Report from CCP SyneRBI for the Period 01/04/20 to 30/09/20

Kris Thielemans, Chair

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1. Background

For medical imaging, the UK is a globally leading country. It has the highest number of medical imaging 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

CCP SyneRBI started in 1/4/2020, following from CCP PETMR. We chose a new name to reflect the widening of the scope to more imaging modalities. (The CCP PETMR grant has been extended for 1 year due to COVID-19, but there is only one report).

On 18 May 2020, we held the first meeting of Steering Panel of our renewed CCP. We had ~40 participants from the UK, EU and USA, reflecting the large interest in our CCP.

On 8 June 2020, we published Release 2.2 of our Open Source software suite SIRF. SIRF is now capable of processing measured data from the Siemens PET-MR scanner, with work-in-progress to support the GE PET-MR system. Major new features of Release 2.2 are the capability to use GPU for PET reconstruction, wrapping of the SPM registration toolkit, registration of complex images (needed for MR) and conversion of ISMRMRD data to other formats. This is a step towards enabling motion correction of MR images.

On 29 June 2020, we held our 26th Software Framework Meeting (~20 attendees) followed by our 6th Hackathon (11 attendees), in which we investigated and extended the use of advanced optimization algorithms from CCPi's Core Imaging Library in SIRF. Our 27th Software Framework Meeting was held on July 6th (~20 attendees), followed by our 7th Hackathon (10 attendees), in which STIR PET scanner support was investigated, initiating several enhancements. These meetings were held online only which mainly required adjustments to the format of the hackathon. As opposed to a few concentrated days with in-person meetings, the virtual hackathons were spread over 1 week with regular meeting check-points, communications via Slack, Teams etc. Feedback on this new format was positive.

We had 4 publications published in this period, where the first 3 describe our software, while the fourth uses it.

1. Ovtchinnikov, Evgueni, Richard Brown, Christoph Kolbitsch, Edoardo Pasca, Casper da Costa-Luis, Ashley G. Gillman, Benjamin A. Thomas, et al. 'SIRF: Synergistic Image Reconstruction Framework'. Computer Physics Communications 249 (1 April 2020): 107087. special issue marking 50th anniversary of the journal, https://doi.org/10.1016/j.cpc.2019.107087.
2. Mayer, Johannes, Richard Brown, Kris Thielemans, Evgueni Ovtchinnikov, Edoardo Pasca, David Atkinson, Ashley Gillman, et al. 'Flexible Numerical Simulation Framework for Dynamic PET-MR Data'. Physics in Medicine & Biology 65, no. 14 (July 2020): 145003. https://doi.org/10.1088/1361-6560/ab7eee.
3. Efthimiou, Nikos, Kris Thielemans, Elise Emond, Chris Cawthorne, Stephen J. Archibald, and Charalampos Tsoumpas. 'Use of Non-Gaussian Time-of-Flight Kernels for Image Reconstruction of Monte Carlo Simulated Data of Ultra-Fast PET Scanners'. *EJNMMI Physics* 7, no. 1 (19 June 2020): 42. https://doi.org/10.1186/s40658-020-00309-8.
4. Akerele, M. I., N. A. Karakatsanis, D. Deidda, J. Cal-Gonzalez, R. O. Forsythe, M. R. Dweck, M. Syed, et al. 'Comparison of Correction Techniques for the Spill-in Effect in Emission Tomography'. *IEEE Transactions on Radiation and Plasma Medical Sciences* 4, no. 4 (July 2020): 422–32. https://doi.org/10.1109/TRPMS.2020.2980443.
5. Deidda D; Akerele MI; Aykroyd RG; Dweck MR; Ferreira K; Forsythe RO; Warda H; Newby DE; Syed M; Tsoumpas C (2021) Improved identification of abdominal aortic aneurysm using the kernelised expectation maximisation algorithm. Royal Society Philosophical Transactions A: at press.

We had 2 awards at major international conferences for submissions by PhD students, presenting work from collaborations initiated during CCP PETMR-funded exchanges:

- Harry Marquis, 2020 Arthur M. Weis Award in Radiation Dosimetry and Safety of the SNMMI . His title was *SPECT/CT-based Dosimetry in PRRT: Using Theranostics to Minimise the Impact of the Partial Volume Effect.* This was a collaboration between researchers from Sydney, Brisbane and London.
- Palak Wadhwa, Best Poster-Pitches in the Imaging Technologies theme of 2020 virtual European Molecular Imaging. Her title was *Anatomically Informed Time-of-Flight PET Image Reconstruction with STIR Toolkit.* This was a collaboration between researchers from Leeds, New York, Teddington and London.

3. Workshops and New Opportunities

Our plans for future workshops are currently on hold due to COVID-19. We continue to engage via online resources and meetings.

We are preparing a Special Issue on Synergistic Image Reconstruction in the Philosophical Transactions A of the Royal Society, with several contributions under review.

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 decreased but we hope to pick this up. All acquisitions of test data are on hold.

Another 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 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.s