Estimation of Point Spread Function (PSF) in Ultrasound Imaging

Clara M Mosquera Lopez

OUTLINE

- Introduction
- Project goals
- Homomorphic filtering for PSF estimation
- Results
- Conclusions and future work

Introduction

- Ultrasound imaging uses high-energy sound waves generated by a transducer in the frequency range 1-20 MHz.
  - Waves pass through the human body and reflect off surfaces of discontinuity in density.
- Intensity levels in an ultrasound image depends on:
  - the amplitude and frequency of the reflected wave,
  - and the time it takes to return from the body to the transducer.

Advantages of ultrasound imaging

- Ultrasound imaging is an important diagnostic and guidance tool due to several factors:
  - It is non-invasive
  - It is free of ionizing radiation
  - It is cheaper than other imaging techniques
  - It produces images in real-time
  - It is portable
- Several applications
  - Prenatal ultrasound
  - Tumor detection
  - Image guided biopsy and surgery
  - Treatment evaluation

Disadvantages of ultrasound imaging

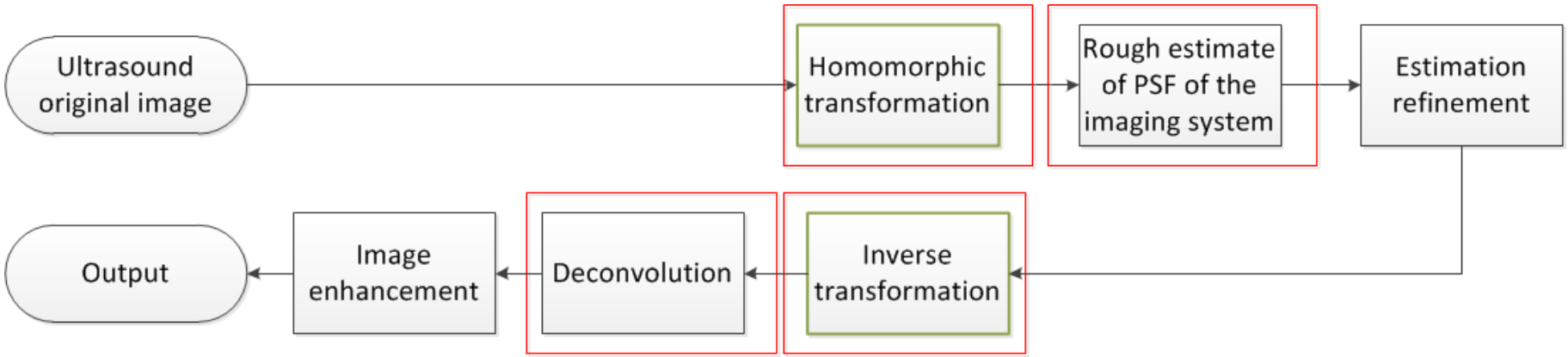
- Poor image quality
  - Attenuation
  - **High levels of speckle noise**
  - Low contrast between regions
    - Not well-defined boundaries
  - Signal dropout during image acquisition

Breast ultrasound image

Project goals

- To find a clean approximation of the spatial reflectance distribution of the internal organs of the human body under study
  - Estimate the point spread function (PSF) of the imaging system
  - Perfom image deconvolution (blind deconvolution) based on the estimated PSF

Scope of Project 1



Initial PSF estimation (1)

Image of the object

Additive noise

$$g(x,y) = f(x,y) * h(x,y) + n(x,y)$$

PSF

Cepstral domain

FFT

log( )

$$g(x,y) \longrightarrow G(u,v) = F(u,v)H(u,v)$$

$$\log|G(u,v)| \approx \log|F(u,v)| + \log|H(u,v)|$$

$$\langle G(u,v) \approx \langle F(u,v) + \langle H(u,v)$$

Initial PSF estimation (2)

$$\log|G(u,v)| \approx \log|F(u,v)| + \log|H(u,v)|$$

$$\langle G(u,v) \approx \langle F(u,v) + \langle H(u,v)$$

Low-frequency components

Initial PSF estimation (3)

