The Intro to Computer Vision labs will be run in Google Colaboratory, a Jupyter notebook environment that runs entirely in the cloud, you don't need to download anything. To run these labs, you must have a Google account.

Step 1: click on the assignment invite link -> **Accept this assignment**. Refresh page -> individual repo for the specific assignment is created automatically

Project 2: 2 weeks
https://classroom.github.com/a/2qgjpVCx

Step 2: Navigate to http://colab.research.google.com/github -> Click the **Include Private Repos** checkbox -> **select the correct repo** (SistemeDeVedereArtificiala/assignment_name-student_name) -> Click on the jupyter notebook of the current assignment

Step 3: [GitHub sign-in window] In the popup window, sign-in to your Github account and authorize Colab to read the private files.

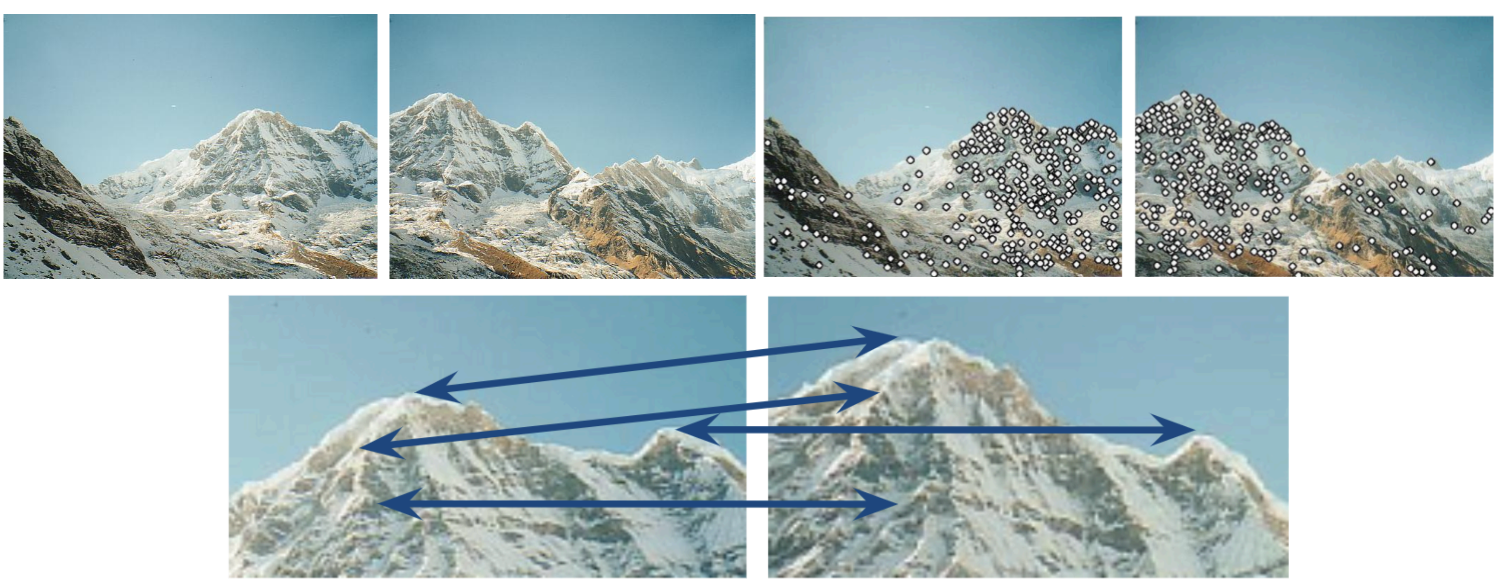
Step 4: [in colab] **File** -> **Save a copy to GitHub**. Select the correct repository for the SPECIFIC assignment -> Click the **Include Colab Link** -> Click **OK**

