TÉCNICO LISBOA

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Principles of Biosignals and Biomedical Imaging

3rd year, P_3 (ECTS: 3.0), LEBiom

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Outline

Image reconstruction

- Reconstruction from noisy and missing data
- Image Tomography / Radon Transform

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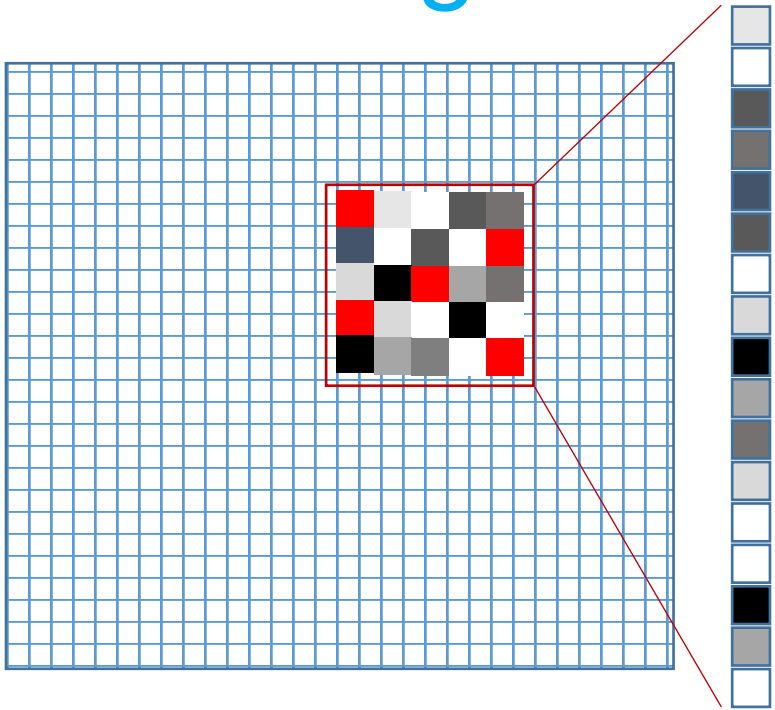
Image Reconstruction

Reconstruction with missing data

Original

Uncomplete (20%)

Reconstruction with missing data



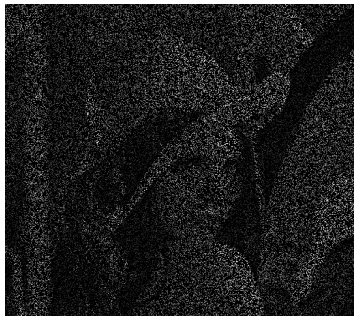
Reconstruction with missing data

```
X.    =double(imread('len_gray.jpg'));
X.    =255*x/max(x(:));
z     = zeros(size(x));

[N,M]  = size(x);
thrs   = 0.80;              %Discarded amount
mask   = rand(size(x))>thrs;

e      = 0;                 % Noise parameter
eta    = e*randn(size(x));  % Noise signal
xNoisy = x+eta;             % Noisy Data

y      = mask.*xNoisy;      % Noisy and missing data

w=5;                        %Dimensão da janela
for I=w+1:N-w-1
   for J=w+1:N-w-1
      aux=y(I-w:I+w,J-w:J+w);
      q=nonzeros(aux(:));
      if (~isempty(q(:)))
         z(I,J)=median(q(:));
      end
   end
end
```

```
SNR=20*log(norm(x(:))/norm(x(:)-z(:)));

figure(1); colormap(gray(256));
subplot(1,3,1); image(x);   axis off; title('Original','fontsize', 18);
subplot(1,3,2); image(y);   axis off; title(strcat('Uncomplete ( ',strcat(num2str(100*(1-thrs)),'%)')),'fontsize', 18);
subplot(1,3,3); image(z);   axis off; title(strcat('SNR(median): ',num2str(SNR,'\b %5.2f')),'fontsize', 18);
```

Original

Uncomplete (20%)



