STIR

SOFTWARE FOR TOMOGRAPHIC IMAGE RECONSTRUCTION

HTTP://STIR.SOURCEFORGE.NET

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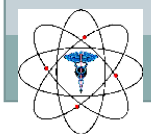
http://asc.uk.com/

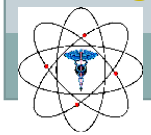
Agenda

- Kris Thielemans (Algorithms and Software Consulting Ltd)
  Introduction to STIR 2.1 - History – Demo
- Charalampos Tsoumpas (King's College London)
  Simulating PET data using STIR
- Dávid Völgyes (University of Oslo)
  Use of STIR for the COMPET project
- **Logo competition**
- **Future of STIR**



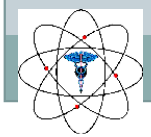
STIR objectives

- Open Source software for image reconstruction and data manipulation in medical imaging (but currently only PET)
- Research enabler
- Extendable and modular
- Portable to any system with a capable C++ compiler
  - GNU C++, MS Visual Studio, Clang, Intel C++
  - Linux, Windows, MacOS, Solaris, …



History: PARAPET

- European Union funded project (ESPRIT), 3 years (end March 2000)
- Aim: Implementation and Evaluation of Reconstruction algorithms for fully 3D PET with feasible run-time
  - Algorithm development, parallel hardware
- Partners
  - Hammersmith Hosp. - MRC, London, UK,
    Terry SPINKS
  - Brunel Univ, Dept of Math. Sciences, London, UK,
    Gautam MITRA
  - Ospedale San Raffaele (HSR), Milan, Italy,
    Maria Carla GILARDI
  - Technion - Israel Inst of Techn, Optimization Center, Haifa, Israel,
    Aharon BEN-TAL, Roni LEVKOVITZ
  - ELGEMS Ltd., Haifa, Israel,
    Michael WILK
  - Geneva Univ Hosp (HUG), Div. of Nucl. Med., Geneva, Switzerland,
    Christian MOREL
  - Parsytec GmbH, Aachen, Germany,
    Carsten RIETBROCK, Stefan KAISER, Volkmar FRIEDRICH

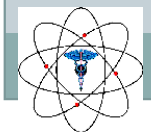


PARAPET Programmers

- Zverovich, Alexey (Brunel)
- Zibulevsky, Michael (MOC)
- Zaidi, Habib (HUG)
- Valente, Patrick (Brunel)
- Thielemans, Kris (MRC)
- Sauge, Damien (HUG)
- Sadki, Mustapha (Brunel)
- Pagani, Elizabetta (HSR)
- Mustafovic, Sanida (MRC)
- Labbe, Claire (HUG)
- Jacobson, Matthew (MOC)
- Hague, Darren (Brunel)
- Gordon, Ekaterina (MOC)
- Belluzzo, Damiano (HSR)

STIR over the years

- *PARAPET* is Dead, Long Live *STIR*!
- IRSL/Hammersmith Imanet period
  - Stir 1.0 (December 2001)
  - Stir 1.4 (January 2006)
  - Stir 2.0 (June 2009)
  - Stir 2.1 (June 2011)
- Current Users
  - Registrations ~ 100 in 2011
  - Announcements mailing list ~ 200 subscribers
  - Users' mailing list ~ 210 subscribers
  - Developers' mailing list ~ 75 subscribers



STIR at this conference

- MIC21.S-87 G. S. P. Mok, T. Sun, T.-H. Wu, M.-B. Chang, T.-C. Huang *"Interpolated Average CT for Attenuation Correction in PET - a Simulation Study"*
- MIC17-3 Polycarpou I, Tsoumpas C, Marsden PK *"Statistical Evaluation of PET Motion Correction Methods Using MR Derived Motion Fields."*
- MIC17-5 A. P. King, C. Tsoumpas, C. Buerger, V. Schulz, P. Marsden, T. Schaeffter *"Real-Time Respiratory Motion Correction for Simultaneous PET-MR Using an MR-Derived Motion Model"*
- MIC16-5 C. Buerger, A. Aitken, C. Tsoumpas, A.P. King, V. Schulz, P. Marsden, and T. Schaeffter *"Investigation of 4D PET Attenuation Correction Using Ultra-Short Echo Time MR"*
- MIC18.M-6 I. Szanda, L. Livieratos, G. Patay, C. Tsoumpas, K. Sunassee, G.E. Mullen, G. Nemeth, P. Major, P. K. Marsden, *"Partial Volume Effect and a Partial Volume Correction for the NanoPET/CTTM Pre-Clinical PET/CT Scanner"*
- MIC21.S-42 C. Tsoumpas, I. Polycarpou, C. Buerger, T. Schaeffter, P. K. Marsden *"The Effect of Regularization on Image Quality and Quantification in Motion Compensated PET Image Reconstruction"*
- MIC18.M-188 K Thielemans, S Rathore, F Engbrant, P Razifar "Device-less gating for PET/CT using PCA"
- + about 10 others

STIR current features (User's perspective)

