Motion-corrected parametric reconstructions in STIR

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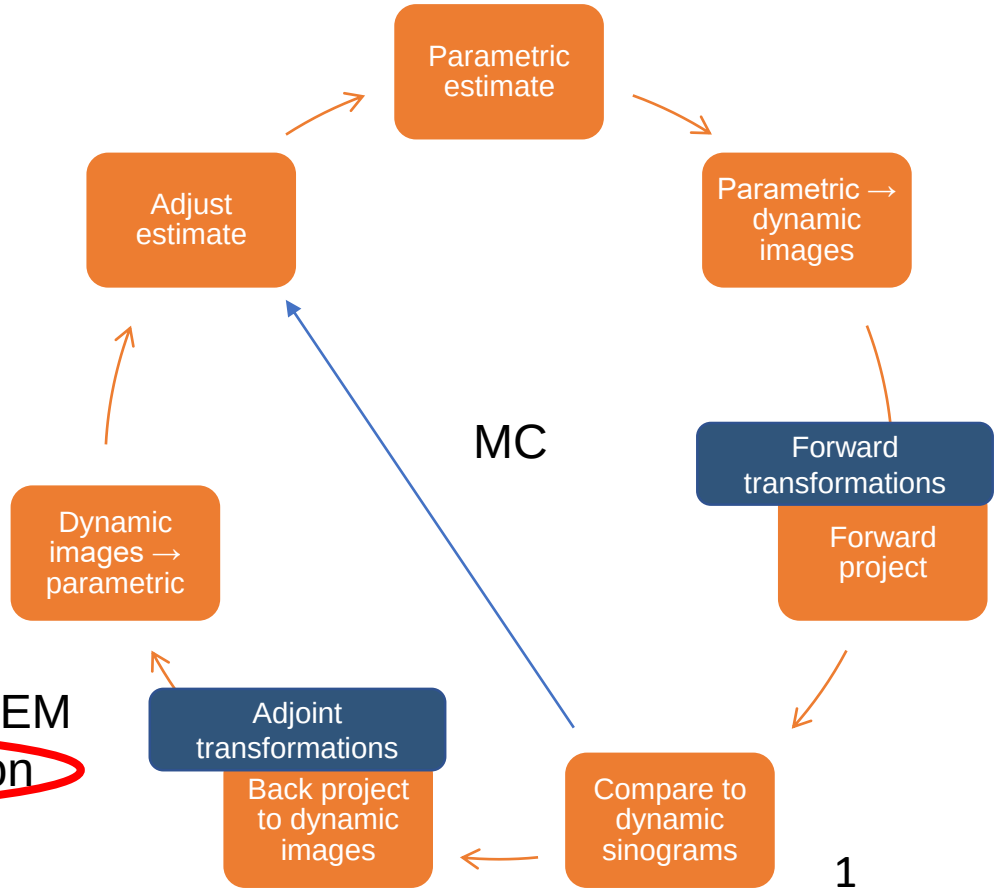
15/11/18

GOAL

- Parametric OSEM (**POSEM**) with **motion correction**
- Very simple…
  - Pass motion information to POSEM
  - Use projectors that handle motion
  - Some I/O improvements



PROJECTORS

- `PresmoothingForwardProjectorByBin` & `PostsmoothingBackProjectorByBin`

- Combine original projector pair with **any DataProcessor**
  - Normally smoothing
  - `NonRigidObjectTransformationUsingBSplines`

  `src/experimental` (used to be `src/local`)

PROJECTORS

```
// Motion
shared_ptr<NonRigidObjectTransformationUsingBSplines<3,float> > fwrd_non_rigid(
            new NonRigidObjectTransformationUsingBSplines<3,float>(_disp_4D, _bspline_order));

// Data processors
shared_ptr<Transform3DObjectImageProcessor<float> > forward_transform(
            new Transform3DObjectImageProcessor<float>(fwrd_non_rigid));
shared_ptr<Transform3DObjectImageProcessor<float> > adjoint_transform(
            new Transform3DObjectImageProcessor<float>(*forward_transform));
adjoint_transform->set_do_transpose(!forward_transform->get_do_transpose());

// Create projectors
shared_ptr<PresmoothingForwardProjectorByBin> fwrd_projector;
shared_ptr<PostsmoothingBackProjectorByBin>   back_projector;
fwrd_projector.reset(
            new PresmoothingForwardProjectorByBin(
                projector_pair_sptr->get_forward_projector_sptr(),
                forward_transform));
back_projector.reset(
            new PostsmoothingBackProjectorByBin(
                projector_pair_sptr->get_back_projector_sptr(),
                adjoint_transform));
```