- Low-pass filter in Haar wavelet domain and median filter

Wavelet-based denoising

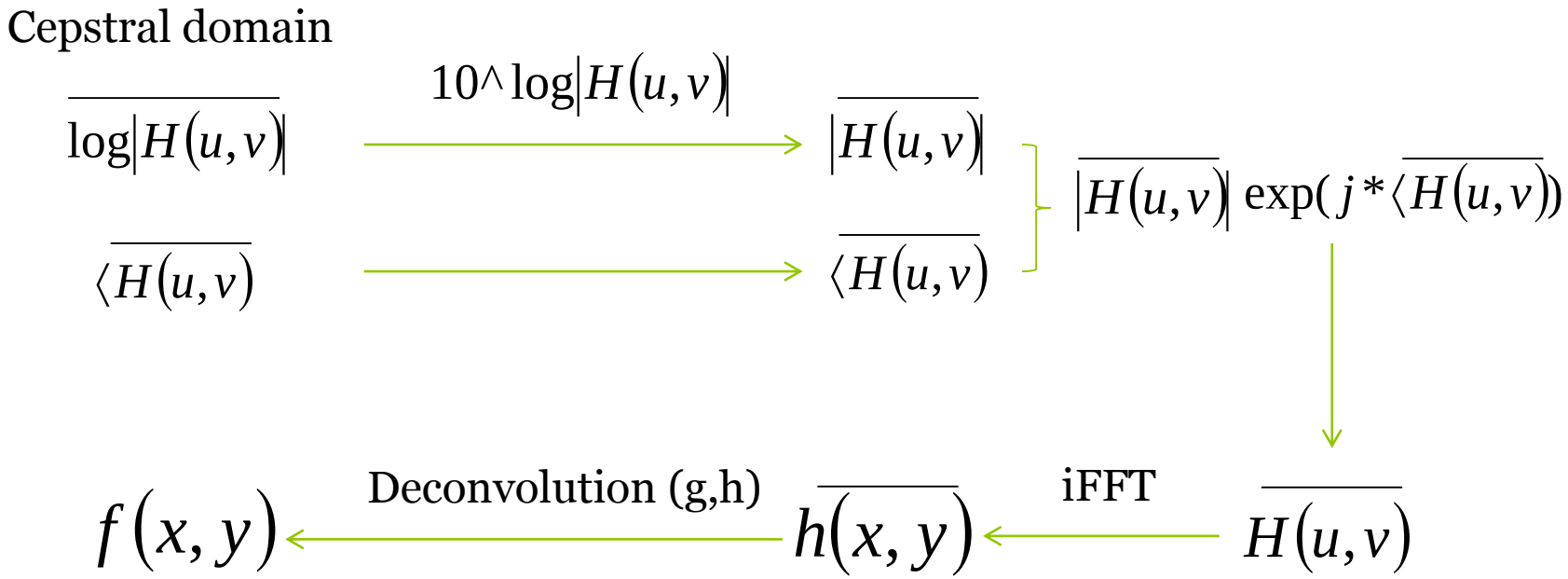
Hard thresholging of detail coefficients

