

Report from CCP SyneRBI for the Period 01/10/20 to 31/03/21

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1. Background

For medical imaging, the UK is a globally leading 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 at bringing 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, thus reducing 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 have made excellent progress on the software, with release 3.0 now imminent. Highlights include the addition of (non-Time of Flight) scatter estimation in PET, initial support for data from the GE Signa PET/MR, and a collaboration with an project on GPU projectors for PET, allowing faster computations.

On 11 February 2021 we held a joint meeting with UCL developers for XNAT, an open source imaging informatics platform that facilitates common management, productivity, and quality assurance tasks for imaging and associated data developed by the Neuroinformatics Research Group at Washington University. Thanks to its extensibility, XNAT can be used to support a wide range of imaging-based projects. The purpose of this joint meeting was to discuss the integration of the SIRF software for image reconstruction. Follow-up meetings are being planned.

In a collaboration with Newcastle University and PET Centre, we have now completed our first test acquisitions of a PET/MR phantom on the GE Signa PET/MR, with contrast in both modalities suitable for checking synergistic applications. This first dataset should lead to recommendations for other centres.

We had 2 publications published in this period.

1. Markiewicz, Pawel J., Julian C. Matthews, John Ashburner, David M. Cash, David L. Thomas, Enrico De Vita, Anna Barnes, et al. 'Uncertainty Analysis of MR-PET Image Registration for Precision Neuro-PET Imaging.' *NeuroImage*, 12 February 2021, 117821.
<https://doi.org/10.1016/j.neuroimage.2021.117821>.

2. Marquis, H., D. Deidda, A. Gillman, K. P. Willowson, Y. Gholami, T. Hioki, E. Eslick, K. Thielemans, and D. L. Bailey. 'Theranostic SPECT Reconstruction for Improved Resolution: Application to Radionuclide Therapy Dosimetry'. *EJNMMI Physics* 8, no. 1 (17 February 2021): 16. <https://doi.org/10.1186/s40658-021-00362-x>.

In addition, we have made good progress with our Special Issue on Synergistic Image Reconstruction for the Philosophical Transactions of the Royal Society A (in collaboration with CCPi). Due to quality of the submitted papers, we will have to split the Issue into 2 parts. In this reporting period, we have 1 paper accepted in this Special Issue (with 2 more accepted just after the reporting period and therefore not listed)

3. Simon R. Arridge, Matthias J. Ehrhardt, and Kris Thielemans, "(An Overview of) Synergistic Reconstruction for Multimodality/Multichannel Imaging Methods ", special issue on synergistic image reconstruction, Philosophical Transactions of the Royal Society A, accepted

Our poster submission for the 16th International Meeting on Fully Three-Dimensional Image Reconstruction in Radiology and Nuclear Medicine, also known as Fully3D, to be held in Leuven (B) in July, was also accepted:

1. Brown, Richard; Kolbitsch, Christoph; Ovtchinnikov, Evgueni; Mayer, Johannes; Gillman, Ashley; Pasca, Edoardo; Delplancke, Claire; Papoutsellis, Evangelos; Fardell, Gemma; Neji, Radhouene; da Costa-Luis, Casper; McClelland, Jamie; Eiben, Bjoern; Ehrhardt, Matthias; Thielemans, Kris, "Status update on the Synergistic Image Reconstruction Framework: version 3.0", accepted for 16th International Meeting on Fully Three-Dimensional Image Reconstruction in Radiology and Nuclear Medicine (2021)

3. Workshops and New Opportunities

We continue to engage via online resources and meetings. We are holding our 8th (virtual) hackathon 19-24 April 2021, with the aim of pushing our SIRF software and associated exercises forwards for use in our Training School for the Synergistic Image Reconstruction Framework (SIRF) and Core Imaging Library (CIL) (see <https://www.ccpsynerbi.ac.uk/SIRFCIL2021>), which we organise together with CCPi. This (online) training school will be associated to the Fully3D conference and will be running over the 3 weeks from 28 June - 16 July. We are investigating using the STFC Cloud for giving participants access to HPC systems.

4. Issues and Problems

All in person meetings were cancelled due to COVID-19 and replaced with online meetings. The frequency of our larger online meetings has now increased again w.r.t. the previous reporting period. We have also restarted acquisitions of test data, but this is still partially on hold.

We have had major problems due to the change of ownership of Travis CI, which we use for Continuous Integration testing and deployment to Dockerhub. Travis CI imposed severe limits on run-time for Open Source Software (OSS) projects, which we regularly exceed in 3 days for every month. Support for OSS in Travis CI is now limited. We are therefore transitioning to GitHub Actions.

As a framework, SIRF is unusual in the number of other software packages that it needs to build, with sometimes interdependencies between the different packages. This creates difficulties for the

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installation of SIRF and its pre-requisites under various Operating Systems. In particular, we have not yet succeeded in the Windows installation of Gadgetron and it no longer supports MacOS. We can run Gadgetron as a server via either a Virtual Machine or Docker. Unfortunately, neither of these are supported in our current Continuous Integration testing. We are exploring alternative options for this, including GitHub Actions.