EE 475 HOMEWORK 3

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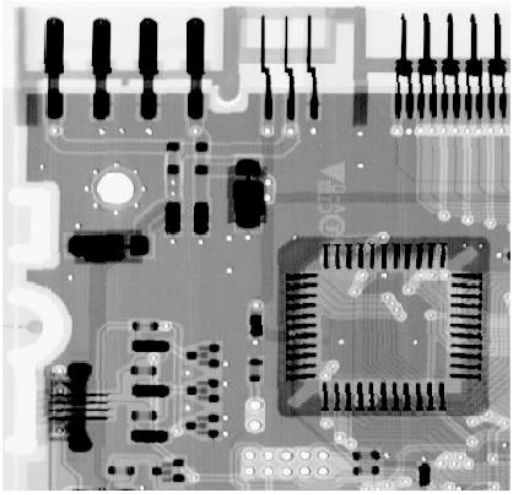
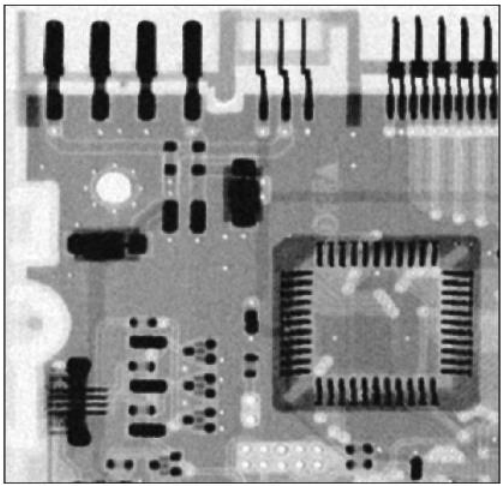
Q1. Adaptive Linear Filtering

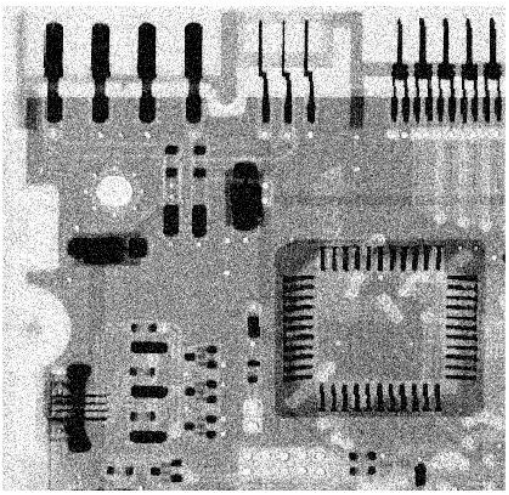
original image



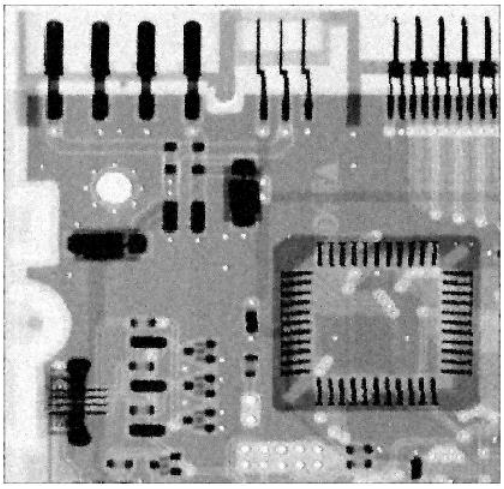
geometric mean filter



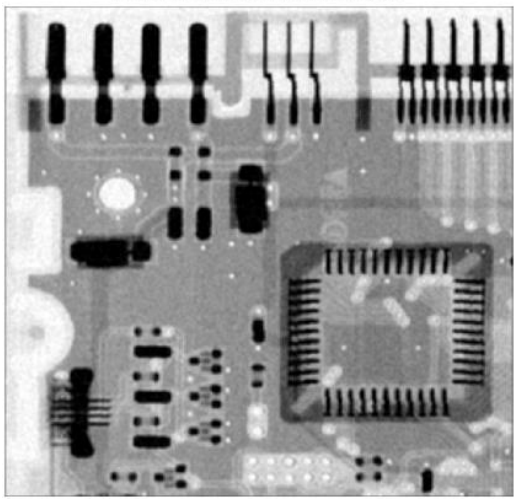
with noise



adaptive linear filter



arithmetic mean filter



Arithmetic mean filters smooth local variations in images and noise is decreased however, it creates blurring.

