Report from CCP SyneRBI for the Period 01/04/22 to 30/09/22

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1.   Background

For medical imaging, the UK is a globally leading country. 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 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

Our work during the reported period mostly progressed according to the job plan. We continued our software development and engineering efforts, adding content to our website www.ccpsynerbi.ac.uk, maintaining our mailing lists, organising online meetings, training courses and Hackathons.

On 6 July 2022 we released SIRF 3.3, our first release that adds a new modality SPECT (Single Photon Emission CT) to the two modalities, PET and MR, we have been covering in our previous releases. This is a major step forward for our Synergistic Image Reconstruction Framework, enabling for instance applications in theranostics, where PET and SPECT are often used for planning and monitoring of treatment.

Our 9th Hackathon, joint with CCPi and (EPRS-grant) PET++, took place on 4 to 7 April 2022. The goal of this hackathon was to establish a suitable reconstruction evaluation strategy, including metrics for image quality and algorithm performance (run-time, memory etc.), taking into account parameter selection for algorithms used. This will lead to an open framework for evaluation of image reconstruction algorithms, as well as at least one journal paper.

Our main training activity was the training school on SPECT/PET/MR Image Reconstruction on 29th of May for the participants of 9th PSMR-TBP Conference on PET/MR and SPECT/MR

and TotalBody PET. The in-person course was taken by 25 people, 10 of which left feedback (4.5 stars out of 5 on average).

CCP SyneRBI, together with CCPi, supported the QUIERO Workshop on Cardiac MRF Simulation & Evaluation, held on 6 July 2022, that provided participants with hands-on experience on simulation of MRF data acquisition and evaluation of T1 and T2 maps in clinical practice and using advanced machine learning approaches.

CCP SyneRBI also sponsored a two-day (12-13 Sept 2022) hybrid workshop at UCL on modern image reconstruction algorithms and practices for medical imaging, concentrating on PET, MRI and CT, with international speakers, including Prof. Jeffrey Fessler (Univ of Michigan) and an attendance of about 50 local and 30 remote. We have also hosted Prof. Craig S. Levin (Stanford University and Leeds University) for discussions and a hybrid seminar "Concepts and systems to advance coincidence time resolution for time-of-flight positron emission tomography".

This period had 2 journal papers using our software and acknowledging CPP SyneRBI by members of our network:

1. Rebecca Gillen, Kjell Erlandsson, Ana M. Denis-Bacelar, Kris Thielemans, Brian F. Hutton and Sarah J. McQuaid. "Towards accurate partial volume correction in oncology SPECT - perturbation for case-specific resolution estimation" EJNMMI Physics 9, 59 (2022). doi:10.1186/s40658-022-00489-5
2. Robert Twyman, Simon Arridge, Zeljko Kereta, Bangti Jin, Ludovica Brusaferri, Sangtae Ahn, Charles W. Stearns, Brian F. Hutton and Kris Thielemans, "*An Investigation of Stochastic Variance Reduction Algorithms for 3D Penalised PET Image Reconstruction*", IEEE Transactions on Medical Imaging (2022) doi:10.1109/TMI.2022.3203237.

3.   Workshops and New Opportunities

CCP SyneRBI co-sponsors this year's XNAT workshop, to be held in London from October 31st to November the 4th 2022. XNAT provides an open-source database + processing platform for medical images and other data. Christoph Kolbitsch (Physikalisch-Technische Bundesanstalt, Berlin, Germany) has developed a plug-in for uploading cardiac MR Data into XNAT with automatic triggering of SIRF image reconstruction for QA. At the workshop, we will have a hackathon to improve this plug-in by supporting MR raw data in XNAT, integration of PET processing and Jupyter notebooks.

We will also continue our collaboration with CCPi team to employ their Core Imaging Library (CIL) for stochastic optimisation, as well as joint motion and reconstruction estimation.

4.   Issues and Problems

CCP SyneRBI and CCPi team member Evangelos Papoutselis is leaving STFC mid October 2022 which will cause a major slowdown in our progress on incorporating advanced reconstruction algorithms into SIRF.