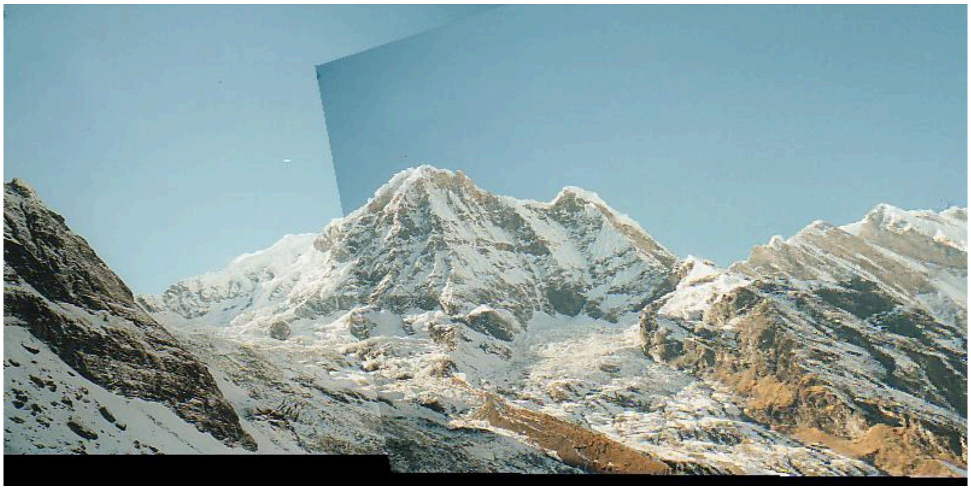
Step 5: [in colab] Navigate to the **Runtime** tab --> **Change runtime type**, under **Hardware accelerator** select **GPU/TPU** (tensor processing unit) according to your needs.

Read the suggestions and accomplish all tasks marked with **#TODO**.

!!! At the end of each laboratory **REPEAT step 4 in order to SAVE** the answers to your private repository (individual for each assignment)