Geomethric mean filters make images smoothing, similarly arithmetic mean filter, however it creates less blurring, loses less image details.

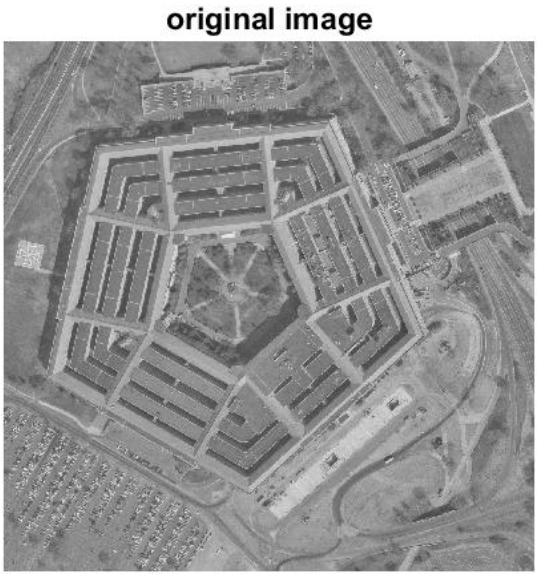
It can be seen that, the legs of circuit components at the image using geomethric mean filter are sharper than at the image using arithmeatic mean filter.

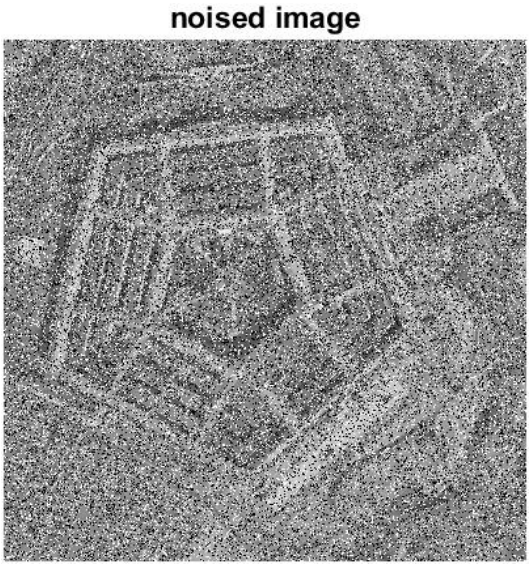
Similarly these two filters, linear adaptive filters remove the noise but it has big advantages for sharpness. The image using adaptive filter is much sharper.

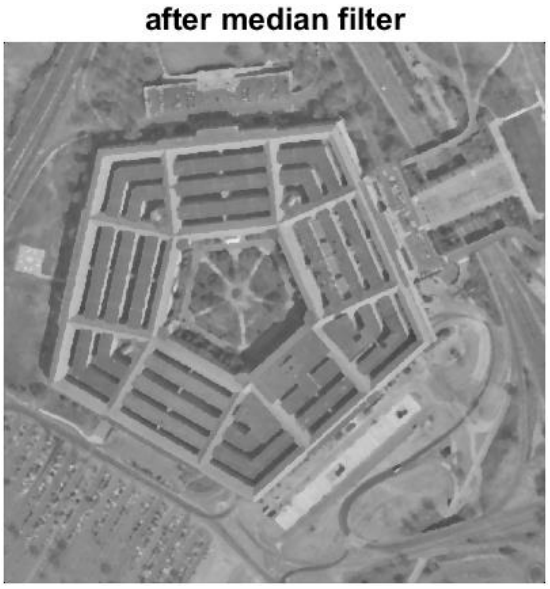
For example, the legs of the components at the image using adaptive filter are much sharpher. Other features, such as holes and the eight legs of the dark component on the lower left-hand side of the image, are much clearer at this image.

