Master MOSiG - M1

Signal Processing

Filtered Back Projection

Computer Exercises N. 5

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1 Tomography

Question 1.1.

Explain in a small paragraph (about 15-20 lines) how X-Ray scanners work.

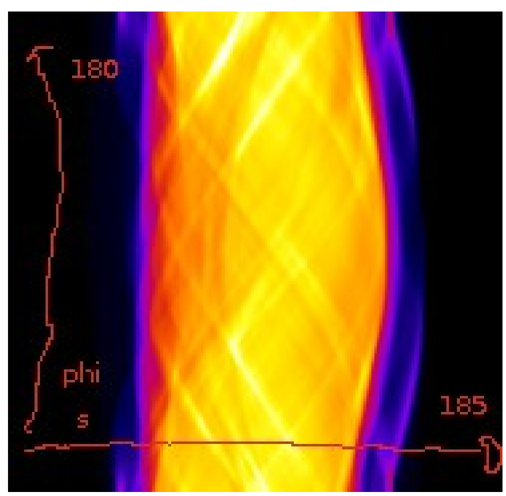
A project financed by EMI – audio industry company – the x-ray the discovery was credited to Wilhelm Conrad Röntgen in 1895.
X-Ray is a electromagnetic wave with a pretty high frequency (means that accumulates a lot of energy) , that's why the X-Ray are so dangerous for Human Beings in high doses, these rays destabilize cells, duo to the amount of energy in which they hit the atoms of the cells.
X-Rays can be classified as soft or hard, according to the wavelength of the Ray; A short wavelength x-ray is called soft x-ray, and a longer wavelength is called hard x-rays.
The wavelength characteristics determine the x-ray level of penetration, so harder x-rays is, more it penetrates in the material.
The radiography, which uses the X-Rays, must use the "hard" x-rays (harmful ones) since it's necessary to penetrate in the material analyzed. The images are produced based on the contrast between of the amount of rays that were not stopped by the material and the ones which were stopped by the material.
They – the x-rays – do not penetrate on dense material, normally metal elements with a high atomic number. That's why usually to take contrasted radiography the observed object(which normally is a biologic material) must drink a liquid based in bohrium element(atomic number 107) is used.
But, as the image depends only on the contrast and it is a 2D representation of an object it loses information about the object analyzed.

Question 1.2.

Represent this sinogram with title, axis labels, etc.

Pole is analogous to the origin in the coordinate system, this system is based in a distance of the pole and an angle, where the center is the pole. We cannot see the image because we are usual to work with image in a coordinate system and not in polar.

The φ (phi) is located at the vertical line (ordinate).
S is located at the horizontal line (abscissa).



2 Filtered...

Question 2.1.

Complete the following code to fill in the list of complex signals sinoFT which contains the Fourier Transform of the sinogram along each direction.

We used the array *sino,* which contains the signals provided by the function *openSinogram* (assuming that this function exists). Each signal represents the Radon Transform of *f* for one angle Phi. We iterate in this array, take the signal, and apply the Fourier Transform in each of them. We storage the result in the array *sinoFT.*

```
ArrayList <ComplexSignal> sinoFT = new ArrayList <ComplexSignal> ();

ArrayList<Signal> sino = openSinogram("data/sino_phi_s");
int nPhi = sino.size();
int nS = sino.get(0).getNbSamples();

for (int i=0; i<=nPhi-1; i++)
    sinoFT.add(sino.get(i).dft());
```

Question 2.2.

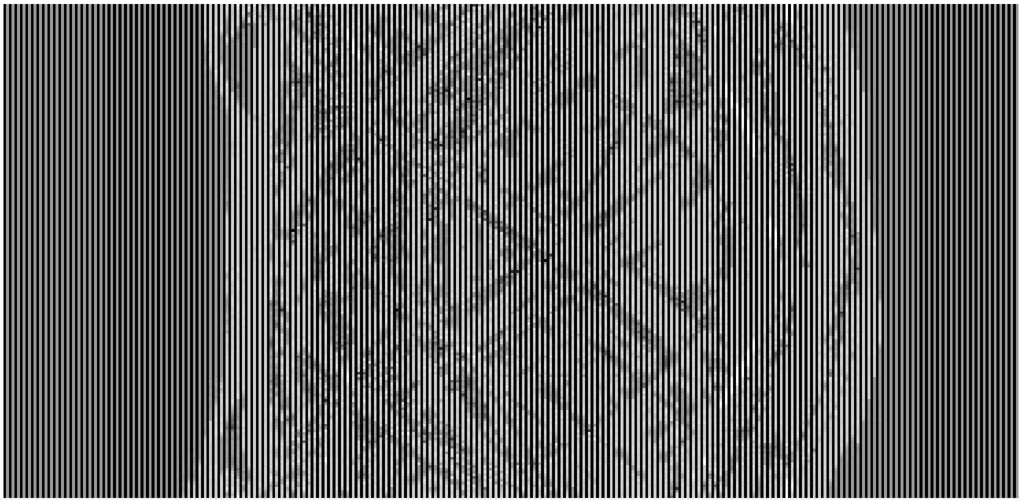
Complete the following code to obtain the expression 2 in the list sinoFiltered.

