PERIODIC NOISE REDUCTION BY FREQUENCY DOMAIN FILTERING

Periodic noise reduction

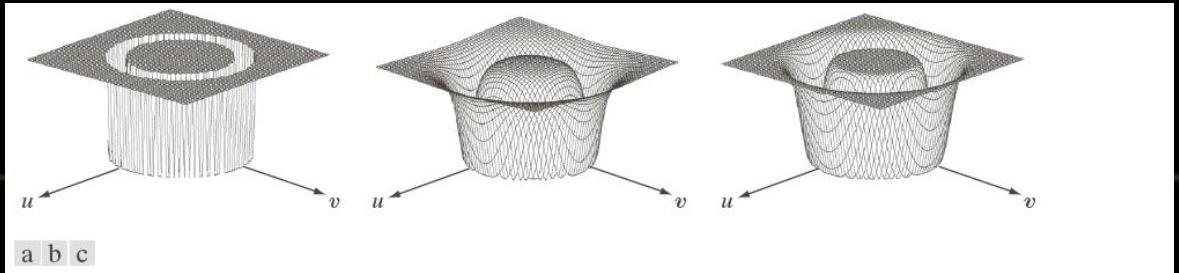
- Periodic noise is a noise pattern that arises due to electrical or electromagnetic interference.
- Periodic noise can be analysed and filtered effectively by using frequency domain techniques.
- The basic idea is that periodic noise appears as concentrated bursts of energy in the Fourier transform, at locations corresponding to the frequencies of the periodic interference.
- Three types of selective filters are used
  - Bandreject Filter
  - Bandpass Filter
  - Notch Filter

Bandreject Filters

- Bandreject filtering for noise removal is used in the applications where the general location of the noise component in the frequency domain is approximately known.

TABLE 4.6
Bandreject filters. W is the width of the band, D is the distance $D(u, v)$ from the center of the filter, D_0 is the cutoff frequency, and n is the order of the Butterworth filter. We show D instead of $D(u, v)$ to simplify the notation in the table.

Ideal	Butterworth	Gaussian
$H(u,v) = \begin{cases} 0 & \text{if } D_0 - \frac{W}{2} \le D \le D_0 + \frac{W}{2} \\ 1 & \text{otherwise} \end{cases}$	$H(u,v) = \frac{1}{1 + \left[\frac{DW}{D^2 - D_0^2}\right]^{2n}}$	$H(u,v) = 1 - e^{-\left[\frac{D^2 - D_0^2}{DW}\right]^2}$