Project 3: Image Stitching

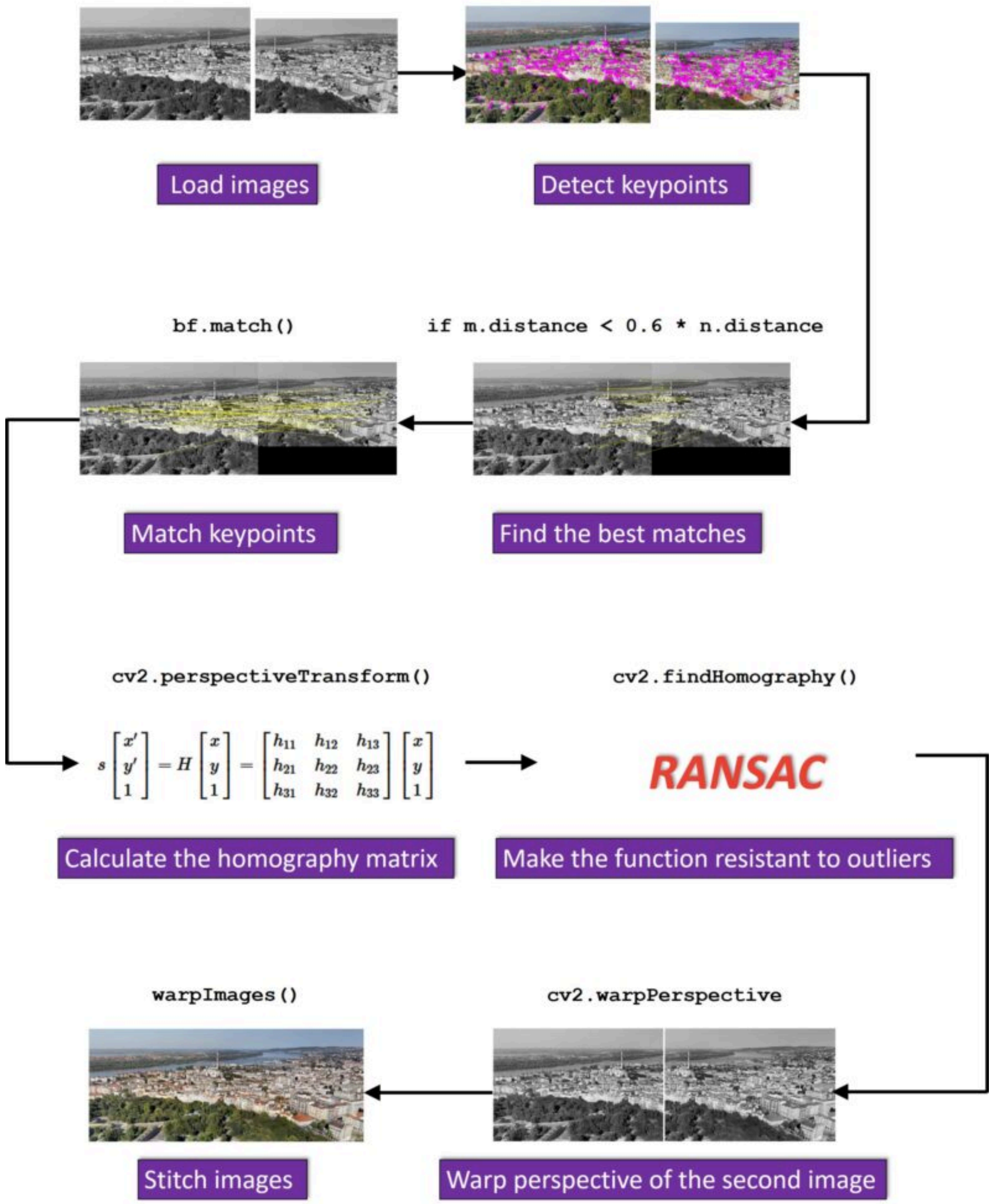




Week 2: RANSAC & perspective transform for image stitching

The process of creating a panoramic image consists of the following steps:

1. Detect keypoints and descriptors (done last week)
2. Detect a set of matching points that is present in both images - overlapping area (done last week)
3. **Apply the RANSAC method to improve the matching process detection (to do)**
4. **Apply perspective transformation on one image using the other image as a reference frame (to do)**
5. **Stitch images together (to do)**



What is a homography matrix?

In the field of computer vision, any two images of the same scene are related by a homography. It is a transformation that maps the points in one image to the corresponding points in the other image. The two images can lay on the same surface in space or they are taken by rotating the camera along its optical axis. The essence of the homography is the simple 3x3 matrix called the homography matrix.

$$H = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix}$$

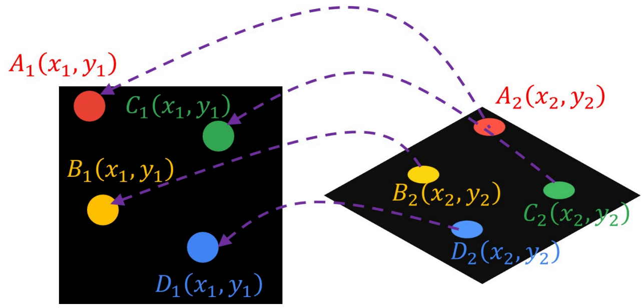
We can apply this matrix to any point in the image. For example, if we take a point A(x1,y1) in the first image we can use a homography matrix to map this point A to the corresponding point B(x2,y2) in the second image.

$$s \begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = H \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Now, using this technique we can easily stitch our images together. It is important to note that when we match feature points between two images, we only accept those matches that fall on the corresponding epipolar lines. We need these good matches to estimate the homography matrix. We detected a large number of keypoints and we need to reject some of them to retain the best ones.

As we already explained this 3x3 matrix will be used to transform the second image to have the same perspective as the first one which will be kept as the reference frame. Then, we will extract information about the transformation of the second image and use that information to align the second image with the first one.

