

CS 484/555  
Spring 2023  
Homework Assignment 2

Due: April, 26th, 23:59

The goal of this assignment is to match objects by comparing their line patterns. In particular, we will try to match books according to the line orientation histograms computed from the images of their covers. We are given a data set of books in which each book has two images.

One of them is the original image of the book cover, and the other one is a rotated version of the cover with respect to an arbitrary angle between 0 and 180 degrees. The goal is to find a match between the original and rotated books, and then, to find the angle of rotation. Fig. 1 shows the original images of 15 books. Fig. 2 shows the rotated images of these books.

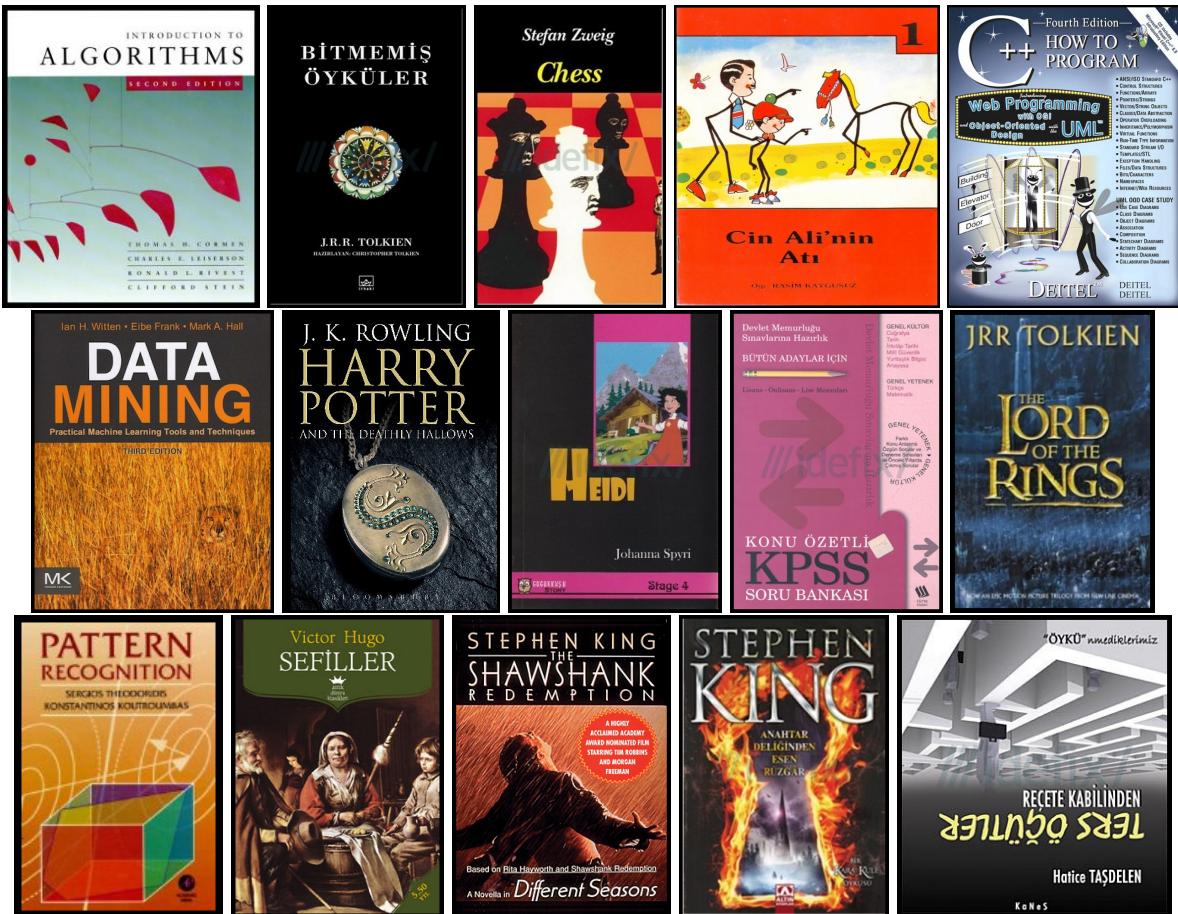


Figure 1: Original book images.



Figure 2: Rotated book images.

The approach can be summarised in terms of the following steps.