SNR(median):30.02

Reconstruction with noisy and missing data

```
x=double(imread('len_gray.jpg'));
x=255*x/max(x(:));

[N,M]   = size(x);
thrs    = 0.80;              %Discarded amount
mask    = rand(size(x))>thrs;

e       = 50;                % Noise parameter
eta     = e*randn(size(x));  % Noise signal
xNoisy  = x+eta;             % Noisy Data

y       = mask.*xNoisy;      % Noisy and missing data
z       = zeros(size(x));

w=5;                         %Dimensão da janela: 2w+1
for I=w+1:N-w-1
   for J=w+1:N-w-1
      aux=y(I-w:I+w,J-w:J+w);
      q=nonzeros(aux(:));
      if (~isempty(q(:)))
         %Test other statistics, e.g., mean, max, min
         z(I,J)=median(q(:));
      end
   end
end
```

Original

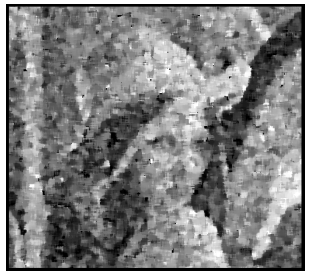
Uncomplete (20%)

SNR(median):28.30

Original

Uncomplete (5%)

SNR(median):23.96



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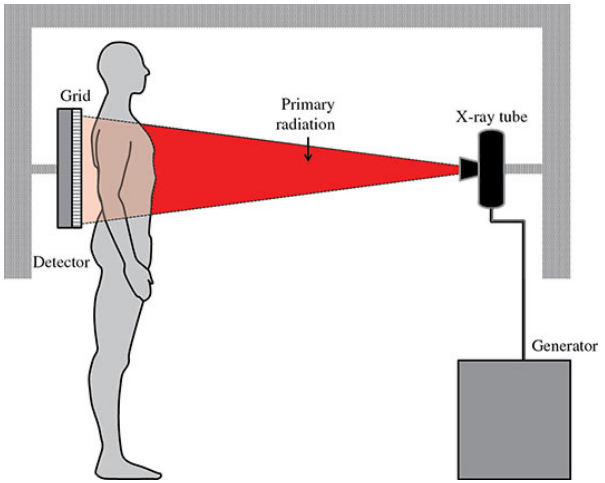
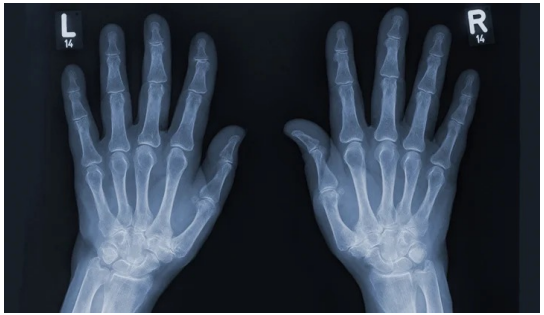
Break

X Ray



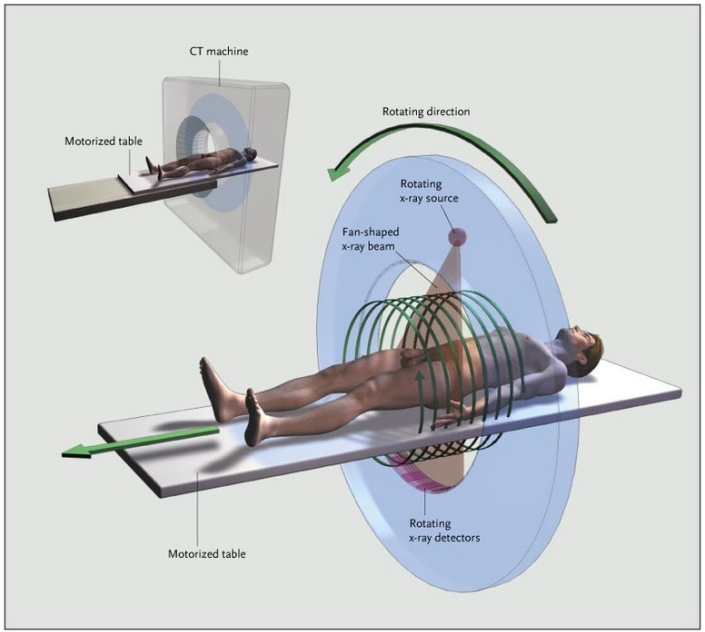


Computer Tomography

1972
Godfrey Hounsfield

The first commercially available CT scanner was created by British engineer Godfrey Hounsfield of EMI Laboratories in 1972. He co-invented the technology with physicist Dr. Allan Cormack. Both researchers were later on jointly awarded the 1979 Nobel Prize in Physiology and Medicine.
(https://catalinaimaging.com/history-ct-scan/)