$$\log|G(u,v)| \approx \log|F(u,v)| + \log|H(u,v)|$$

$$\langle G(u,v) \approx \langle F(u,v) + \langle H(u,v)$$

Median filtering 3x3

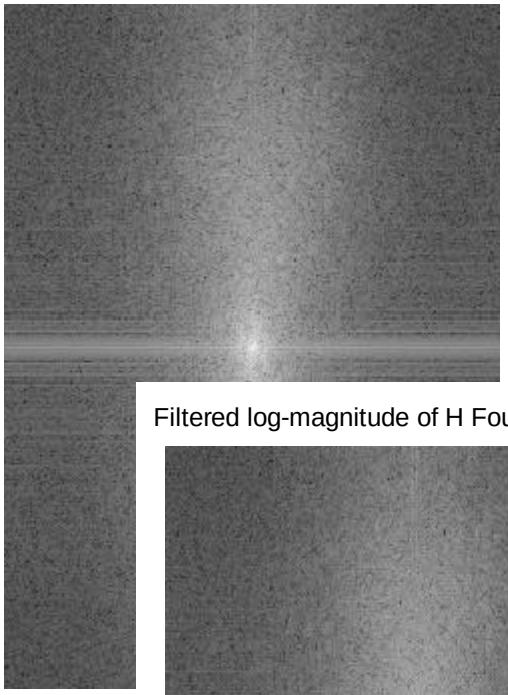
Inverse tramsformations



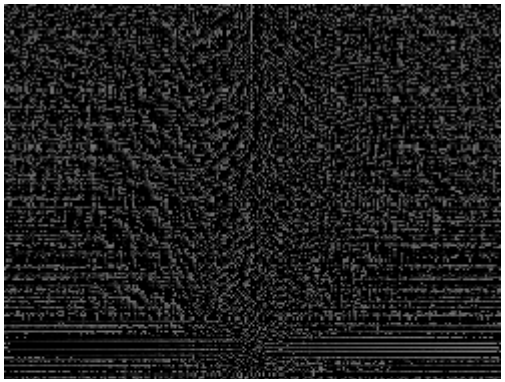
Results

Degraded image

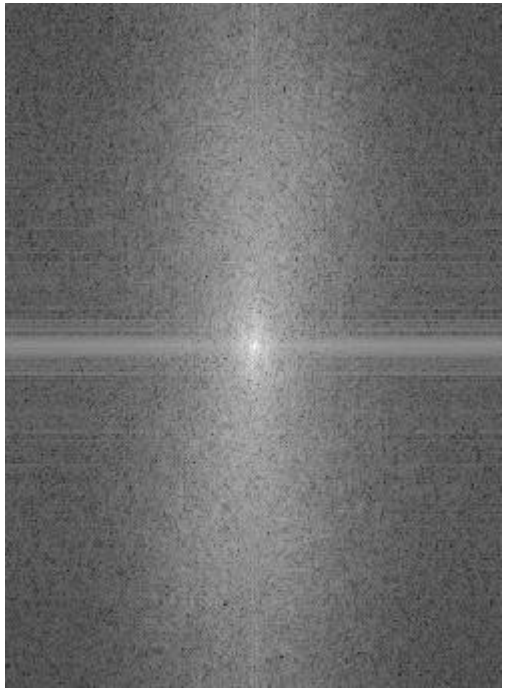
log-magnitude of G Fourier transform



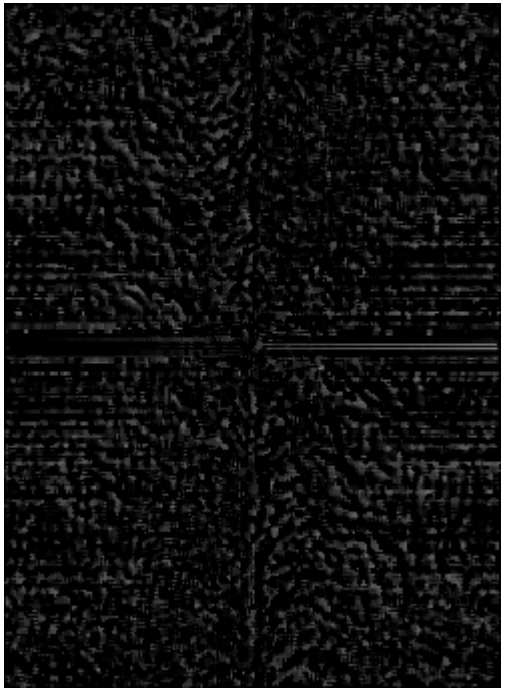
Phase of G Fourier transform



Filtered log-magnitude of H Fourier transform



Filtered phase of H Fourier transform



Obstetric ultrasound image (1)

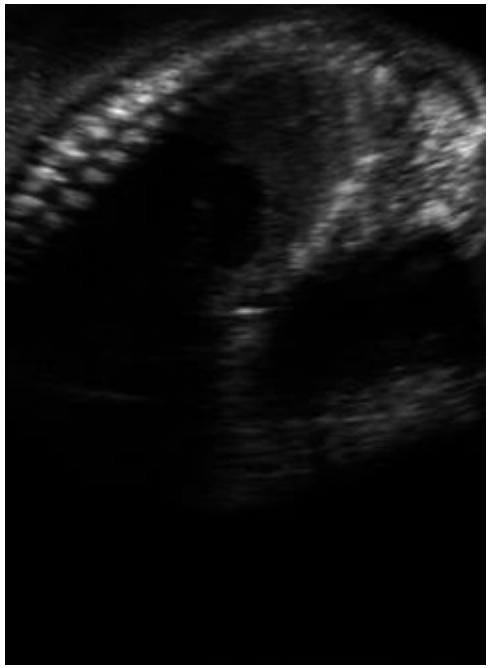
Degraded image

Filtered image

Obstetric ultrasound image (2)

Degraded image

Filtered image



Conclusions and future work

- A homomorphic filter was implemented in order to estimate the PSF of an ultrasound imaging system **from the image itself**. The estimated PSF is used in a deconvolution algorithm to get an improved version of the image produced by a given device
- Future work:
  - To obtain a quantitative metric to evaluate the performance of the algortihm
  - To refine the PSF estimation

Thanks for your attention!!

References

Benameur S., Mignotte, M., and Lavoie, F., “A homomorphic filtering and expectation maximization approach for the PSF estimation in ultrasound imaging,” Proc. SPIE Image Processing: Algortithms and Systems X, 8p., 2012.