EE3206/EE3206E INTRODUCTION TO COMPUTER VISION AND IMAGE PROCESSING

Semester 1, 2013/14

Experiment 2

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1 INTRODUCTION

As in the first experiment, IPL is used here as well. The topics covered are enhancement and feature measurement for object recognition. The ideas covered in the lectures are revised and extended so as to reinforce comprehension of the material. The open-ended nature of some of the experiments and questions will enhance your understanding.

To derive maximum benefit, you should go through the lab sheet before you come for the experiment. If there are topics that you are not familiar with, you should read up the notes or the reference books. Please note the following:

- The experimental work is to be done in the **Vision and Machine Learning Lab** (E4-08-25)**.**
- Bring along a thumb drive for storing the images.
- Use only the **Temp** folder for storing your results, and delete all your files before you leave. Do not try to overwrite the image files that are already in Temp; the system may hang.
- Save results in c:\temp, zip the images and then transfer to your thumb drive. You need not save the test images as they can be downloaded from IVLE.

2 PROCEDURE

2.1 Enhancement

2.1.1 The brightness and contrast settings on the monitor have a significant effect on the appearance of the image being viewed. Load ***lena*** and adjust the brightness and contrast to obtain a good quality, high-contrast image.

2.1.2 Load ***test2 and test3.*** For each image, briefly describe the visual quality, highlight the deficiencies, and relate (where possible) the main features of the histogram to the visual appearance of the image.

2.1.3 In image processing, histogram equalization is an important tool for improving *image contrast*. Perform histogram equalization on ***test2*** to give ***test2a.*** Save ***test2a***. Compare the histogram-equalized image with the original in terms of appearance, histogram, mean gray level and gray-level variance.

2.1.4 Repeat 2.1.3 for ***test3.bmp.***

Q1. Do you think histogram equalization yields a good quality image in the case of ***test2*** *and* ***test3****? Elaborate.*

Q2.Describe some situations in which histogram equalization does not work well.

Q3.Sketch the cumulative histograms of ***test2*** *and* ***test2a.*** *Comment on the results.*

Q4.What is the effect of applying histogram equalization more than once? Explain your answer.

2.1.5 Try using the method of histogram specification to enhance ***test2***. Compare your best result with that obtained by histogram equalization. How does the specified histogram compare with the actual histogram obtained?

2.1.6 Experiment with the enhancement methods under the **Edit** submenu (e.g., contrast and gamma enhancement) on ***test2***. Which method gives the best result? Describe how your enhanced images are better than the original and where they are still deficient.

2.1.7 Sometimes it is advantageous to apply different enhancement techniques to different regions of the same image. Experiment with this approach on ***test2*** and describe the results obtained. (A sub-region of the image, the AOI, may be defined with the mouse.)

2.2 Feature Measurement

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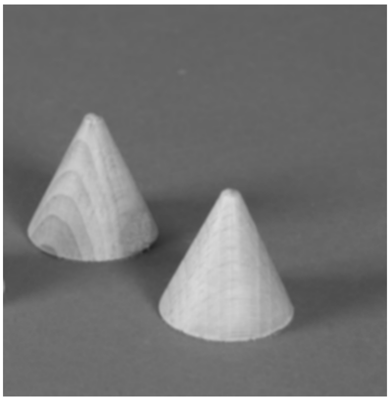
2.2.1 Load ***test4.*** There are two objects, Cone 1 (left) and Cone 2 (right), in this image. What is the threshold T_{opt} that you think is optimum for segmenting both cones? Compare this thresholded image with the one obtained using the intermeans algorithm (threshold T_{im}). Why do you think intermeans thresholding does not work well in this case?



test4.bmp

2.2.2 Threshold ***test4*** using T_{opt}. Use these morphological operations to clean up the image: opening followed by closing with 5×5 structuring elements. Measure these features[1] – perimeter, area, compactness and the moments ϕ_1 and ϕ_2 – for each object. The two cones are identical but their measured features may differ because of different illumination. Comment on how robust (invariant) these features are to different illumination conditions.

[1] Analysis → Feature Measurement → Connected Component, then R-click on component.

2.2.3 Load ***test5***. This is an image of the same objects acquired under different conditions. We are interested in the cone to the right that lying on its side (call it Cone 3). Threshold ***test5*** manually to extract Cone 3, and measure its perimeter, area, compactness and the moments ϕ_1 and ϕ_2. Compare the feature values and those measured in Section 2.2.2.

> *Q5. Object descriptors or features should ideally be somewhat invariant to threshold values. Discuss this with respect to the features and objects (Cones 1, 2 and 3) above.*

2.2.4 The major axis of an object may be computed using image moments. In this case, it is defined as the straight line that goes though the object centroid and makes an angle θ_A with the *x* axis, where θ_A is obtained by solving

$$\tan(2\theta_A) = \frac{2\mu_{11}}{\mu_{20} - \mu_{02}}$$

Obtain the major axis for Cone 3 (in ***test5***) and sketch it on the image. On the same image, sketch the major axis obtained using the definition in the lecture notes.

2.2.5 Repeat Section 2.2.4 using ***test6*** and ***test7***.

2.2.6 Compare and discuss the two definitions of the major axis.

> *Q6. How is the major axis a useful object descriptor in computer vision? Can you describe some other methods of defining the major axis?*

3 REPORT

3.1 Submit the formal report within TEN DAYS of the lab session to the Vision and Machine Learning Lab (E4-08-27). The focus of the report should be on answering the questions and discussing and explaining your observations.

3.2 **Reminder:** The results and report must be your own work. Plagiarism is a serious offence.

Notes on Using IPL

(a) The **active image** is identified by the blue title bar of the image window. Image operations are performed on the active image. The result may be displayed in the same window or a new window, depending on the operation. Clicking the LMB (left mouse button) on the title bar or anywhere in the image window will make this image the active image.

(b) Image operations are generally performed on the pixels within the **area of interest** (AOI). The default area of interest is the entire image. Defining an area of interest is achieved by clicking and dragging with the LMB. If the AOI is very small (e.g., 8×8), it is still shown but the AOI will still be the full image. Clicking the LMB alone will set the AOI to the entire image. The AOI may be defined by using the toolbar box of the IPL window or the Edit menu.

(c) The **image origin** (0, 0) is the top left corner. The *x* axis points across and the *y* axis points down.

(d) The **cursor position** and the gray level are displayed at the bottom status bar.

(e) An **Undo** function (under Edit) will help you recover from errors, but it can only recover one previous operation.

(f) **Clone** (under Edit menu) replicates the image – it is useful, e.g., when you wish to try out different operations on one image.

(g) Gaussian noise is defined by the standard deviation while uniform and Rayleigh noise are defined by the variance.

(h) Do not use the DFT function as it is very slow.

(i) The image histogram and a gray-level profile can be saved as image files.

(j) $$\mathrm{SNR} = 10\log_{10}\left(\frac{\sum\sum f_{\mathrm{ref}}^2(x,y)}{\sum\sum\left[f_{\mathrm{ref}}^2(x,y) - f_t^2(x,y)\right]}\right)$$

where $f_{\mathrm{ref}} = \text{reference image}$ and $f_t = \text{test image}$.