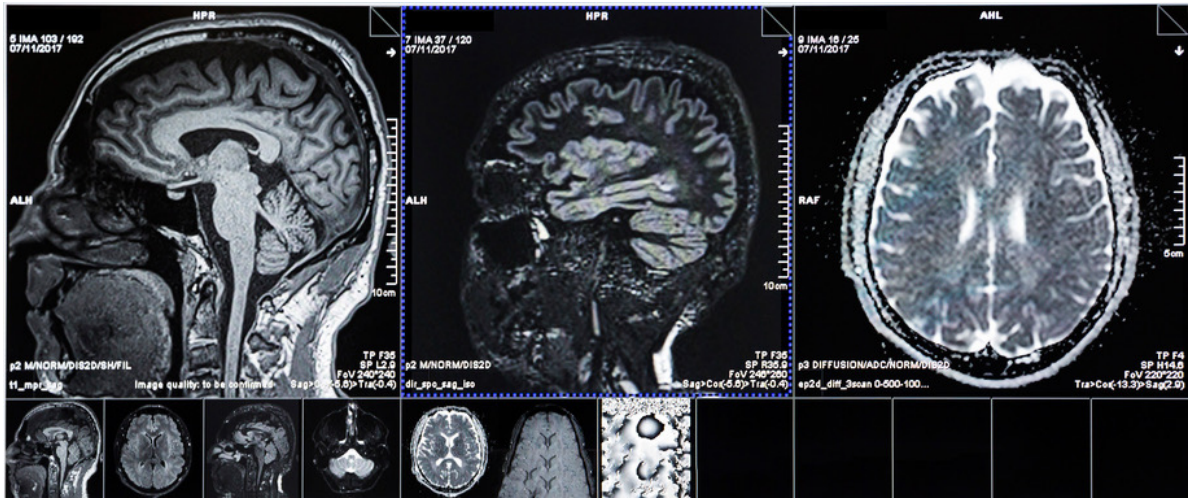
Computer Tomography



Computer Tomography

X-Ray

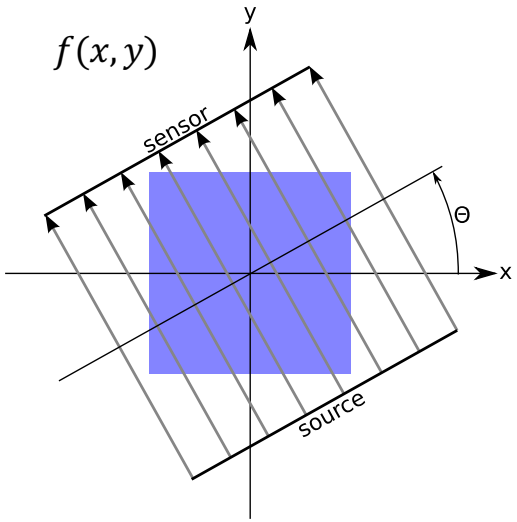
CT

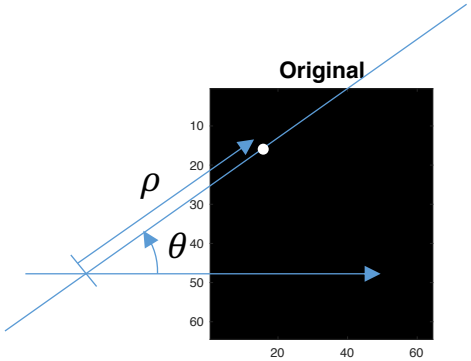


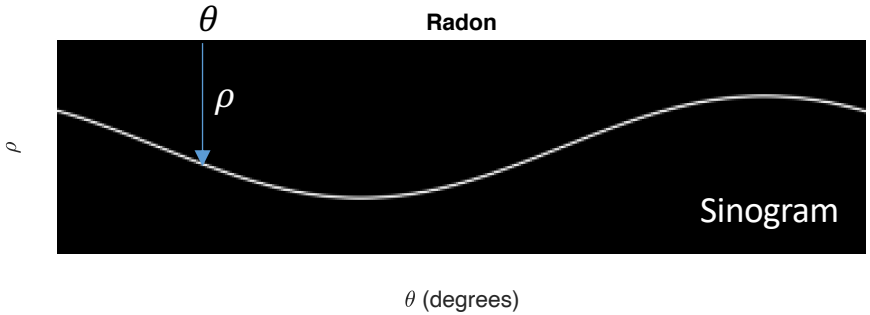
https://two-views.com/ct/brain-scan.html