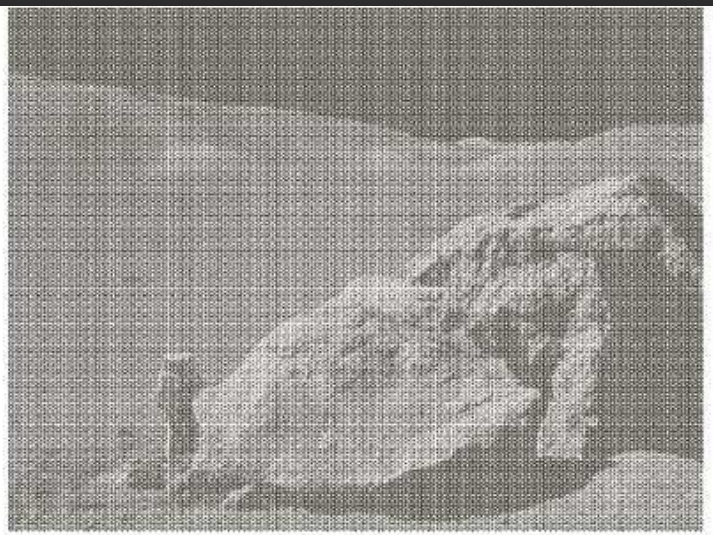


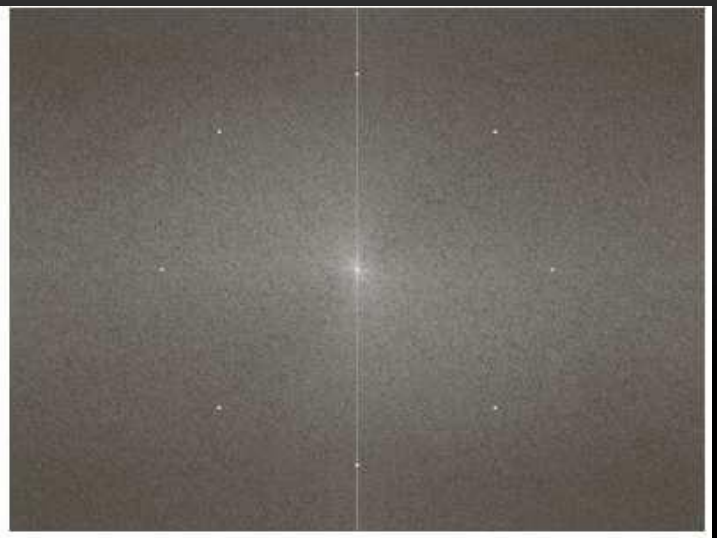
a b c

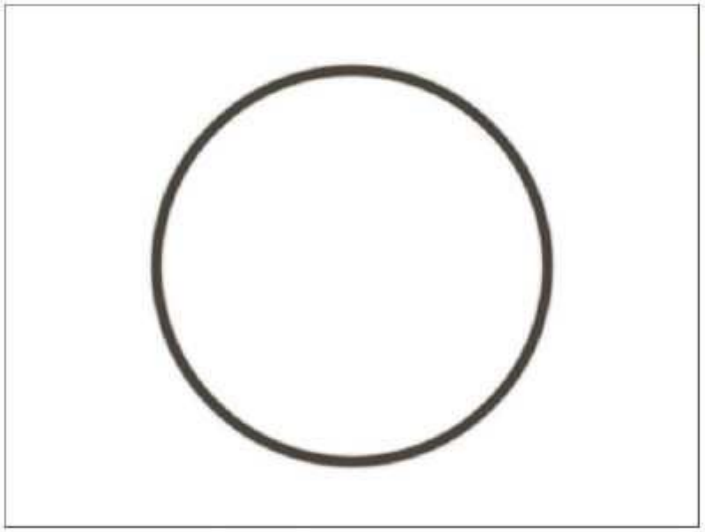
FIGURE 5.15 From left to right, perspective plots of ideal, Butterworth (of order 1), and Gaussian bandreject filters.

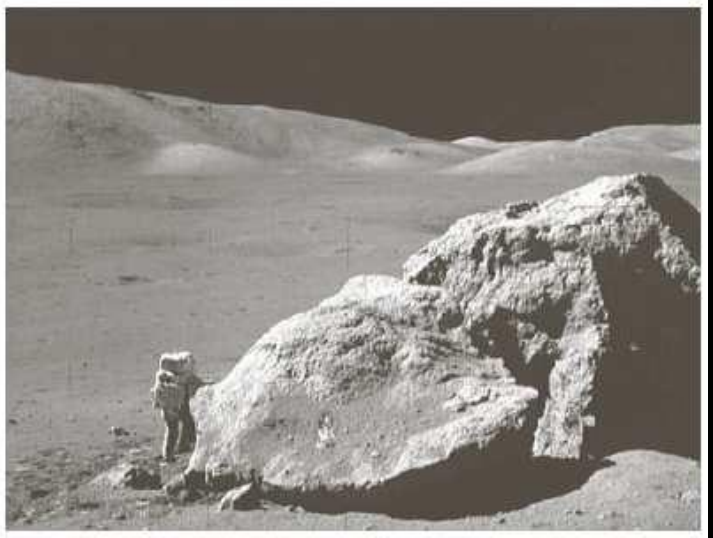
a b
c d

FIGURE 5.16
(a) Image corrupted by sinusoidal noise. (b) Spectrum of (a). (c) Butterworth bandreject filter (white represents 1). (d) Result of filtering. (Original image courtesy of NASA.)









Bandpass Filter

A bandpass filter performs the opposite operation of a bandreject filter.

The transfer function $H_{BP}(u,v)$ of a bandpass filter is obtained from a corresponding bandreject filter transfer function $H_{BR}(u,v)$ by using the equation

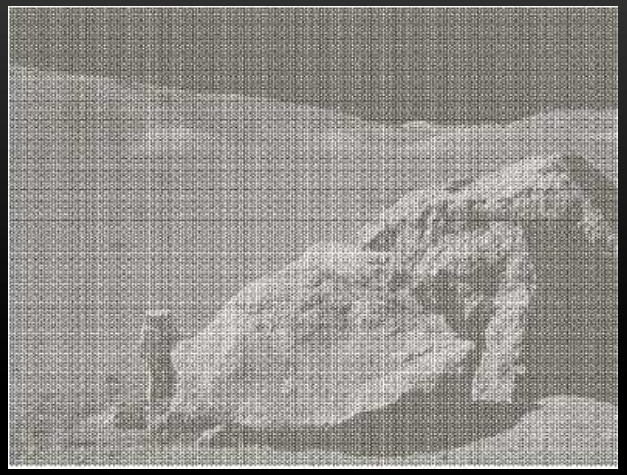
$$H_{BP}(u,v) = 1 - H_{BR}(u,v)$$

Performing straight bandpass filtering on an image is not a common procedure because it generally removes too much image detail. However, bandpass filtering is useful in isolating the effects on an image caused by selected frequency bands.

