Grand Challenges

The Collaborative Computational Project Synergistic Reconstruction for Biomedical Imaging (CCP SyneRBI)

Over the next five to ten years, CCP SyneRBI develop state-of-the-art open-source software tools and machine learning strategies to translate into higher-performing biomedical scanning software, ultimately improving the quality and longevity of life for people affected by cancer, dementia and other serious illnesses

The Community

www.ccpsynerbi.ac.uk

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, 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 Positron Emission Tomography (PET) imaging quality and vice versa, and the latest scanners can acquire Magnetic Resonance (MR) and PET data simultaneously. CCP SyneRBI 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 named SIRF (Synergistic Image Reconstruction Framework). SIRF is simple enough to 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.

The Challenge

Improving imaging quality to detect early stages of disease or treatment response as changes are difficult to detect or identify

While tremendous progress has been made in diagnosis and treatment of disease, there is a continuing need to improve early detection, identify correct treatment pathways and monitor advanced therapies. Early diagnostics of cancer saves lives and ameliorates the quality of life for patients with dementia and their families. Medical scanners can exploit different physics and biological properties, leading to different imaging modalities such as PET, Magnetic Resonance Imaging (MRI) and x-ray Computed Tomography (CT), each with their own properties and advantages. Medical imaging is increasingly used to help clinicians make the correct decisions. Clinical trials of new therapeutics increasingly use imaging for assessing effectiveness

and side effects. However, early stages of disease or treatment response are very difficult to identify since changes can be very small and hard to detect and quantify. This makes any improvement in the quality of imaging produced by medical scanners truly invaluable.

There is a continuous push towards more efficient medical examinations and while there is continuing research to improve scanner hardware, nowadays the biggest innovations come from novel data processing methods, with considerable expertise available in the UK. For instance, research has shown that the use of MRI images can improve PET image quality, and vice versa, with promising results of extending these techniques to other cases, such as using for Molecular Radio Therapy (MRT), a rapidly growing alternative cancer treatment. In addition, there is considerable potential for AI and machine learning to deliver high quality images in challenging conditions. However, the image reconstruction software supplied by the vendors is often proprietary, which prevents researchers to investigate and improve the underlying methods. Current research therefore mostly concentrates on using machine learning on reconstructed images. This presents challenges due to confounding factors introduced by vendor- and site-specific image reconstruction.

These could be reduced by using harmonised image reconstruction methods, but this requires software capable of handling data from various scanners/vendors. Even more powerful is to apply machine learning directly to the measured data from different imaging modalities and integrating it in the image reconstruction process, as this is likely to reduce the risk of hallucinations as well as increase diagnostic sensitivity. Unfortunately, the barrier of entry for researchers from other disciplines (e.g. computer science) to fully exploit multi-modal/multi-vendor data is very high, as it requires detailed knowledge of relevant physics, scanner models, data formats, etc. In addition, it is difficult for bio-medical researchers to remain abreast of the continuous innovation in scanner hardware, preventing current state-of-the-art approaches to be applied in clinical practice and benefitting patients. A further challenge for researchers is that developing and testing such novel methods needs access to large datasets, pooled from several centres.

The Solution

Explore potential of using AI and machine learning, developing flexible open-source software tools for different imaging modalities

CCP SyneRBI brings together the bio-medical research community to enable research into, and translation of, advanced methods in processing methods of multi-modality data, exploiting AI and machine learning strategies. We are developing flexible and fast open-source software tools combining capabilities for different imaging modalities as well as machine learning strategies. The software tools are designed to be simple enough in use for research and teaching purposes and, at the same time, powerful enough to handle real scanner data efficiently. The immediate impact of the software we develop is a much lower “barrier for entry” for new contributors to bio-medical imaging research and development, and the dramatic reduction in

time a researcher would spend on the coding - from months to days. This should accelerate the progress in the development of efficient image reconstruction and processing algorithms and foster multi-disciplinary research. In addition, this allows start-up companies to bring their novel devices to market much faster and cheaper.

The Outcome

State-of-the-art quality scanning software that enables better quality and longevity of life for people affected by serious illness

The open-source software model will allow incorporating contributions from researchers world-wide, with automated and manual checks on software quality. Together with research in exploiting the latest computing hardware, this will ensure long term sustainability. In addition to developing high quality software tools, CCP-SyneRBI are working with UK and international academics to establish standards for raw data, acquisition protocols, data storage and processing methods, as well as enabling automated processing pipelines for processing large and heterogeneous data-sets, ultimately integrated into large data infrastructure projects.These steps should translate into higher quality of bio-medical imaging scanners' software and, eventually - and most importantly - to better quality and longevity of life for people affected by cancer, dementia and other serious illnesses.

More Information

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