Radon transform

$$\rho = x\cos(\theta) + y\sin(\theta)$$



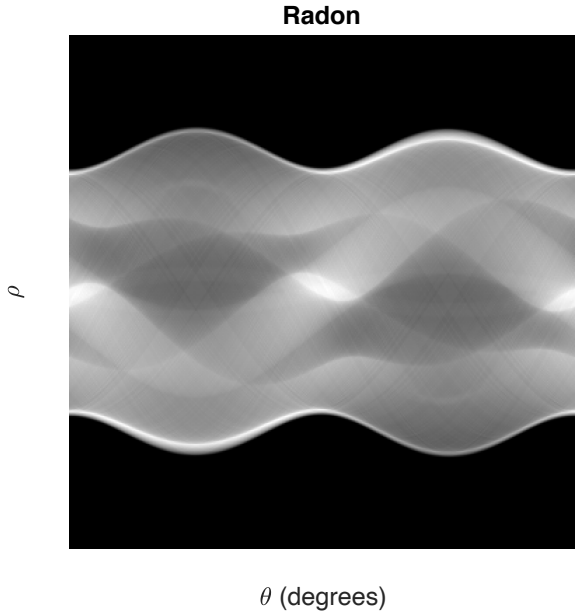




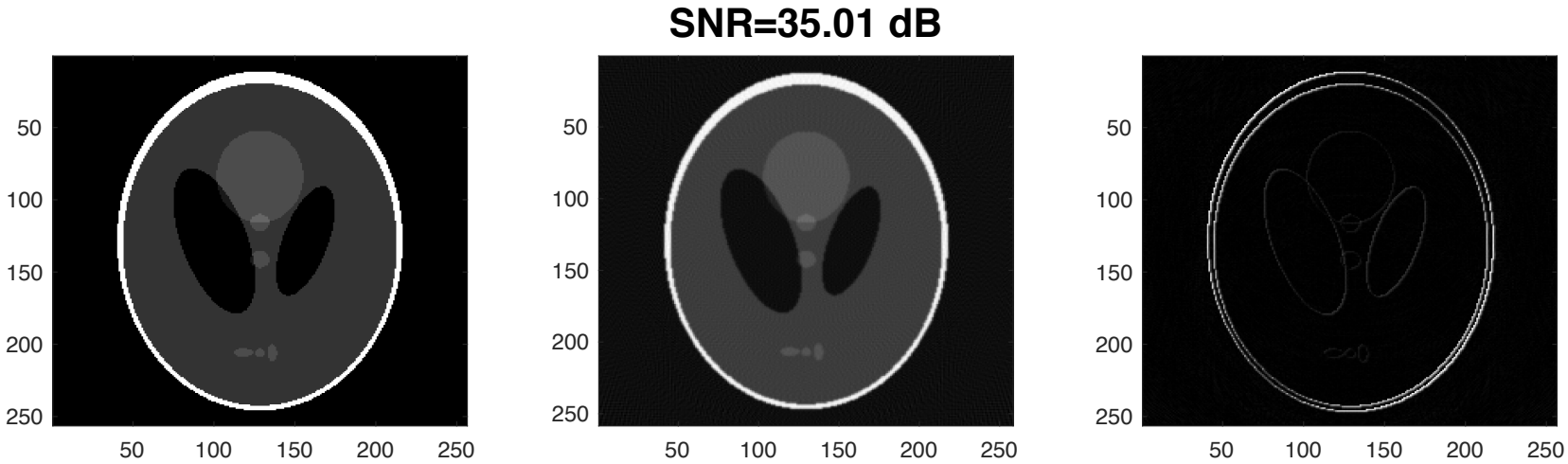
$$R(\rho,\theta) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\delta(\rho - x\cos\theta - y\sin\theta)dx\,dy$$

