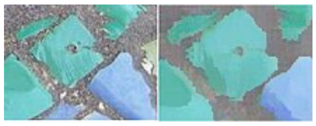
Kuwahara Filter

Kuwahara filter is a non linear Smoothing filter for adaptive noise reduction. "Low-Pass Filter."
Effectively reduce noise but also blur out the edges.

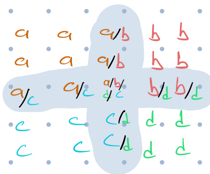


The Kuwahara Operator

Suppose that $I(x,y)$ is a gray Scale image and that we take a square window of size $2d+1$ centered around a point (x,y) in the image. This square can be divided into four smaller square regions $Q_{i=1\ldots4}$ each of will be

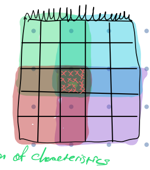
$$Q_i(x,y) = \begin{cases} [x, x+a] \times [y, y+a] & \text{if } i=1 \\ [x-a, x] \times [y, y+a] & \text{if } i=2 \\ [x-a, x] \times [y-a, y] & \text{if } i=3 \\ [x, x+a] \times [y-a, y] & \text{if } i=4 \end{cases}$$

Small variance of tones.



The arithmetic mean $m_i(x,y)$ and std $\sigma_i(x,y)$ of the four regions centered around a pixel (x,y) are calculated and used to determine the value of the central pixel.
The output of the Kuwahara filter $\Phi(x,y)$ for any point (x,y) is then given by $\Phi(x,y) = m_i(x,y)$ where $i = \arg\min_j \sigma_j(x,y)$

Similarly to the median filter the Kuwahara filter uses a sliding window approach to access every pixel in the image. The size of the window is chosen in advance and may vary depending on desired level of blur in the final image.
Bigger windows typically result in the creation of more abstract images whereas small window produce images that retain their detail.



A use of this filter is reducing the effect of the Gaussian noise or in general of any noise of zero average.
A secondary use of this filter is to produce a water painting effect.

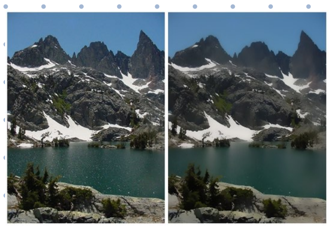
It is one of the pioneering techniques in image filtering with edge preservation proposed in 1976 had the primitive purpose of assisting in the processing of RI-angiocardiography images of the cardiovascular system because of the utility in the extraction of characteristics and segmentation due to the preservation already mentioned.

Median Filter

The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. The pattern of neighbors is called the "window" which slides, entry by entry, over the entire signal
For 2D data (or more) the window must include all entries within a given radius.

Bilateral Filter

It replaces the intensity of each pixel with a weighted average of intensity values from nearby pixels. This weight can be based on a Gaussian Distribution



$$I_{filtered}(x) = \frac{1}{W_p}\sum_{x_i \in \Omega} I(x_i)\, f_r(\|I(x_i) - I(x)\|)\, g_s(\|x_i - x\|) \rightarrow W_p = \sum_{x_i \in \Omega} f_r(\|I(x_i) - I(x)\|)\, g_s(\|x_i - x\|)$$

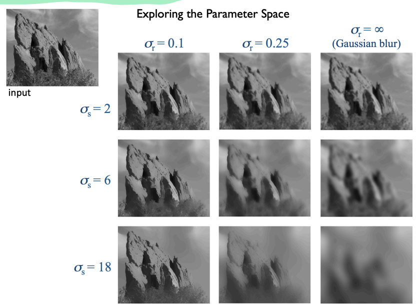
Bu adımdan sonra Smoothing operasyonları var.

$$w(i,j,k,l) = \exp\left(-\frac{(i-k)^2 + (j-l)^2}{2\sigma_d^2} - \frac{\|I(i,j) - I(k,l)\|^2}{2\sigma_r^2}\right)$$

σ_d and σ_r smoothing parameter

After calculating the weights, normalize them

$$I_D(i,j) = \frac{\sum_{k,l} I(k,l)\, w(i,j,k,l)}{\sum_{k,l} w(i,j,k,l)}$$



Guided Filter

Compared to the bilateral filter, the guided image filter has two advantages: bilateral filters have heavy computational complexity, while the guided image filter uses simpler calculations with linear computational complexity.
Bilateral filters sometimes include unwanted gradient reversal artifacts, and cause image distortion.

One key assumption of the guided filter is that the relation between guidance I and the filtering output q is linear. Suppose that q is a linear transformation of I in a window w_k centered at the pixel k.
In order to determine the linear coefficient (a_k, b_k) constraint from the filtering input P are required. The output q is modeled as the input P with unwanted components n, such as noise/textures subtracted.

$q_i = a_k I_i + b_k, \forall i \in w_k$

$q_i = P_i - n_i$

$$n_i = P_i - a_k I_i - b_k \qquad E(a_k, b_k) = \sum_{i \in w_k} \left((a_k I_i + b_k - P_i)^2 + \epsilon a_k^2\right)$$

$\epsilon \rightarrow$ regularization
$w_k \rightarrow$ window centered at k pixel

Anisotropic Diffusion "Perona - Malik Diffusion"

More Detailed.

Reducing image noise without removing significant parts of the image content, typically edges, lines, or other details.

Anisotropic diffusion resembles the process that creates a scale space, where an image generates a parameterized family of successively more and more blurred images based on a diffusion process. Each of the resulting images in this family are given as a convolution between the image and a 2D isotropic Gaussian filter, where the width of the filter increases with the parameter.

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