If the variance of the noise is not known exactly, the proper value can be estimated trying some values. If the value is too high, the ratio would be higher than 1 and it is set as 1, then the result image would be same the image using arithmetic mean filter. So, the variance value should be decreased. If the variance value is too low, the ratio would be too low and the result image is similar to input image. The variance value should be increased. Also, the variance values of submatrices can be used to estimate proper values.

Q2. Adaptive Median Filtering







Median filters are successful and common to remove certain types of random noises. They provide excellent noise-reduction capabilities with considerably less blurring than linear smoothing filters.

When median filters and adaptive median filters are compared, adaptive median filters have significant advantages. It can preserve more details than median filters. Both of them can remove the salt-pepper noise at the pentagon image effectively, the median filter causes significant loss of details. The adaptive filter is better to preserve sharpness and details.

For example, the cars at the image using the adaptive filter can be shown clearly but the cars at the image using median filter are blurry. The preservation capability of the adaptive filter is better.

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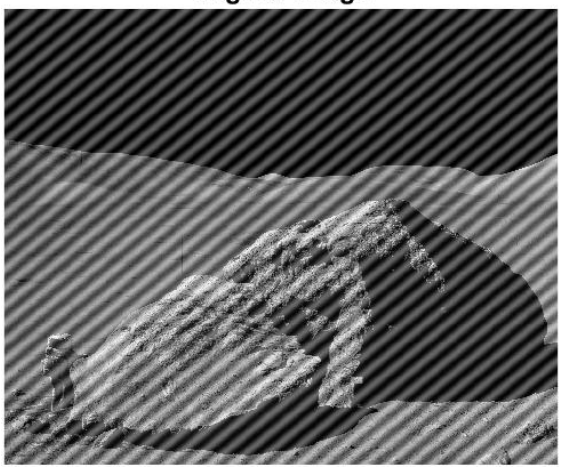
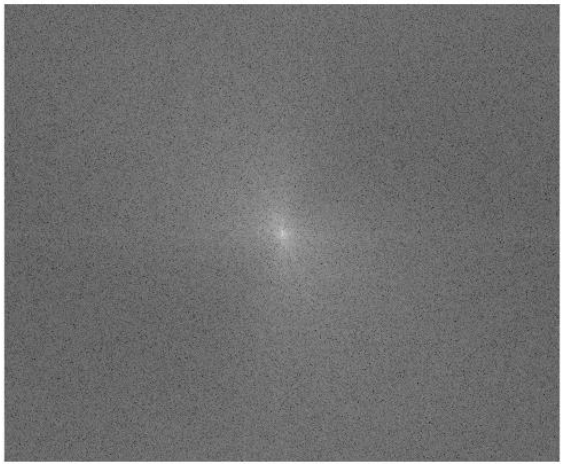
Q3. Notch Filtering

original image

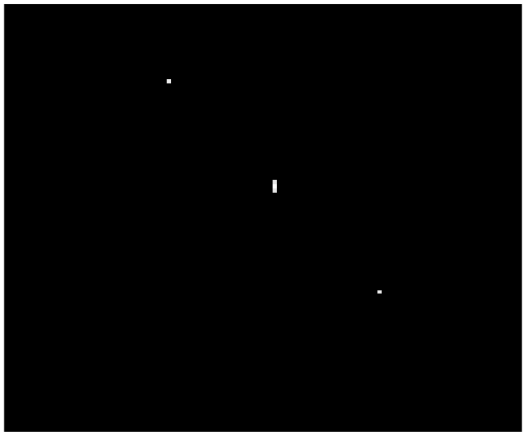


fourier transformation

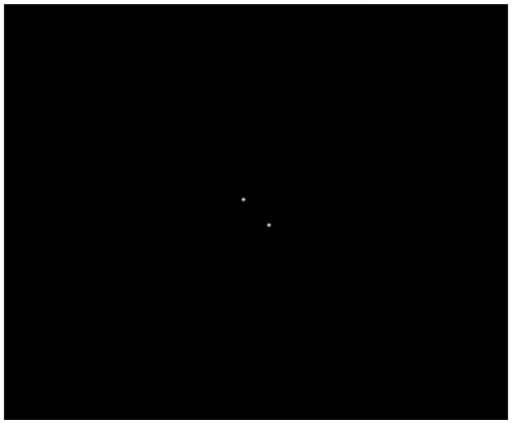


after threshold

after threshold (zoom in)



