CS4243 Recess Review Questions

Question 1 Point Processing

Matching of equations to functions:

1. $x = p + 128$ corresponds to c).
   Since the image is simply brighter and the eyes of the child turn gray instead of black
2. $x = p - 128$ corresponds to a).
   Since the head of the child is completely black after the transformation (was previously < 128).
3. $x = p/2$ corresponds to b).
   Since no values are absolute black (0) just but overall darker.
4. $x = 2p$ corresponds to d).
   By process of elimination.

Question 2 Linear Filtering

(a) The 7×7 box kernel was applied to image b), as it shows rectangular artifacts on the blurred regions, where the original image has a high contrast.

Conversely the 7×7 gaussian kernel as applied to image a), as it does not show these artifacts and is simply a smoother version of the original image.

(b) A separable filter kernel k is one which can be split into two smaller kernels f, g as follows:

$$k = f * g \tag{1}$$

A box filter of size 7 can be written as:

$$k = \frac{1}{49} \begin{bmatrix} 1 & \dots & 1 \\ \vdots & \ddots & \vdots \\ 1 & \dots & 1 \end{bmatrix} = \frac{1}{7} \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix} * \frac{1}{7} \begin{bmatrix} 1 & \dots & 1 \end{bmatrix} = f * g \tag{2}$$

Question 3 Corner Detection

(a) Suitability of the functions for finding corners:

(a) $R = \min(\lambda_1, \lambda_2)$
If the eigenvalues λ_1, λ_2 are both large, their minimum will be as well. This corresponds to large streching in both dimensions of H, corresponding to a large change in the image patch in both directions. In all other cases R is small, corresponding to a small change in the image patch in at least one dimension.

(b) $R = \det(H) - \kappa \cdot (tr(H))^2 = \lambda_1\lambda_2 - \kappa(\lambda_1 + \lambda_2)^2$
If only one eigenvalue is large. Assume w.l.o.g. $\lambda_1 \gg \lambda_2 > 0$:

$$R = \lambda_1\lambda_2 - \kappa(\lambda_1 + \lambda_2)^2 \leq \lambda_1\lambda_2 - \kappa(\lambda_1^2 + 2\lambda_1\lambda_2) \approx -\kappa\lambda_1^2 < 0 \tag{3}$$

However if $\lambda_1 = \lambda_2 \gg 0$:

$$R = \lambda_1\lambda_2 - \kappa(\lambda_1 + \lambda_2)^2 = \lambda_1^2 - 4\kappa\lambda_1^2 \underset{\kappa<1/4}{\approx} \lambda_1^2 > 0 \tag{4}$$

(c) $R = \frac{\det(H)}{tr(H)+\epsilon} = \frac{\lambda_1\lambda_2}{\lambda_1+\lambda_2+\epsilon}$
If only one eigenvalue is large. Assume w.l.o.g. $\lambda_1 \gg \lambda_2 > 0$:

$$R = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2 + \epsilon} < \frac{\lambda_1\lambda_2}{2\lambda_1} = \lambda_2 \tag{5}$$

so $R \in O(\lambda_2)$ and therefore small.
However if $\lambda_1 = \lambda_2 \gg 0$:

$$R = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2 + \epsilon} = \frac{\lambda_1^2}{2\lambda_1 + \epsilon} \approx \lambda_1/2 \tag{6}$$

So R is large as well.

(b) the second or third function is preferable over the first one, as it represents the same notion of c̈orneness; but does not require the expensive computation of the eigenvalues λ_1, λ_2 of H.

(c) If $\lambda_2 > k \cdot \lambda_1 \geq 0$ with $0 \leq k \leq 1$
When gradually increasing k the constraint $\lambda_2 > k \cdot \lambda_1$ gradually becomes more constricting until $\lambda_2 > \lambda_1$ for $k = 1$. This forces both eigenvalues to be of similar magnitude, giving a large cornerness score by the metrics above. Therefore the number of corners found in an image if the constraint is fulfilled by every H matrix an image patch, grows with k.

Question 4 System Design

(a) To create a fabric fault detector, one needs to create a feature description which can detect large changes in texture. For this a texton representation is suitable. Here each image is processed by filters chosen from a filter bank. If the response is large everywhere but small in just one spot across multiple filters, this can be considered as a fault in the fabric.

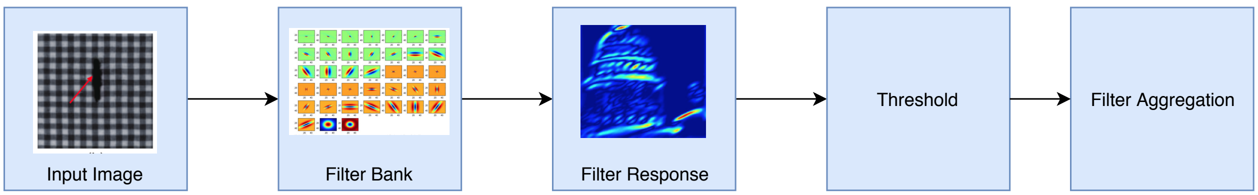

Figure 1: Fabric fault detector pipeline

  (a) **Input image**:
  (b) **Filter Bank**:
  (c) **Filter Response**:
  (d) **Threshold**:
  (e) **Filter Aggregation**:

(b) for detecting each of the faults in the given images, the Threshold and aggregation sections of the classifier needs to be fitted to classify them as faults.