Report from CCPSyneRBI for the Period 01/04/21 to 30/09/21

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

Kris Thielemans (UCL), PI

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1.   Background

For medical imaging, the UK is a globally leading country. As an example, it has the highest number of PET/MR machines per capita in the world, evenly spread throughout the country. The Collaborative Computational Project in Synergistic Biomedical Imaging (CCP SyneRBI), established in 2015 as CCP in Positron Emission Tomography and Magnetic Resonance imaging (CCP PETMR) and extended in 2020 under the new name until 2025, aims to bring together the best of the UK's 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, PET and other imaging modalities can deliver. The main deliverable of the project is an open source reconstruction software framework we named SIRF (Synergistic Image Reconstruction Framework). SIRF is simple enough in use for educational and research purposes, aiming to reduce the "barrier for entry" for new contributors to imaging research and development, and at the same time powerful enough to process real scanner data.

2.   Highlights for the Current Reporting Period

We continued our software development and engineering efforts, maintaining our steadily growing mailing lists (we now have 103 members on the announcement list, 38 on the developers and 82 on the users' lists), organising online meetings, training courses and Hackathons.

Our main training activity was an online, 3-week, training course provided from 28 June to 16 July 2021 with three live Zoom sessions per week. This was organised together with the CCPi team as well as many people within the SyneRBI network. This course covered SIRF together with the image reconstruction, optimisation and regularisation software library CIL (Core Imaging Library) of the CCPi team. The course was taken by 50 people, 15 of whom were very active and 20 left positive feedback. Several new developments were put in place including ability to deploy on the STFC Cloud using JupyterHub. This course and its material will provide the foundation for future training courses and also for self-training.

During May and June 2021 we released SIRF 3.0 and 3.1. We updated versions of software packages on which SIRF depends and incorporated new functionality, with highlights being preliminary support for the PET data of the GE Signa PET/MR scanner and additional GPU projectors for PET. These releases also contain contributions from the community and in particular the support for our first non-Cartesian MR sequence (contributed by researchers from the PTB, Germany). Finally, we also transitioned our Continuous Integration (CI) testing

to GitHub Actions instead of the previously used Travis CI due to continuing problems with credits on Travis CI.

This reporting period saw the publication of our Special Issue on Synergistic Image Reconstruction for the Philosophical Transactions of the Royal Society A (in collaboration with CCPi) in two parts. In addition to the paper accepted in the previous reporting period, these special issues contain five publications directly acknowledging our network, with the first two listed describing SIRF and CIL, the main software outputs of SyneRBI and CCPi. We had 2 presentations and 5 conference abstract accepted, all at international conferences.

On 17 Sep 2021, we held the third Steering Panel meeting of CCP SyneRBI, on which we reviewed the progress on the implementation of the 3 Work Packages of our Project Work Plan: 1) Networking activities and Community Engagement, 2) Research software development, and 3) Translation towards Biomedical researchers, and discussed further steps to be taken.

1. Brown, Richard, Christoph Kolbitsch, Claire Delplancke, Evangelos Papoutsellis, Johannes Mayer, Evgueni Ovtchinnikov, Edoardo Pasca, et al. 'Motion Estimation and Correction for Simultaneous PET/MR Using SIRF and CIL'. *Philosophical Transactions of the Royal Society of London A* 379, no. 2204 (23 August 2021): 20200208. https://doi.org/10.1098/rsta.2020.0208.
2. Jørgensen, J. S., E. Ametova, G. Burca, G. Fardell, E. Papoutsellis, E. Pasca, K. Thielemans, et al. 'Core Imaging Library - Part I: A Versatile Python Framework for Tomographic Imaging'. *Philosophical Transactions of the Royal Society of London A* 379, no. 2204 (23 August 2021): 20200192. https://doi.org/10.1098/rsta.2020.0192.
3. Polycarpou, Irene, Georgios Soultanidis, and Charalampos Tsoumpas. 'Synergistic Motion Compensation Strategies for Positron Emission Tomography When Acquired Simultaneously with Magnetic Resonance Imaging'. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 379, no. 2204 (23 August 2021): 20200207. https://doi.org/10.1098/rsta.2020.0207.
4. Deidda, Daniel, Mercy I. Akerele, Robert G. Aykroyd, Marc R. Dweck, Kelley Ferreira, Rachael O. Forsythe, Warda Heetun, David E. Newby, Maaz Syed, and Charalampos Tsoumpas. 'Improved Identification of Abdominal Aortic Aneurysm Using the Kernelized Expectation Maximization Algorithm'. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 379, no. 2200 (28 June 2021): 20200201. https://doi.org/10.1098/rsta.2020.0201.
5. Mayer, Johannes, Yining Jin, Thomas-Heinrich Wurster, Marcus R. Makowski, and Christoph Kolbitsch. 'Evaluation of Synergistic Image Registration for Motion-Corrected Coronary NaF-PET-MR'. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 379, no. 2200 (28 June 2021): 20200202. https://doi.org/10.1098/rsta.2020.0202.

3.   Workshops and New Opportunities

We have submitted a project proposal to the EPSRC Software for Research Communities call on combining our software with Machine Learning for image reconstruction.

We are in the final planning stage of a joint hackathon (EPSRC-funded PET++, SyneRBI and CCPi) on implementation of stochastic optimisation algorithms for image reconstruction, to be held in November 2021. We will follow that up with another hackathon on evaluation of these algorithms, which should lead to a journal submission with a comprehensive evaluation of these algorithms for PET image reconstructions.

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 STFC cloud computing service and Jupyter notebooks as a mechanism to simplify installation for users.

Our activities on integrating with the XNAT database for integration into clinical trials is now on hold due to CoSeC funding restrictions. We hope to restart this again soon.

In person visits and exchanges are still on hold due to COVID19.