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Introduction to Image & Video Processing Exam 31.3 2020

1/

a/ The output would be constant 8-bit gray-level image with ~~black~~ gray dot at origin

b/ Its name would be notch filter.

c/ The output image in freq domain would be

$G(u,v) = H(u,v).F(u,v)$.

$\Rightarrow g(x,y) = Real(\mathcal{F}^{-1}\{H(u,v)F(u,v)\})$.

$g(x,y) = lp_1(x,y) + hp_2(x,y) * f(x,y)$

$= [lp_1(x,y) + [\delta(x,y) - lp_2(x,y)]] * f(x,y)$.

d/ From c/ we have the linearity characteristic from taking the inverse Fourier transform. Thus ~~tl~~ $H(u,v)$ is linear filter.

e/ the $H(u,v)$ is a band reject filter.

2/ (a) From lecture slide.

$$m_L = \frac{1}{3.3}\sum_{(s,t)\in S_{xy}} x_{s,t} = \frac{1}{9}\sum_{(s,t)\in S_{xy}} x_{s,t}$$

which $x_{s,t}$ ~~is~~ are pixel of S_{xy}.

(b). variace σ_L^2

$$\sigma_L^2 = \frac{1}{3.3}\sum(x_{s,t} - m_L)^2$$

$$= \frac{1}{9}\sum(x_{s,t} - m_L)^2$$

(c). In case there is no noise $\sigma_n^2 = 0$

Thus

$g(x,y) = f(x,y) - 0$

$= f(x,y)$.

which return the input image.

(d). When local area contain important ~~image~~ details e.g edges, the local variance will be high compare to noise variance $\sigma_L >> \sigma_n$. Thus the output image will be reserved with ~~ed~~ important details.

(e). When local area is smoth, the local variance σ_L is small compared to noise variance σ_n. But the ratio $\frac{\sigma_n}{\sigma_L}$ will not exceed 1. Thus the ~~filter~~ ~~would approximate to~~ output image will approach the arithmetic mean value of pixel in S_{xy}.

$g(x,y) \to m_L$ when σ_n low.

3/

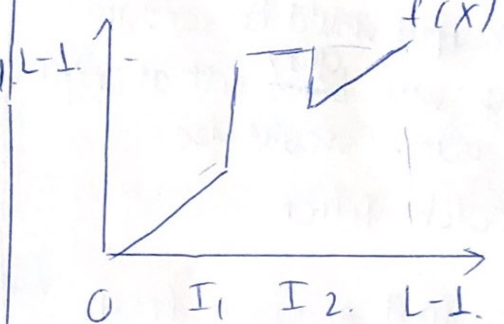
a/. I think median filter would be used in order to remove the bright, dark & isolated spot that is no interest. Median filter will work as replacing the value ~~of~~ centre pixel by the median of intensity value in the neighborhood of that pixel, with less bluring the image.

b/. I thing highpass spatial filter ~~such as~~ to sharpening. It can be used (in specific) ~~Lapla~~ highboost filter such as Laplacian filter to enhance the sharpness.

c/. The constrast can be enhanced by using intensity transformation on image such as log transformation $s = cr^{\gamma}$ with $c > 0$ & $0 < \gamma < 1$.

d/. since we want to shift some gray-level value to our desired with specification, thus histogram matching would be used.

e/. The grey-level transformation as below would work.



$$f(x) = \begin{cases} L-1 & (I_1 \le x \le I_2) \\ x & \text{otherwise} \end{cases}$$

would remain gray-level outside the range $[I_1, I_2]$.

4/ a/ We would apply the Fourier transform to the image & in frequency domain, there are some frequencies that correspond to those horizontal streak, we could remove them. Afterward, we apply the inverse Fourier to restore the image without the streak.

b/. we would. ~~apply~~ use the histogram of image. to compared with some noise model. histogram to detect what type of noise it is

c/ Since spatial filtering only help to remove additive random noise, it won't work in our case. ~~M~~ Geometric mean filter would help to reduce a random noise while preserve much more ~~details~~ detail compared to arithmetic mean filter. In addition, we could use contraharmonic mean filter to remove the black dot' with order of filter $Q > 0$ (black dot is the same as pepper noise).

d/. Median filter can be used to preserved the fundamental detail while removing the bright spot of the image.

e/. In addition to those ad-hoc method, other addition method should be done advancely such as applied deep learning (machine learning) to to local neighborhood of each input ~~IP~~ pixel.

6/.

a/ error propogation risk.

- If I-picture is damaged.
  → propogate damage to P-picture which predict from it
- ~~IP~~. It can propogate to P picture that predicted from that damge P_picture & so on.
- It may propogate to B-pictures that predict from I and indirectly from P-picture

Thus a damage to I-pictures can affect the display of every picture in GOP.

b/ Modern. MPEG-2 video ~~dec~~ decoder are able to detect error in bitstream & take ~~act~~ action to mitigate the issue. Detection occurs at 2-level which are transport stream level. In addition, MPEG-2 video decoder can look for illegal syntaxes or oddities in MPEG-2 video bit stream. (e.g: detecting the illegal motion vector).

e/. If the 4^{th} (P-picture) get damged, all the following P-picture & B-picture directly or indirectly from that P would be damged until next I Image appears.

So if the 4^{th} picture damaged it will ~~dag~~ do damage to 2^{th}, 3^{rd}, 5^{th}, 6^{th}, 7^{th} pictures.

c/ the cost is that some packets have to be dropped during the transpartation to ~~guar~~ control the error propagation.

d/ However, our eyes hardly detect these missing picture. Thus the cost is not really big deal in general. □

5/ ~~a~~ a & b/ The image of bottom left ~~show the~~ obtained from the transformation from middle left which show the gray-level band correspond to the explosive, bag & background respectively. The explosive & background has different intensity level but both coded with same color as result of periodic sine wave. The image of bottom right was obtained from transformation function in middle right. In this case, the bag & explosive intensity band were mapped by similar transformation, which allow airport security to see through the explosive (loptop in ~~our~~ our case), ~~producing~~.

The background mapping in bottom left would produce almost identic color assignment for 2 ~~pse~~ pseudocolor image.

5/c/.

The goal of this is to simultaneously compress dynamic range & enhance the constrast of the image.

This Gaussian high-pass filter will allow both low & high frequencies to be adjusted simultaneously.

with γ_H & γ_L define the filter behavior at the frequencies extreme and c control the slop of transition.

In case $\gamma_L < 1$ & $\gamma_H > 1$ the low-freq will be removed & high-freq will be boosted.

Thus it create a great improvement in constrast. By doing this before apply color transformation, the spotted of explosive (laptop) would be clearer and easier with high accuracy.