Assignment A5: Geometry

CS 4640
Fall 2021

Assigned: 19 October 2021

Due: 28 October 2021

1. Investigate shape boundary segmentation by developing an algorithm to find the cap boundary on the middle bottle and measure its goodness of fit to a cap template using the Procrustes method. This consists of the following steps:

- Create a cap boundary template.
  - Find cap-red pixels (produce a binary image with red areas).
  - Found boundary (use Matlab boundary function);
  - cap template is $nx2$ boundary pixels.
- For every test image:
  - Find red-cap pixels
  - If enough pixels in middle bottle cap area, find boundary.
  - Compute [D,Z,T] using Matlab Procrustes function.
- Implement CS4640_cap_shape function described by the given header.
- Report development process, issues faced, and remaining problems. Provide results on images with middle red cap (by visual inspection). Show results on some examples.

```
function cap = CS4640_cap_shape(im,model)
% CS4640_cap_shape - find cap boundary of middle bottle
% On input:
%     im (MxNx3 array): RGB image
```

```
%     model (nx2 array): cap boundary template points
% On output:
%     cap (MxN array): binary cap boundary image
% Call:
%     cap = CS4640_cap_shape(bot1,cap_model);
% Author:
%     <Your name>
%     UU
%     Fall 2021
%
```

2. Investigate shape registration by developing an algorithm, and the corresponding function CS4640_register, to detect the middle bottle based on a small set of interest points:

1. Determine a set of reference points which can be found consistently in correct images. Describe your points and why you picked them. What is the minimum number of points required? Why? What's a good number of points to use? Why?

2. Given a test image, make sure it will have the interest points, find them, and then solve for the coefficients of the transform. Assume the following general form:

$$x' = ax + by + c$$

$$y' = dx + ey + f$$

where (x, y) the interest point location in the model, and (x', y') is the interest point location in the test image, and a, b, c, s, d, e, f are the coefficients. Create the helper function CS4640_create_linear_system to produce the linear system from the reference and transformed points.

3. Create an image which has a gray level version of the test image as the base image, with overlayed red marker for the transformed model point locations (i.e., $\{(x', y')\}$ transformed points).

4. Discuss the development process for this, the issues encountered, and any remaining problems. Report results on all dataset images that satisfy the interest point criteria.

```
function [imo,C] = CS4640_register(im,ref)
% CS4640_resgister - use reference points to register model to image
% On input:
```

```
%     im (MxNx3 array): RGB image
%     ref (nx2 array): reference point locations
% On output:
%     imo (MxN array): gray level version of im overlayed with model
%     points
%     C (6x1 vector): coefficients of transform (a,b,c,d,e,f)
%         x' = ax + by + c
%         y' = dx + ey + f
% Call:
%     [imo,C] = Cs4640_register(bot1,ref);
% Author:
%     <Your name>
%     UU
%     Fall 2021
%


function [A,b] = CS4640_create_linear_system(pts,ptsp)
% CS4640_create_linear_system - use pts and transformed pts to get
% system
% On input:
%     pts (Nx2 array): reference points
%     ptsp (Nx2 array): transformed points
% On output:
%     A (2Nx6 array): linear matrix
%     b (2Nx1 vector): constant vector
% Call:
%     [A,b] = Cs4640_create_linear_array(pts,ptsp);
% Author:
%     T. Henderson
%     UU
%     Fall 2021
%
```