To find this transformation matrix, we need to extract coordinates of a minimum of 4 points in the first image and corresponding 4 points in the second image. These points are related by homography so we can apply a transformation to change the perspective of the second image using the first image as a reference frame. In the following image, you can see an example of this transformation.



RANdom SAmple Consensus (RANSAC)

- An example of a "voting"-based fitting scheme
- Each hypothesis gets voted on by each data point, best hypothesis wins
- There are many other types of voting schemes
  - Hough transforms

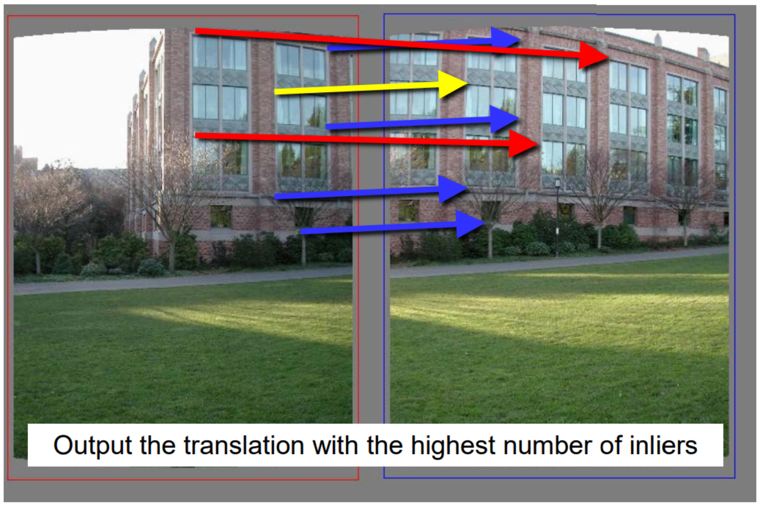
General version:

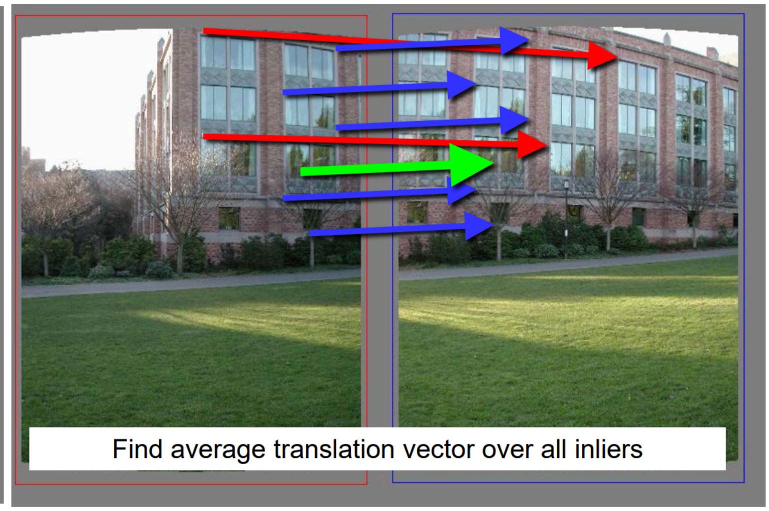
1. Randomly choose s samples
   Typically s = minimum sample size that lets you fit a model
2. Fit a model (e.g., line) to those samples
3. Count the number of inliers that approximately fit the model
4. Repeat N times
5. Choose the model that has the largest set of inliers

Idea:

1. Given a hypothesized line
2. Count the number of points that "agree" with the line
   a. "Agree" = within a small distance of the line
   b. I.e., the inliers to that line
3. For all possible lines, select the one with the largest number of inliers

Note: All the inliers will agree with each other on the translation vector; the (hopefully small) number of outliers will (hopefully) disagree with each other.





Further study at:

1. Computer Vision: Algorithms and Applications, Chapter 6.1.