Overview of the J-PET analysis and simulation software

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3rd Symposium on Positron Emission Tomography Kraków, 11.09. 2018

J-PET software



Monte Carlo simulations

Detector calibrations

Data analysis

Data Acquistion System

Session 8:

- R.Y. Shopa
- L. Raczyński

Monte Carlo simulations



Data analysis

- In this session:
- K. Kacprzak
- A. Gajos
- + many more talks

4

Monte Carlo simulations

Detector calibrations

Data analysis

Data Acquistion System

Image reconstruction Data analysis

Monte Carlo simulations

Detector calibrations

Data Acquistion System

- Data analysis framework,
- MC simulations,
- Image reconstruction algo,
- MC/data postprocessing



C++



- Data analysis framework,
- MC simulations,
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Python



- Image reconstruction prototyping,
- validation studies,
- simple MC simulations







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ba&sh

+ many more











Taken from http://faculty.washington.edu/aalessio/papers/alessioPETRecon.pdf

Standard algorithms

Filtered Back-Projection (FBP)



Taken from Kamil Rakoczy' bachelor thesis (2017)

Standard algorithms

Filtered Back-Projection (FBP)

Maximum Likelihood-Expectation Maximization (MLEM)



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Image reconstruction – current status

Home-made implementations:

- MLEM (A. Strzelecki)
- 2-D FBP (K. Rakoczy)
- "Naive" online reconstruction (G. Korcyl)



 BPF + regularization methods (L. Raczyński)



Software for Tomographic Image Reconstruction

FBP (P. Kopka, K. Klimaszewski)



FBP +KDE (R. Shopa)

Image reconstruction- challenges

Conventional tomography

- Adapt known algorithms to exploit (or at least not deteriorate) J-PET advantages:
 - timing resolution
 - multiple layers
- Incorporation of all standard image correction procedures (attenuation, scatter corrections)

Three-photon tomography, 2+1 tomography, PALS, quantum tomography...

• Still a lot of work to be done on low-level reconstruction and MC tests

Monte Carlo simulations

• Experimental sensitivity studies

D. Kaminska et al. Eur. Phys. J. C (2016) 76:445 P. Kowalski et al. Phys. Med. Biol.(2018) 63, Number 16

- Calibration procedure development
- Selection criteria during data analysis
- Studies of optimal detector setups





Monte Carlo simulations



GATE

(D. Kisielewska, S. Sharma)

https://github.com/JPETTomography/J-PET-geant4

(P. Kowalski, M. Bała, Y. Fedorova) + Bronowice group



Simulations of Preclinical and Clinical Scans in Emission Tomography, Transmission Tomography and Radiation Therapy

https://github.com/JPETTomography/Gate

• Standalone simulation package (R. Masełek)

https://github.com/JPETTomography/j-pet-ortho-simulations

We are not only users but also developers !!!!

J-PET software



Calibrations



Way to "fix" imperfection of the real world :-)

Calibrations





- See the dedicated session 5
- All calibrations implemented
- as Tasks in the J-PET Framework

Way to "fix" imperfection of the real world :-)

*Stolen from very old presentations of M. Skurzok and M. Silarski



J-PET Framework = platform for data analysis

- Reflect "reality" (use familiar "language"),
- Standarize common tools and operations,
- One task = interexchangable block

W. Krzemien et al. Acta Phys.Polon. A127 (2015) 1491-1494



Technicalities



- Open source project
- Mainly developed in C++11
- ROOT-based data structure (ROOT5, ROOT6 in the next release)
- Heavy usage of BOOST library,
- Quality ensured by automatic set of tests (Jenkins & Travis)









A pair of JPetHit objects

Scheme of the analysis with J-Pet framework

Each analysis module is a separate C++ class.



J-Pet Framework v6 (soon :-))

- Incorporation of MC
- ROOT6 compatibility
- Iterative scheme (e.g. for time calibration)
- Data streams (medical/physics/cosmics)
- Inter-treshold calibration
- Better error-handling
- MLEM package incorporation

J-PET Framework at GitHub

Framework core (library): https://github.com/JPETTomography/j-pet-framework

Usage examples: https://github.com/JPETTomography/j-pet-framework-examples



Continous integration and testing





flexible project management

961	Rozszerzenie	New	Low	Check the acceptance map output from MLEM package	Kamil Rakoczy	2018-07-02
960	Blad	Answer	Normal	Update includes for current Framework version in Event Display	Kamil Rakoczy	2018-06-27
959	Rozszerzenie	New	Normal	Improve LargeBarrel example	Aleksander Gajos	2018-06-20
953	Blad	In progress	Normal	Problem with Unpacker	Aleksander Gajos	2018-05-17
947	Wsparcie	In progress	Normal	Verify that the incomplete setups (missing TRef-s) are harmless for Examples' UT-s	Krzysztof Kacprzak	2018-04-30
945	Rozszerzenie	New	Low	MC implementation of small annihilation chamber		2018-04-26
944	Rozszerzenie	New	Low	MC implementation of collimator		2018-04-26
943	Rozszerzenie	Answer	Normal	MC Implementation of missing DecayVertex structures	Wojciech Krzemien	2018-04-26
942	Rozszerzenie	In progress	Normal	MC time optimization -> Energy cuts	Sushil Sharma	2018-04-26

Recommended way to report a bug

Github contributors



Github contributors



core maintainance & support a.k.a. "dirty job nobody appreciates": A. Gajos, W. Krzemień, K. Rakoczy

Collaborative work



https://xkcd.com/1597/

J-PET software workshops & tutorials



- STIR FBP 3D Workshop, NCBJ, Warszawa, 22.03.2018
- GATE and Reconstruction Workshop, NCBJ, Warszawa, 22.03.2018
- Second J-PET Framework Workshop, UJ, Kraków, 20-21.03.2017
- J-PET Software Workshop, UJ, Kraków, 07-08. 07.2016
- First J-PET Framework Workshop, NCBJ, Warszawa, 09.04.2015

Data analysis is hard



dealing with the complexity

Physicist vs Programmer

It compiles and runs, so the program must be correct

Physicist vs Programmer

The best solution is to put my 10000 lines of code in one function



Investing in software quality is not a waste of time

- Common analysis procedures \rightarrow faster start for newcomers
- Less stupid errors
- Examples of other projects (e.g. @CERN)

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It does not directly give us the confirmation of CP violation in the positronium ...

but in the long term provides high quality scientific results.



New contributors are welcome!!! Framework developers meetings ~2 weeks:

http://koza.if.uj.edu.pl/petwiki/index.php/Framework_developers_meetings

Thank you for attention