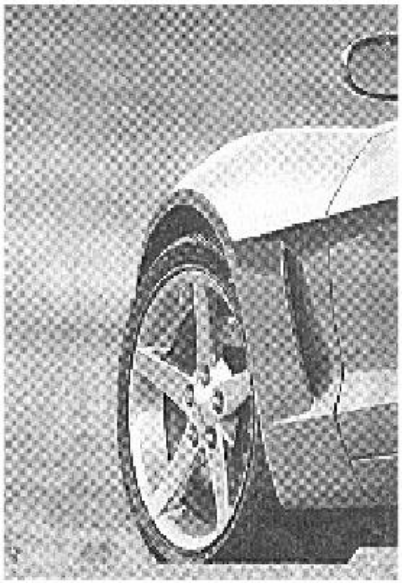
notch filter (inverse)



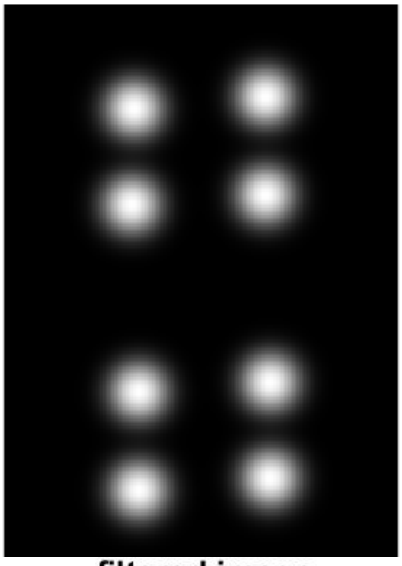
filtered image

noise pattern

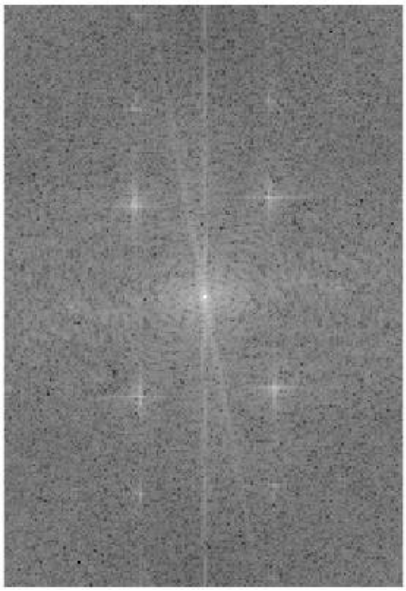
original image



notch filter (inverse)