- ***The data:*** the images come as two zip files along with the homework assignment. Half of the images belong to the original books, and the remaining belong to the rotated ones.
- ***Perform edge detection:*** run the Canny edge detector on each image after converting it to a greyscale image. The output of this step is a binary edge image that marks pixels that represent a significant change. You have to experiment with the parameters to obtain important edges that will be useful in the following steps. After evaluating different parameter values for a subset of the data set, you must fix them and use the same values for all images. Fig 3 shows some examples.
- ***Perform line fitting to find line segments:*** find straight line segments in the edge detector outputs using Hough transform. After performing the Hough transform, you can find the bins that accumulated the most points in the Hough array. You can play with the minimum number of peaks to find a reasonable number of lines. Fig. 4 shows some examples.
- ***Compute line orientation histograms:*** the orientation values are typically in the range  $[-\pi, +\pi]$ . You can divide this range into uniform bins, and compute a histogram of line orientations weighted by line lengths. That is, a line should contribute to its corresponding bin by its length instead of just 1. You have to experiment with the number of bins to find a good representation.
- ***Find a match and compute the angle of rotation for each rotated book:*** in this step, your task is to find the original book of each rotated book using the orientation histograms. Rotated book histograms can be considered as shifted versions of the corresponding original book histograms. The number of bins in a rotated book histogram that has to be shifted to match the corresponding original book histogram should be approximately proportional to the angle of rotation. Hence, the angle of rotation can be estimated by finding how many bins the second histogram has to be shifted so that the two orientation histograms are similar. The original book of each rotated book can be found by shifting the rotated book histogram to one bin at each iteration and calculating the Euclidean distances between the shifted histogram and the original book histograms. As a result, the original book that results in the minimum Euclidean distance can be a reasonable match. Also, the amount of shift needed can

be used to find the approximate angle of rotation. Note that you should use circular shifts when you compare the histograms.

- Discuss your results: you should discuss the results of each step and compare how the performance is affected by different parameters (i.e., Canny parameters, Hough transform parameters, number of bins).

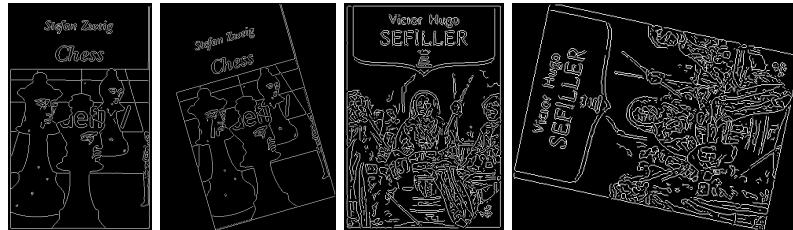


Figure 3: Edges on sample original and rotated images.

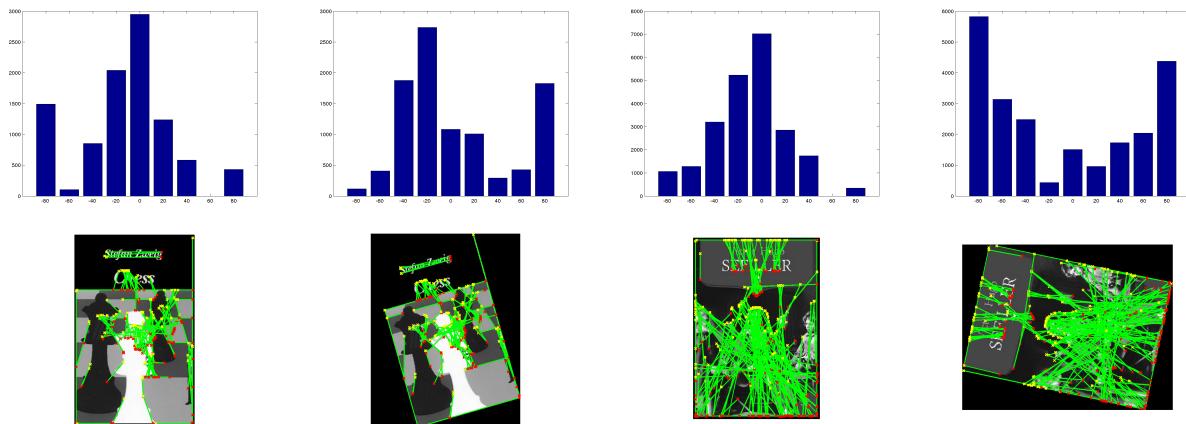


Figure 4: Lines overlayed on sample original and rotated images.

### Submission:

- A report (pdf file) that includes:
  - The results for edge detection for different parameters. You can use edge detection code from other sources but you must cite the source that you used.
  - The results for line detection in which detected lines are overlayed on the original images. You can use Hough transform code from other sources but you must cite the source that you used.
  - Example line orientation histograms. You must provide results for different numbers of bins.
  - Results for matching the rotated books to the original books as well as the estimated rotation angles. You must provide a result for each book, i.e., 15 results. You can provide additional results for different parameter settings.
- A well-documented script that runs the particular sequence of operations and reproduces the result presented in your report for computing the line orientation histogram using the line detection results and for matching the line orientation histograms for different books using circular shifts and Euclidean distances. You must write your **OWN CODE** for this part.

You will upload a SINGLE zip file to Moodle. For any questions, please contact [sepehr@bilkent.edu.tr](mailto:sepehr@bilkent.edu.tr) via email.