

# Machine Learning and Computer Vision Assignment 1

Huihuang Zheng, huihuang@utexas.edu

hz4674 Fall 2015

## 1 Short Answer Problems

1. Suppose we have filter  $f_1 \in \mathbb{R}^{1 \times n}$ ,  $f_2 \in \mathbb{R}^{n \times 1}$ . We have convolution  $f_1 * f_2 \in \mathbb{R}^{n \times n}$ . Suppose we have a picture  $g$  of  $k \times m$  pixels. Time complexity of performing  $(f_1 * f_2) * g$  is  $O(kmn^2)$ . That's because  $f_1 * f_2 \in \mathbb{R}^{n \times n}$ . But the time complexity of performing  $f_1 * (f_2 * g)$  is  $O(kmn)$ . That's because size of  $(f_2 * g)$  is still  $O(k \times m)$  and performing the  $(f_2 * g)$  needs  $O(kmn)$ . Time complexity of perform  $f_1 * (f_2 * g)$  is  $O(kmn)$ .

**A simple example:**  $f_1 = [1, 2, 1]$ ,  $f_2 = [1, 2, 1]^T$ ,  $g = \begin{pmatrix} 2 & 2 & 2 & 2 & 2 \\ 3 & 3 & 3 & 3 & 3 \\ 4 & 4 & 4 & 4 & 4 \\ 5 & 5 & 5 & 5 & 5 \\ 6 & 6 & 6 & 6 & 6 \end{pmatrix}$ .  $f_1 * f_2 =$

$\begin{pmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{pmatrix}$ . And we let output size equals  $g$ 's size. Performing  $(f_1 * f_2) * g$  needs

$9 * 25$  multiplications. Performing  $h = f_2 * g$  needs  $3 * 25$  multiplications and  $f_1 * h$  needs  $3 * 25$  multiplication.  $f_1 * (f_2 * g)$  needs total  $6 * 25$  multiplications.

2.  $[0, 1, 1, 1, 1, 1, 1, 1]$
3. From filter  $f'$ ,  $[x_1, x_2, x_3, x_4, x_5]$ 's first derivative is  $(x_4 - x_2)/2$ . So second derivative is  $(\frac{x_5 - x_3}{2} - \frac{x_3 - x_1}{2})/2$ . So  $f'' = [\frac{1}{4}, 0, -\frac{1}{2}, 0, \frac{1}{4}]$ .
4. 1. Using higher threshold. 2. When smoothing with Gaussian. Using larger  $\sigma$  value.
5. TODO
6. TODO