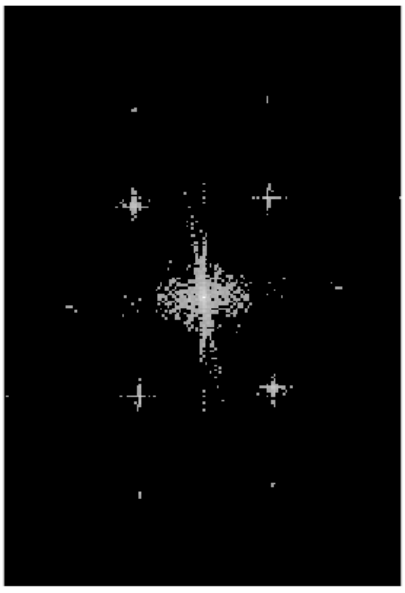


fourier transformation

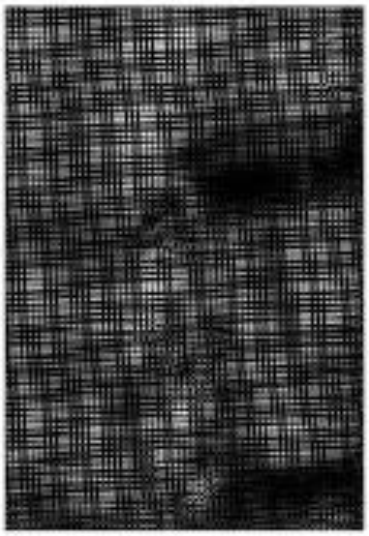


filtered image

after threshold



noise pattern

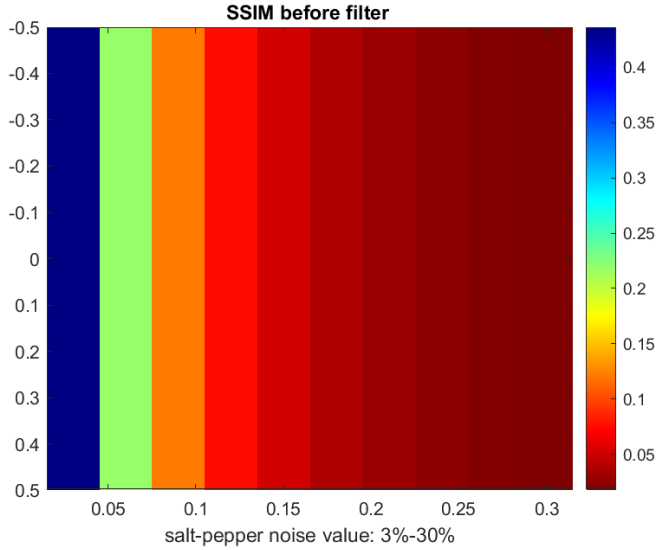


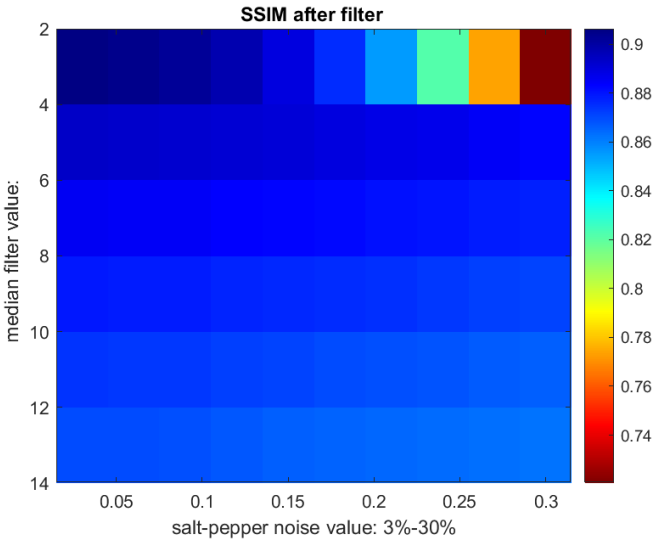
There is one pair at the fourier transformation of the moon image and there are four pairs at the fourier transformation of the car image. These pairs are about noise patterns and they have specific frequency values which can be shown at the fourier transformations. These noise patterns can be removed from the image with notch filter. After the notch filter, the images become more clear and have less noise.

Q4. Heat Maps

I compared the original image and filtered images which has different gaussian noise by using SSIM.

There are 10 images with different noise and 6 different median filters, so there are 60 results.





Before using median filters, the best SSIM value is 0.0525 which is worse than the worst SSIM value after using median filters. It means using median filter for all these images with noise increases the structural similarity and when the variance of the gaussion noise increaeas, the structural similarity decreases.

When the SSIM values after filtering are investigated, the image had noise with variance 30% and filtered 3X3 median filter (maximum variance for noise and minimum window size) has the worst value. The image had noise with variance 3% and filtered 3X3 median filter (minimum variance for noise and minimum window size) has the best value. The best and worst results are taken by using smallest window size and average results are taken by larger windows.

If the variance of the noise is unknown, the using 3x3 or 5x5 windows can be good idea.