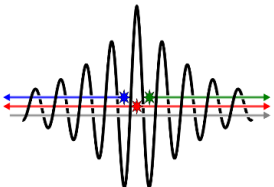


Implementation of reconstruction algorithms in SIRF/CIL

Kris Thielemans

Different levels

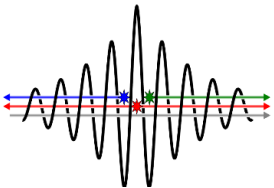
1. Use existing implementation of the underlying “engine”
(e.g.: `sirf.STIR.OSMAPOSLReconstructor`,
`sirf.Gadgetron.CartesianGRAPPAReconstructor`)
2. Use (parts of) an existing reconstructor/algorithm
(e.g. run 1 iteration, then filter, or implement your own handling of a “prior” (prox/ADMM/MAPEM))
3. Use (parts of) an existing objective function
4. Implement using an AcquisitionModel



Example of fourth level Least squares optimisation with gradient descent

$$F(x) = \frac{1}{2} \|Ax - y\|^2$$
$$\text{grad } F = A^*(Ax - y)$$

`x = x -`
`step * A.adjoint (A.direct (x) - y)`

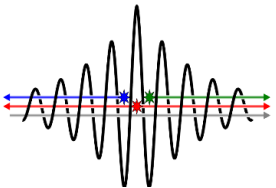


Example of third level

Gradient ascent (see later)

```
obj_fun =  
    pet.make_Poisson_loglikelihood(y)  
obj_fun.set_up(x)
```

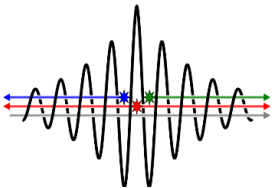
```
x = x +  
    step * obj_fun.gradient(x)
```



Example of second level Inter-iteration filtering

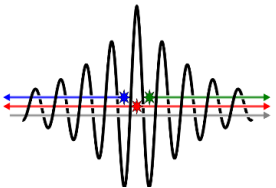
```
recon.update(x)  
x=myownfilter(x)
```

```
def myownfilter(x):  
    from scipy.ndimage import convolve  
    arr=convolve(x.as_array(),weights)  
    x.fill(arr)
```



SIRF/CIL quirks

- `sirf.STIR` objective function is “log-likelihood + log-prior”
⇒ maximisation
- `sirf.Gadgetron` and `cil` have no pre-defined objective functions, but are easy to construct



Some caveats

$$y = Ax + b$$

```
y=acq_model.forward(x)
```

```
y=acq_model.direct(x)
```

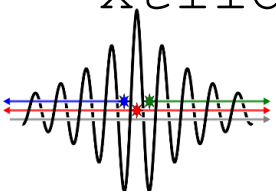
$$\text{if } b = 0, \tilde{x} = A^*y$$

```
xtilde= acq_model.backward(y)
```

```
xtilde= acq_model.adjoint(y)
```

$$\text{if } b \neq 0, \tilde{x} = A^*y$$

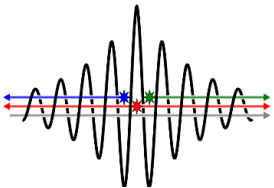
```
xtilde= acq_model.backward(y)
```



Why is A^* the “backward” operation?

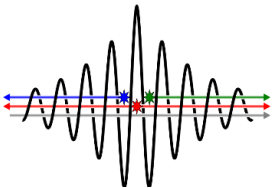
$$f(A_i x + b_i) = f\left(\sum_j A_{ij} x_j + b_i\right)$$

$$\frac{\partial f}{\partial x_j} = A_{ij} f'(A_i x + b)$$



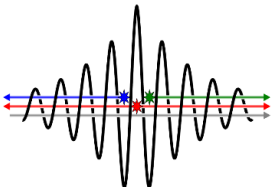
Some algorithms need a linear model

- Example: pdhg



What about image registration?

- Forward model is non-linear in terms of the deformation field
- Planned for SIRF 4.0



Summary

- Large similarities between modalities

Synergistic/gradient_descent_mr_pet_ct.ipynb

- Some specific algorithms needed to handle data