- Support for any cylindrical PET scanner (2D/3D)
- Normalisation/randoms/attenuation correction
- Scatter estimation/correction
- Analytic and iterative 3D reconstruction algorithms

  FBP, SSRB, OS-MAP-OSL (including MRP), OS-SPS
- Parametric image construction

  Linear kinetic modelling; from either image or sinogram
- Various utilities (e.g. precorrection, ROI, …)
- Sinogram data formats: Interfile, ECAT 7 Matrix and partially GE VOLPET

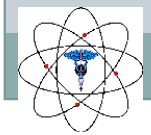
- Test suite

Run-time parameter selection

```
OSSPSParameters :=
objective function type:= PoissonLogLikelihoodWithLinearModelForMeanAndProjData
PoissonLogLikelihoodWithLinearModelForMeanAndProjData Parameters:=
 input file := test.hs
 projector pair type := Matrix
     Projector Pair Using Matrix Parameters :=
         Matrix type := Ray Tracing
             Ray tracing matrix parameters :=
             End Ray tracing matrix parameters :=
     End Projector Pair Using Matrix Parameters :=
 Bin Normalisation type := From ProjData
    Bin Normalisation From ProjData :=
        normalisation projdata filename:= norm.hs
    End Bin Normalisation From ProjData:=
 prior type := quadratic
     Quadratic Prior Parameters:=
          penalisation factor := 1
    End Quadratic Prior Parameters:=
end PoissonLogLikelihoodWithLinearModelForMeanAndProjData Parameters:=
initial estimate:= some_image
output filename prefix := test
number of subsets:= 12
number of subiterations:= 24
relaxation parameter := 1
relaxation gamma:=.1
END :=
```

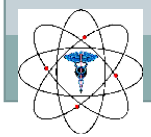
Developer's perspective

- Object-oriented (C++) and modular
- Documented (doxygen)
- Test framework
- Extendable
  - Mechanism for extending library such that current STIR applications can use your module (e.g. projector) after recompilation
  - Mechanism for writing new applications using (original or extended) library

