line h formed by the intersection of the image plane Π with the plane parallel to Φ and passing through the pinhole.

4. Derive the perspective equation projections for a virtual image located at a distance d *in front* of the pinhole.

5. Visit
   `https://www.mentalfloss.com/article/514964/10-award-winning-optical-illusions-and-brain-puzzles`
   Browse through the illusions and try to understand how each of them works.

List 2 of your favourite illusions and explain in short why each of them works (This will be graded). Can you try to come with an illusion? (This part will not be graded.)

You can find more here: `https://www.insider.com/best-optical-illusions-photos-2017-10`.

6. (No submission required for this exercise) Figure out the blind spot in your eye, i.e. the spot on the retina where the optic nerve leaves the eyeball. You can do it in the following way:

   (a) On a piece of paper, make a small dot with a black marker.

   (b) About six to eight inches to the right of the dot, make a small plus sign (+).

   (c) With your right eye closed, hold the paper about 20 inches away from you.

   (d) Focus on the plus sign with your left eye, and slowly bring the paper closer while still looking at the plus sign.

   At some point, the dot will vanish from your sight. This is the blind spot of your retina. If you close your left eye and look at the dot with your right eye, and repeat the process, the plus sign should disappear in the blind spot of your other eye.