Radon transform

This is the observation



Inverse Radon



Inverse Radon

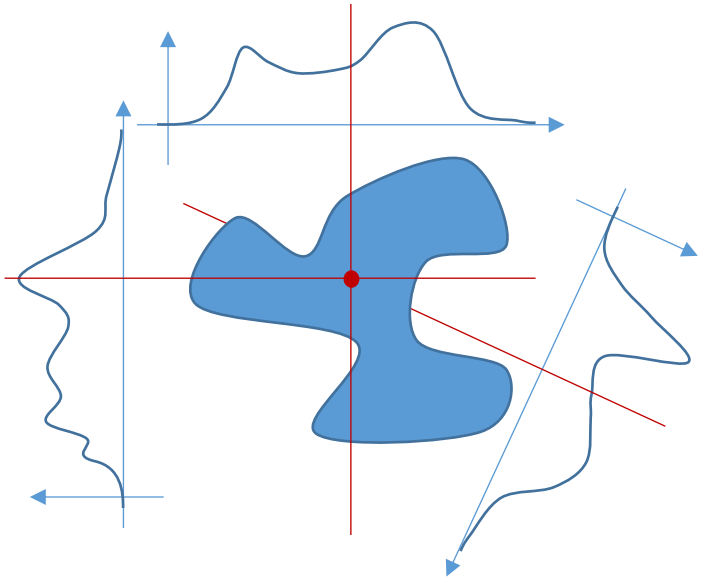
Reconstruction Methods

- Fourier Reconstruction
- **Backprojection** Filtering
- Fourier Filtered Backprojection

Backprojection

The value of the backprojection B(x,y) is evaluated by integrating $R(\rho, \theta)$ over θ for all lines that pass through that point.

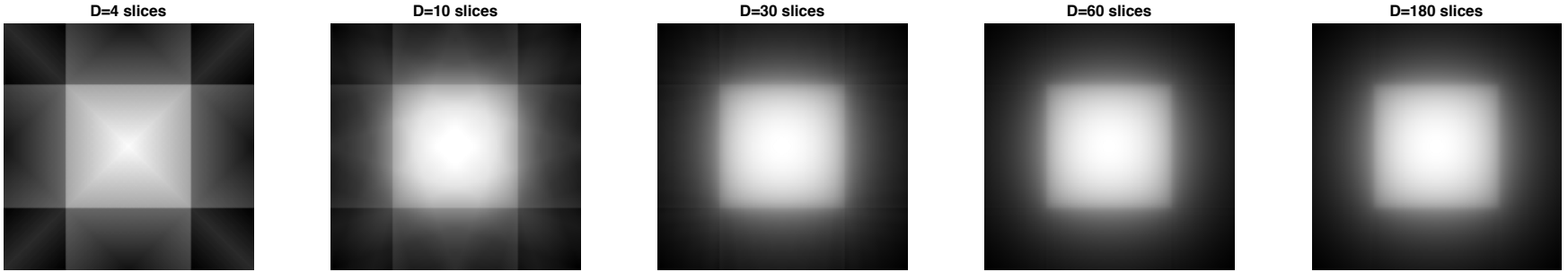
$$B(x,y) = \int_0^{\pi} R(\rho = xcos(\theta) + ysin(\theta), \theta)\, d\theta$$



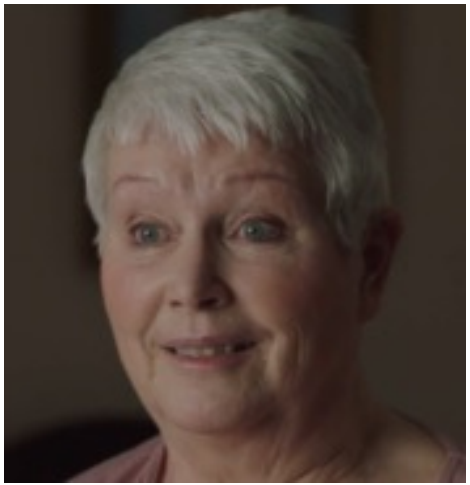
Backprojection

Discrete number of projections

$$\tilde{B}(x,y) = \sum_{k} R(\rho = xcos(\theta_k) + ysin(\theta_k), \theta_k)$$



Lena



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