Report from CCP PET-MR for the Period 01/04/18 to 30/09/18

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## 1.	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.

## 2.	Highlights for the Current Reporting Period

In the reported period, we published two releases of our Open source software suit SIRF (Synergistic Image Reconstruction Framework): Release 1.0 (3 April 2018) and Release 1.1.1 (17 May 2018). These releases are based on PET reconstruction package STIR (Software for Tomographic Image Reconstruction) and MR reconstruction package Gadgetron. Unlike our previous releases, these two are capable of processing measured data from Siemens and GE PET-MR scanners. Major new features in Release 1.1.1 are the implementations of Parallel Level Set Prior, a crucial step in establishing the synergy of PET and MR modalities, and 2D Filtered Back Projection. SIRF distribution includes source code, installation instructions and scripts, test and demo scripts and documentation. An Oracle Virtual Machine (VM) and Docker container are also provided with all the necessary software (except Matlab) pre-installed and work on Conda installation is in progress. These are available on public CCP website. Integrated help and user guides, as well as links to the OneDrive and Drupal archives are in continual development.

CCP PET-MR has funding to support the exchange of researchers (staff and students) between institutions. In the reported period, we supported two exchange programs: between UCL and Physicalisch-Technische Bundesanstalt (PTB) Berlin, Germany, and between UCL and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia.

We contributed to the PET-MRI School for students and early stage researchers at PSMR 2018, the 7th Conference on PET-MRI and SPECT-MRI in May 2018, La Biodola, Isola d'Elba, Italy, with a hands-on PET-MR software training session using SIRF attended by 25 people.

We presented our Flagship work on Motion-corrected PET reconstruction with SIRF at PSMR2018 and contributed a presentation on SIRF and STIR to mini-symposium "Solving Inverse Problems in minutes: Software for imaging" at Society of Industrial and Applied Mathematics (SIAM) Conference on Imaging Science, Bologna, Italy, June 5-8, 2018.

On July 26-27 this year we held our first Hackathon meeting, a brainstorm session tackling various difficult issues we are facing and trying out new opportunities such as the joint development of reconstruction algorithms with the CCPi team based on SIRF and CCPi's Core Imaging Library (CIL), which already largely adopted the SIRF Object-Oriented design, with minor adjustments made to both libraries during the Hackathon. The Hackathon was attended by 12 people from RAL, UK universities, PTB and CSIRO.

In October 2018 we run a user survey regarding the requirements of target platform: which OS, which endpoint (Python, MATLAB), which type of machine and parallelism. This survey was completed by 37 users and confirmed the heterogeneity of SIRF user base and requirements. It has confirmed that both MATLAB and Python wrappers are fundamental; that user prefer OS native binary distribution methods and prebuilt Virtual Machine. Regarding parallelism the user base seem to be wary of long-term implication of GPU coding and favour CPU multithreading.

3.   Workshops and New Opportunities

We plan to continue with our regular meetings: Working Group meetings every 6 months, bi-monthly Executive Group meetings, Software Framework meetings every 6 weeks and bi-weekly brainstorming tele-conferences.

Following our participation in CCPi Fringe Meeting to the Advances in X-ray Imaging Workshop 14/06/2018, we will continue our joint CCPPETMR-CCPi effort on sharing reconstruction/analytics algorithms across the modalities and CCPs.

The second CCPPETMR Hackathon will take place in December 2018 at KCL.

On IEEE NSS/MIC 2018 conference, we will present the following two papers:

1.   Richard Brown, Benjamin A. Thomas, Alaleh Rashidnasab, Kjell Erlandsson, Evgueni Ovtchinnikov, Edoardo Pasca, Andrew Reader, Julian Matthews, Charalampos Tsoumpas and Kris Thielemans, "*Motion-Corrected Reconstruction of Parametric Images from Dynamic PET Data with the Synergistic Image Reconstruction Framework (SIRF)*", IEEE NSS/MIC, 2018.

2.   P. Wadhwa, K. Thielemans, O. Bertolli, N. Efthimiou, E. Emond, B. A. Thomas, M. Tohme, G. Delso, W. Hallett, R. Gunn, D. Buckley, C. Tsoumpas, "*Implementation and Validation of Image Reconstruction for PET Data From GE SIGNA PET/MR Scanners In the STIR Library*", IEEE NSS/MIC, 2018.

A journal paper on SIRF is in preparation.

4.   Issues and Problems.

Our main stumbling block remains the installation of SIRF and its pre-requisites under various Operating Systems. In particular, we have not yet succeeded in the Windows installation of Gadgetron. In order to run our SIRF MR scripts under Windows we employ our Virtual Machine running pre-installed Gadgetron as a Gadgetron server. In our SIRF training sessions we also use Microsoft Azure cloud computing service and Jupyter notebooks.