I/O

- Reading

```
typedef itk::ImageFileReader<ITKImageMulti> ReaderType;
ReaderType::Pointer reader = ReaderType::New();
reader->SetFileName(filename);
reader->Update();

// Only support Nifti for now
if (strcmp(reader->GetImageIO()->GetNameOfClass(), "NiftiImageIO") != 0) {
    error("read_file_itk: Only Nifti images are currently support for multicomponent images %s:%d.",
          __FILE__, __LINE__);
    return NULL; }

if (reader->GetImageIO()->GetPixelType() != itk::ImageIOBase::VECTOR) {
    error("read_file_itk: Image type should be vector %s:%d.",
          __FILE__, __LINE__);
    return NULL; }

warning("Only displacement fields are currently supported in STIR (not deformations). "
        "There is no way of verifying this from the nifti_image metadata, so you need to "
        "make sure that the image you are supplying is a displacement field image.");

ITKImageMulti::Pointer itk_image = reader->GetOutput();

return convert_ITK_to_STIR<ITKImageMulti, STIRImageMulti>
  (itk_image, true);
```

I/O (2/3)

- Read and write **interfile**:
- `ParametricDiscretisedDensity`
- `DynamicDiscretisedDensity`

```
!INTERFILE  :=
name of data file := MC_10.v
!GENERAL DATA :=
originating system := Siemens mMR
!imaging modality := PT
patient orientation := head_in
patient rotation := supine
!GENERAL IMAGE DATA :=
!type of data := PET
imagedata byte order := LITTLEENDIAN
!PET STUDY (General) :=
number of time frames := 1
image duration (sec)[1] := 1950
image relative start time (sec)[1] := 750
energy window lower level := 430
energy window upper level :=  610
number of image data types := 2
index nesting level := {data type}
image data type description[1] := slope
image data type description[2] := intercept
!PET data type := Image
process status := Reconstructed
!number format := float
```

I/O (3/3)

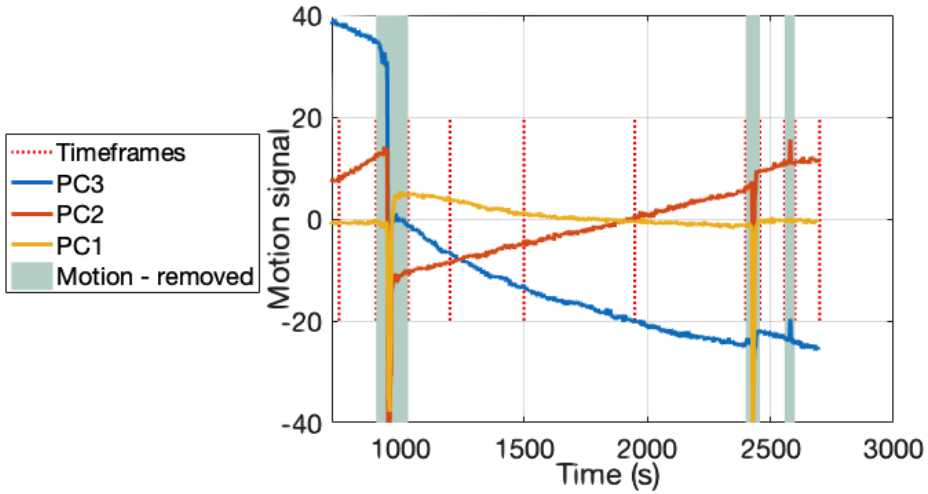
- New format, **Multi** (images, sinograms, etc.)

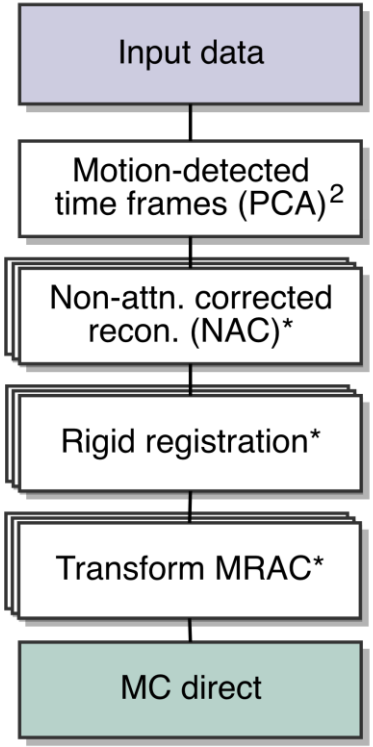
```
Multi :=
    total number of data sets := 7
    data set[1] := sino_f1.hs
    data set[2] := sino_f2.hs
    data set[3] := sino_f3.hs
    data set[4] := sino_f4.hs
    data set[5] := sino_f5.hs
    data set[6] := sino_f6.hs
    data set[7] := sino_f7.hs
```