We didn't compute the Complex part of the formula (the part where appears "*e*") because it is complicated and it was recommended by professor skip this part.
We did the same code as before, adding the part that multiplies the result of the Fourier Transform for ω.

```
ArrayList<ComplexSignal> sinoFiltered = new ArrayList<ComplexSignal>();
ArrayList<Signal> sino = openSinogram("data/sino_phi_s");
int nPhi = sino.size();
int nS = sino.get(0).getNbSamples();

for (int i=0; i<=nPhi-1; i++){
    ComplexSignal cs=new ComplexSignal();
    cs=sino.get(i).dft();
    for (int j=0; j <= nS-1; j++) {
        cs.get(j).multiplyByReal(2*Math.PI/nS);
    }
    sinoFiltered.add(cs);
}
```

Question 2.3.

Display the resulting sinogram and explain what it represents.



The basic idea behind back projection, which is to simply run the projections back through the image (hence the name “back projection”) is to obtain a rough approximation to the original. The projections will interact constructively in regions that correspond to the transmitter sources in the original image. One thing that we can observe in the original image is the blurring. From the geometry of this motion, a single *plane* within the object remains in focus, while structures outside this plane become blurred. The interfering objects are not *removed* from the image, only *blurred*. The resulting image quality is usually too poor to be of practical use. Filtered backprojection is a technique to correct the blurring encountered in simple backprojection, as we can observe at the result image.

3 ...Back Projection

Question 3.1.

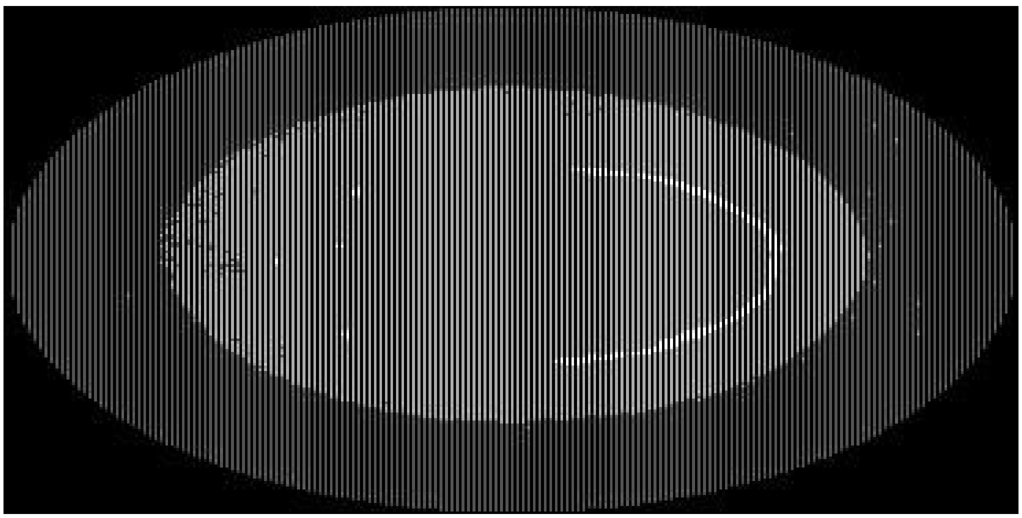
Complete the following code:

```
double [ ] [ ] image = new double [ nS ] [ nS ] ;
double x , y ;
for ( int j = 0 ; j < nS ; j++) {
for ( int i = 0 ; i < nS ; i++) {

/** looking to the Cartesian representation we can see that x grows as i grows, so they are direct proportional.. we keep the proportion by using rule of three. **/
x = i/nS;
y = j/nS;
image [ j ] [ i ] = 0 ;

if ((x>=1&&x<=-1) && (y>=1&&y<=-1)) {
/** This ensures that x and y belongs to [-1,1] **/
for ( phi = 0 ; phi < nPhi ; phi++) {
```

```
Signal phiOriented = sinoIdft.get( phi ) ;
/**
/** To calculate the radius we can use the pithagoras, having as the edges x and y, so: r^2=x^2+y^2
**/
double r = Math.sqrt(x*x + y*y);
phiOriented.
/** Using inverse proportion to put r between 0 and nS-1**/
double rx = r*(nS-1);
s=(int)Math.floor(rx) ;
/** just following the instruction and calculating the avarage **/
double val = image [ j ] [ i ] + (rx+r)/2;
val = 2 . 0 / nPhi val ;
image [ j ] [ i ] = val ;
}
}
```

Question 3.2.

Display and comment the final image.



Since the dots in the back projection are the sum of the angles, the image is a circle. The pixels of the images are sum also, so an very high colored (well contrasted) object in the image indicates a high number of pixels intersection.

As we can see in the image, the most white part of the image is accumulated at the center, which means that most part of object is in the center of the image.

At the right side of the image we can see an arc with 180°, this is probably an object that was at the beginning of the arch of at the end of it.