Report from CCP PET-MR for the Period 01/04/17 to 30/09/17

Evgueni Ovtchinnikov (STFC, RAL, SC), Project Manager

Kris Thielemans (UCL), PI

1 Nov 2017

Background

For medical imaging, the UK is a globally leading country. It has the highest number of Positron Emission Tomography and Magnetic Resonance (PET-MR) medical imaging machines in the world, evenly spread throughout the country. The CCP PET-MR project established in 2015 aims at bringing together the best of the UK's PET-MR imaging expertise to capitalise on the investment in this area. New research shows that the use of MRI intermediate results can improve PET imaging quality and vice versa, and latest scanners can acquire MR and PET data simultaneously. Our CCP is dedicated to exploiting exciting new capabilities that the synergy of MR and PET imaging can deliver. ***The main deliverable of the project will be an open source PET-MR reconstruction software framework we named SIRF (Synergistic Image Reconstruction Framework).*** SIRF will be simple enough in use for educational and research purposes, thus reducing the "barrier for entry" for new contributors to PET-MR imaging research and development, and at the same time powerful enough to process real scanner data.

STFC CoSeC support for this CCP currently focusses on developing the SIRF code base that provides an easy-to-use script-language (Python and Matlab) environment built around existing open source reconstruction software. This includes maintaining network, website, running workshops and training courses, on top of the software engineering effort that contributes to SIRF development, testing, deployment and documentation.

Highlights for the Current Reporting Period

Our work during the reported period progressed according to the job plan: software development and engineering efforts, adding content to our website www.ccppetmr.ac.uk, maintaining mailing lists (we now have 88 members on the CCP-PETMR announcement list, 18 on the developers and 60 on the users lists), organising working group and executive meetings, organising a series of well-attended Developers Days' to present and discuss progress in our software framework development.

The first two public releases of our open source software suite SIRF took place in June (Release 0.9.0) and September (Release 0.9.2) 2017. These releases are based on the PET reconstruction package STIR (Software for Tomographic Image Reconstruction) and the MR reconstruction package Gadgetron. The SIRF distribution includes source code, installation instructions and scripts, test scripts, demo scripts and several layers of documentation. An Oracle Virtual Machine (VM) is also provided that has all the necessary software (except, for licensing reasons, Matlab) pre-installed for a quick start in any operating system that supports VMs. All this software is available for free download on our public website www.ccppetmr.ac.uk and via github.com/CCPPETMR.

We have obtained official agreement from GE Healthcare to provide open source software for reconstructing of their PET data, directly from the raw data from the scanner, i.e. disclosing the previously confidential file format. We have received considerably help and code from GE. This capability is now being incorporated into STIR at UCL and Leeds (due to the nature of the agreement). In addition, postdocs and students at Hull, UCL and Leeds have added Time-Of-Flight capabilities to STIR. These additions are under final stages of development and testing by participants in our community. This code will also be applicable to GE PET/CT systems, increasing the impact of our work considerably.

Researchers at the PTB (Germany) have acquired a test-suite of MR data to test capabilities for Siemens MR scanners with good results. Some issues were uncovered related to repeated sequences and orientations. These are now being addressed.

The development of SIRF opens up significant opportunity for the user community to adopt or test the codes in a real PET-MR system. For the first time ever the community will have access to a software system that facilitates end-to-end PET-MR imaging method testing, from pre-processing to reconstruction to post-processing, all under one software framework. We expect that this new development will significantly ease the efforts and time required to test and validate PET-MR methods and algorithms.

Workshops and New Opportunities

We continue with our regular meetings: Working Group meetings every 6 months, bi-monthly Executive Group meetings, Software Framework meetings every 6 weeks (average attendance ~20) and bi-weekly brainstorming tele-conferences (average attendance ~5).

A poster introducing SIRF Release 0.9.0 was presented at PSMR 2017, the 6th Conference on PET-MRI and SPECT-MRI in May 2017, Lisbon, Portugal, and a PET-MRI School for students and early stage researchers took place at this conference with a hands-on PET-MR software training session. A poster introducing SIRF Release 0.9.2 was presented at IEEE Nuclear Science Symposium and Medical Imaging Conference 21-28 October 2017.

We continue consultation with the community regarding the content of SIRF Release 1.0 planned for December 2017 and a roadmap towards Release 2.0 in 2018.

Issues and Problems

SIRF relies on a large number of existing open source software packages ("dependencies"). It has taken considerable time and effort to manage this in a stable but user-friendly way. Our main stumbling block remains to be the installation of SIRF and its pre-requisites under Windows. In particular, we have not yet succeeded in the Windows installation of Gadgetron. Consequently, the only way to run our SIRF MR scripts under Windows at present is via our Virtual Machine running Gadgetron, where it is pre-installed.

Training / Outreach

Our main outreach activities during the reported period continued to be our regular (every 6 weeks) Software Framework meetings, where we discussed our development progress with our potential users from PET-MR research community (KCL, Leeds, Manchester and other Universities' researchers) and representatives of major imaging scanner manufacturers, including Siemens and GE. We note that a majority of the universities and companies attending our developers' meetings are funded independently, i.e. outside of the core CCP support, indicating a strong community commitment. Furthermore, we have already attracted independently funded university researchers who are now actively contributing to the testing and documentation of the codes, despite the early stage of the project.

CCP PET-MR has funding to support the exchange of researchers (staff and students) between institutions. Two exchange programs were supported in the reported period: between UCL and Medical Imaging Research Center, Katholieke Universiteit Leuven (KUL), Leuven, Belgium, and between UCL and University of Leeds.

We contributed to the PET-MRI School for students and early stage researchers at PSMR 2017, the 6th Conference on PET-MRI and SPECT-MRI in May 2017, Lisbon, Portugal (25 attendants) with a hands-on PET-MR software training session using SIRF. We funded UK attendants to the school.

Courses by our network members (advertised via our CCP) included
- In May 2017, on the 9th and 10th, Dr Tsoumpas (Leeds) presented two seminars to attendees from PET centres in Japan (Akita, Chiba, Fukushima, Tohoku) which highlighted the new developments of our CCP network. At the University of Tohoku in Sendai, Japan, for a class of 12 students, Dr Tsoumpas also gave a 2 day course on PET reconstruction including practical exercises using the CCP PET-MR VM and STIR, and discussing the role of the synergy between PET and MR for more accurate modelling of the acquisition process.
- The 3rd UCL/UCLH PET MRI Course took place on 11-13 May 2017,
- KCL Course on Simultaneous PET-MR: Science and Practice on 28 June 2017.

Major code developments

Code Name	Highlight	Comments
SIRF	• Create installation script (via CMake) that installs user-specified versions of SIRF and its pre-requisites on Linux and MacOS. • Introduce post-build testing system based on CTest.	• Complete • Complete

	• Implement PET acquisitions and images algebra.	• Complete
	• Implement Matlab run-all-demos scripts and test scripts.	• Complete
	• Implement storage scheme (file/memory) management for PET and MR acquisitions.	• Complete
	• Add more documentation, including inline doxygen documentation in C++ sources and SIRF Developer Guide.	• Ongoing
	• Add more real data functionality (scattering etc.)	• Ongoing
	• Add advanced features Appendix to User Guide	• Ongoing
STIR	• Addition of Time-of-Flight capability • IO and processing for GE Signa PET/MR	• Ongoing • Ongoing