SOFTWARE FOR TOMOGRAPHIC IMAGE RECONSTRUCTION

HTTP://STIR.SOURCEFORGE.NET

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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
  - 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
  - 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”
- 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
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 must 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

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
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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