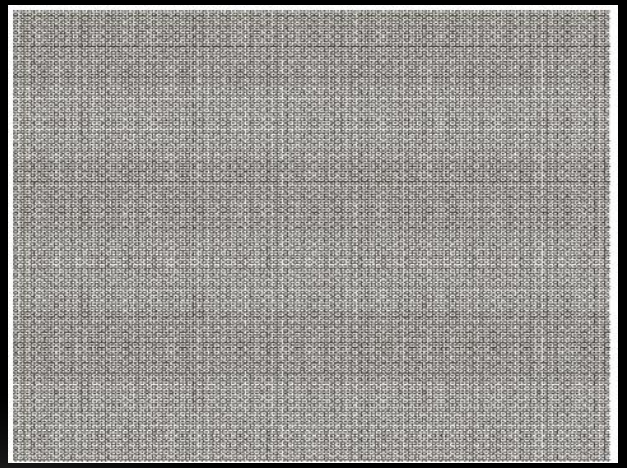
The image shown was generated by

(1) using the equation $H_{BP}(u,v) = 1 - H_{BR}(u,v)$ to obtain the bandpass filter corresponding to the bandreject filter used.

(2) taking the inverse transform of the bandpass-filtered transform.



Noise pattern of the image for bandreject filter



Noise pattern of the image obtained by bandpass filtering

Use : It simplifies analysis of the noise, reasonably independently of image content

Example:

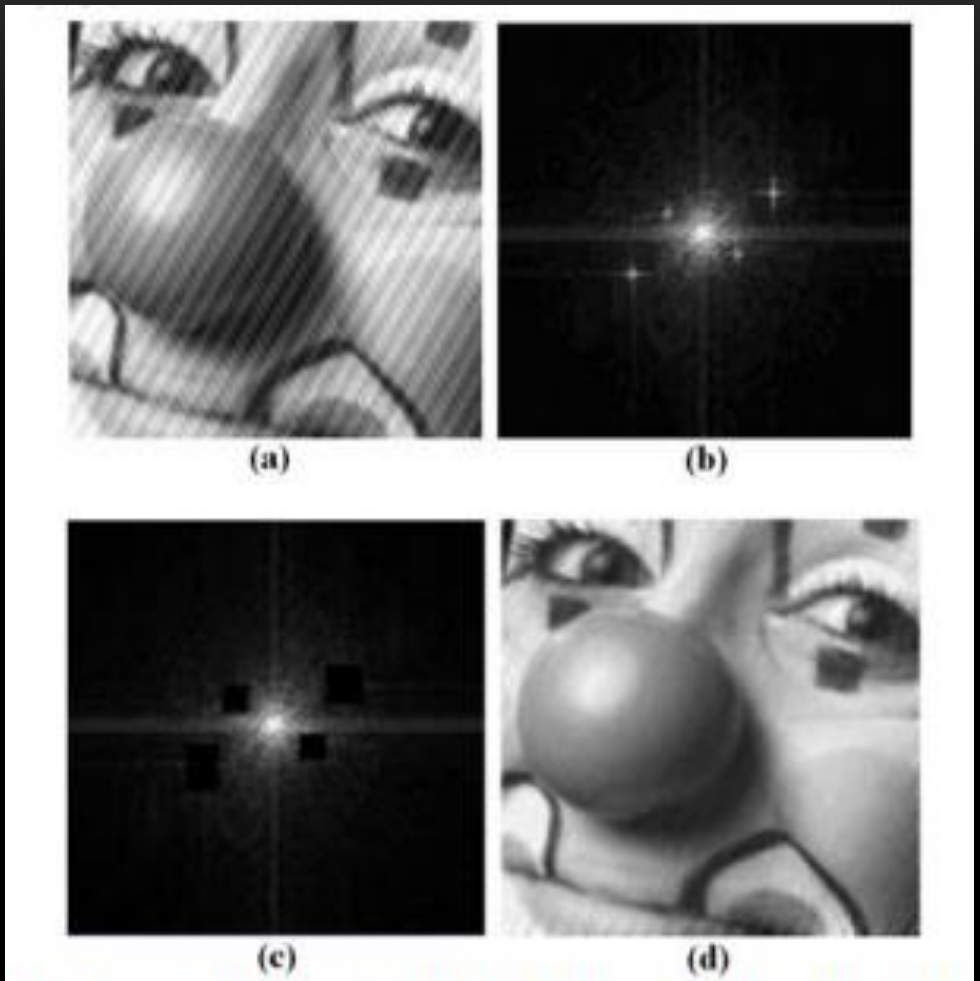


Figure 2: Different step to reduce the periodic noise effect from a sample joker image. a)Input image contaminated by additive two periodic sinusoidal signals. b) 2-D Fourier transform of the input image. c) Removing periodic noise frequencies by the proper squared type notch-reject filter and d) Restored image after applying the notch-reject filter.