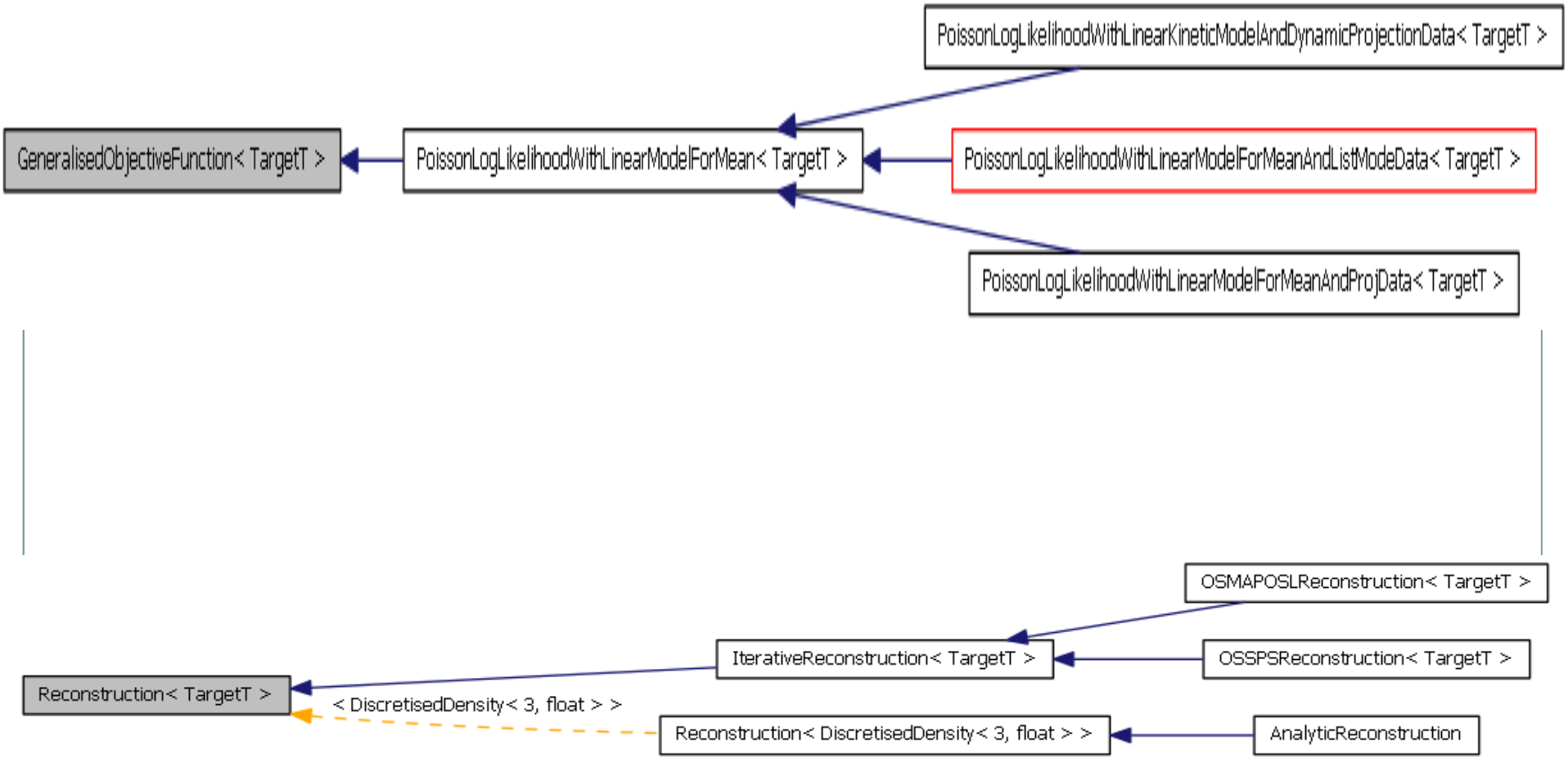


Object-oriented programming

- Advantages
  - modularity & robustness:
    each class can be developed/tested ‘independently’
  - flexibility:
    data-representation can be adapted to situation
  - generality:
    ‘generic’ programming in terms of base-classes
  - extendability:
    new extensions can benefit from old code by inheritance
  - ease-of-use for the ‘user’

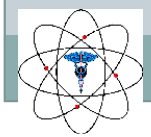


Example hierarchies



Example code

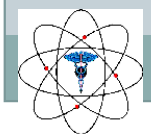
```
///////////////// provide short-hand for the image type we're using
typedef DiscretisedDensity<3,float> ImageType;

///////////////// read in data
shared_ptr<ProjData> proj_data_sptr =
    ProjData::read_from_file(input_filename);
shared_ptr<ImageType> density_sptr =
   read_from_file<ImageType>(filename);

///////////////// back project
BackProjectorByBinUsingInterpolation back_projector;
shared_ptr<ProjDataInfo> proj_data_info_sptr =
    proj_data_sptr->get_proj_data_info_ptr()->clone();
back_projector.set_up(proj_data_info_sptr, density_sptr);
density_sptr->fill(0);
back_projector.back_project(*density_sptr, *proj_data_sptr);

///////////////// output
OutputFileFormat<ImageType>::default_sptr()->
      write_to_file("output.hv", *density_sptr);
```



Support

- Documentation
  - User's Guide, Developer's Guide, Glossary, …
  - Doxygen generated documentation
  - Wiki (includes FAQs)
- Mailing lists
  - stir-users/stir-devel@lists.sourceforge.net
  - Use for all your questions
  - Searchable
- Specific requests, paid for support

http://asc.uk.com



License

PARAPET license

No restrictions, but give credit to PARAPET partners

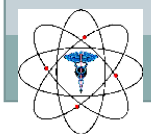
Lesser GNU Public License (LGPL) for library

'free', if redistributing, then source code most be available and modifications have to be included (and LGPL'ed)

GNU Public License (GPL) for applications

LGPL+ if redistributing, then whole application must be GPL

Free, but NO warranty



A new logo for STIR

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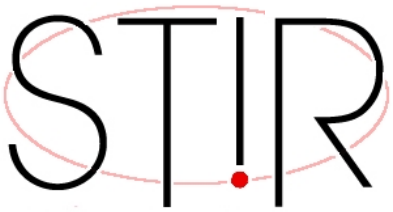

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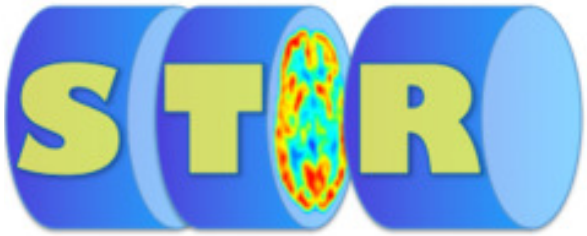

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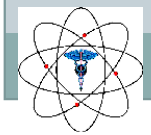
1,5 Mario Cañadas Castro
2 Charalampos Tsoumpas
3,6 Pablo Aguiar
4 William Hunter
7 Robbie Barnett
8 Matthew Jacobson

The future of STIR

- Hammersmith Imanet/GE no longer involved with STIR
- Need to expand developer community
- How to accept contributions

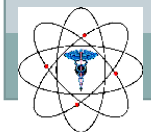


Example 1

Free Software Foundation

Insight Consortium (until recently?)

Contributors assign copyright to “foundation” (possibly retaining rights)



Example 2

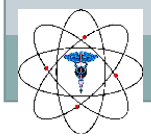
OpenGATE collaboration

- Semi-closed community with collaboration agreement
- First access to new code
- Occasional official public releases
- Other users can submit their contribution

Example 3

Truly open-source

- Approved developers get write access to source code repository
- Everyone gets read access to repository
- Occasional public releases



Missing features

- Non-cylindrical scanner
- Testing of list mode reconstruction
- TOF
- Normalisation factor estimation
- More priors
  - e.g. Fessler's "kappa"
- Speed
  - Multi-threading (OpenMP)
  - GPU
- Closer connection with SimSET/GATE
- Interfaces with other languages
- SPECT

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