4D Nifti's

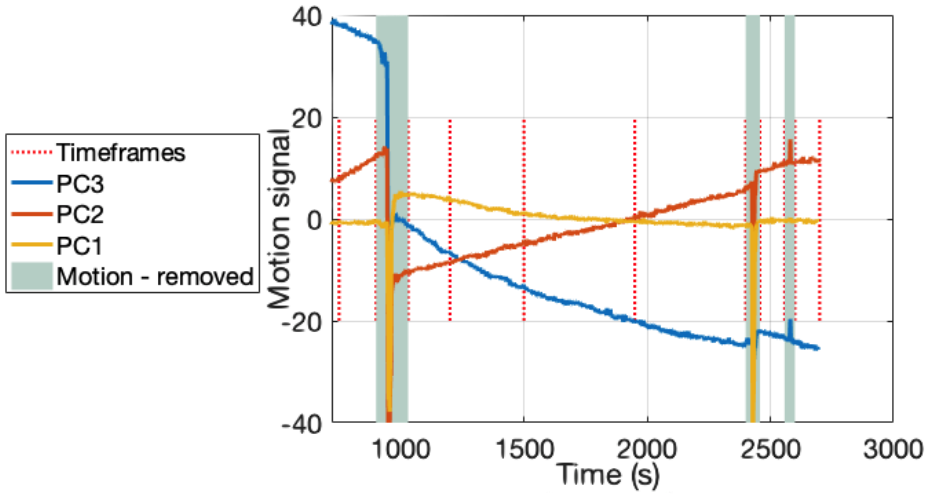
- This method requires 4D Nifti's. How to get them?
- Synergistic Image Reconstruction Framework – **SIRF**
  - Branch – **SIRFReg**, wrapper around **NiftyReg**
- Export 4D Nifti's for **rigid, affine and non-rigid** registrations

RESULTS 1/2

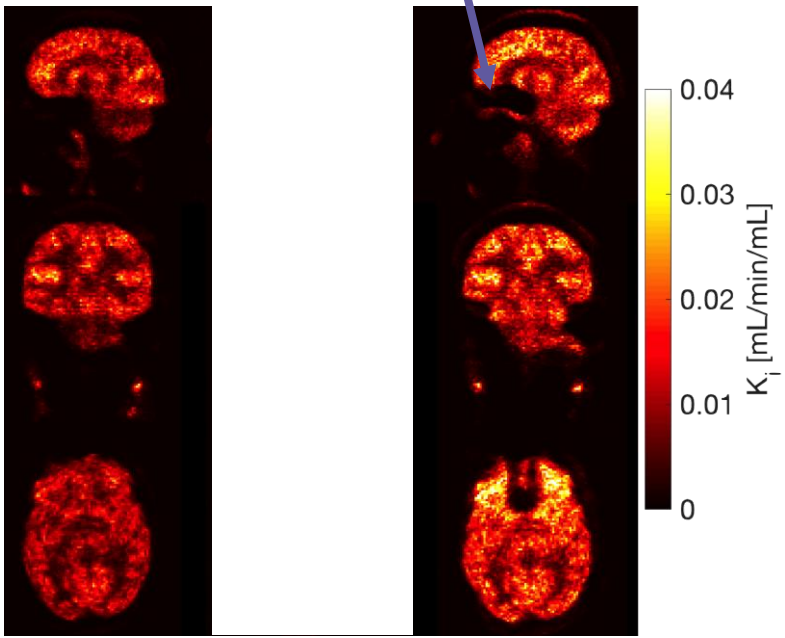

Timeframes
PC3
PC2
PC1
Motion - removed
Motion signal
40
20
0
-20
-40
1000
1500
2000
2500
3000
Time (s)


Input data
Motion-detected time frames (PCA)^2
Non-attn. corrected recon. (NAC)*
Rigid registration*
Transform MRAC*
MC direct

RESULTS 2/2



Underestimation of inferior frontal lobe.



MC direct *noMC direct*

EXTRAS

Moved `src/local` to `src/experimental`

Executables:

- `extract_dynamic_images`
  static images from dynamic image
- `postfilter`
  dynamic and **parametric** images
- `non_rigid_transform`
  using b-splines
- `get_dynamic_images_from_parametric_image`
- `make_parametric_image_from_components`

Still to do…

- Back projection with motion currently **breaks openMP compatibility**.
  - back projection now **accumulates into single image**, fundamental change to projection method in STIR
  - Once fixed, **merge PR**

Future

- Parametric priors (PLS)