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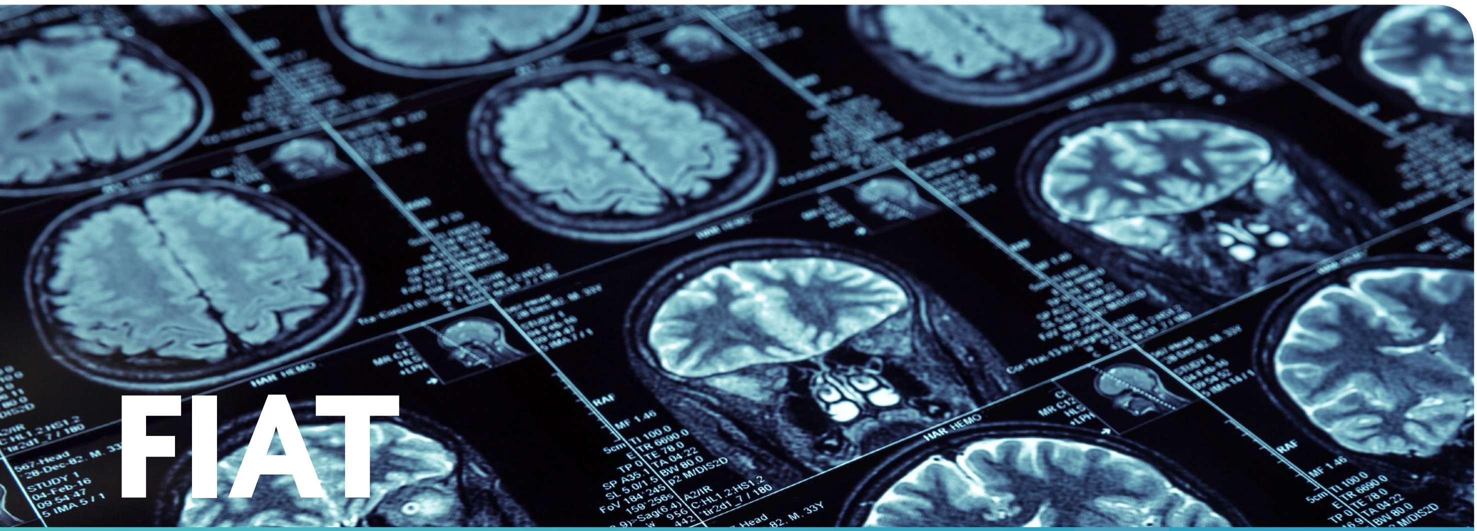
HEALTH



FIAT

Unlocking the potential of 'functional imaging' to quantify tumor response to treatment earlier and more accurately

Oncologists have great expectations of new ways to quantify a tumor's response to treatment (and better assess the effectiveness of cancer therapies). Functional imaging, whereby a tumor's activity (metabolism, blood flow, diffusion characteristics, etc.) is investigated rather than its size, is a promising approach to do so. Yet, while the potential of functional imaging in the domain of oncology may be great, using it in clinical practice hinges on overcoming some important limitations.

During the FIAT project, a consortium of researchers and industry partners (both from the hardware and the software side) explored the potential of several functional image modalities to quantify tumors more accurately. They did so by setting up two parallel research tracks (i.e. small animal as well as clinical imaging), using the research outcomes of both paths to reinforce one another. Particular attention was paid to computed tomography (CT) perfusion imaging, and the quantification of positron emission tomography (PET) for small animal imaging.

"The use of functional imaging in clinical practice faces several hurdles," explains Jef Vandemeulebroucke (imec - ETRO - VUB) who coordinated FIAT's research effort. "First of all, the domain is lacking standards on how to acquire and analyze the images. Secondly, it is challenging to obtain quantitative imaging biomarkers, i.e. reproducible measurements that are representative of a tumor's state and that can lead to practical response criteria."

"Specifically for CT perfusion, the principal technical challenge was how to reduce X-ray radiation induced to patients as part of the imaging process," adds FIAT's project lead Julien Milles (Philips Healthcare).

THE OUTCOMES

1. Improved tumor quantification in small animals – using benchtop MRI and novel isotropic sequences for diffusion-weighted MRI

"During the FIAT project we used a benchtop magnetic resonance imaging (MRI) device for small animal imaging which can easily be placed next to other equipment. As such, we were able to flexibly combine MRI with other imaging modalities and assess if anatomical MRI can lead to improved tumor quantification," says Jef Vandemeulebroucke. "We thus found out that using PET imaging in combination with MRI indeed led to a significantly better correlation with ex-vivo data – compared to combining it with commonly-used (contrast-enhanced) CT."

"MRI technology can actually generate a whole range of different types of images," continues Julien Milles. "One example is diffusion-weighted MRI which, simply put, looks at how water molecules are diffusing – or spreading – through a tissue sample. The problem was that up to now you could get a good-resolution image in two directions, yet at the expense of the third dimension. But thanks to the novel isotropic sequences for diffusion-weighted MRI that were developed as part of FIAT, it is now possible to accurately quantify diffusion in any direction."

2. Reducing perfusion CT radiation exposure with a factor 5 to 10

In clinical imaging, it is important to limit the radiation patients receive. Especially in the case of cancer treatment – with images being taken on a regular basis to see how the pathology evolves – this is key.

"We therefore built novel reconstruction methods, specifically designed for CT perfusion, that require 5 to 10 times fewer projections while achieving comparable perfusion estimates," explains Jef Vandemeulebroucke. "In layman's terms: thanks to the

FIAT technology, we can produce good-quality CT images with an up to 10 times lower radiation dose for the patient. While further research is required to refine this technology, this really has been a significant breakthrough, and could completely change the way we use perfusion CT in clinical practice."

3. De-noising medical images more than 32 times faster

In the case of CT imaging, lowering the radiation exposure typically leads to noisier images. That is why, as part of the FIAT project, algorithms were developed to remove noise more effectively. The approach resulted in a significant quantitative and visual enhancement of image quality, improving the signal-to-noise-ratio on average by 6.56 dB (2D denoising) and 7.56 dB (3D denoising).

"As you can imagine, this is a task that is computationally very intensive. Hence, next to the development of the actual de-noising algorithms, the FIAT researchers made use of the revolutionary Quasar technology – developed by researchers from imec - Ghent University – to speed up this process," says Julien Milles. "What used to take 3.5 minutes, can now be done in 6.4 seconds."

NEXT STEPS

Industry partner MR SOLUTIONS has already integrated FIAT's novel isotropic sequences for diffusion-weighted MRI into its family of products.

A research collaboration between University of Antwerp and MR SOLUTIONS was initiated, including support by MR SOLUTION's staff for engineering and software developments. As such, MICA, MR SOLUTIONS and the Bio-Imaging Lab will continue to improve the MRI acquisitions that can lead to automated tumor delineation, initiated in this project.

icometrix will include CT perfusion in their clinical product for the quantification of strokes, while imec - VUB researchers and UZ Brussels are currently investigating how to collaborate on related dynamic (4D) medical imaging applications – such as heart imaging, where also a time component is involved.

"Philips as well is investigating how we can leverage – and build on – the FIAT research results," says Julien Milles. "First of all we need to further develop the FIAT methodologies, then we should test them in a clinical setting and – in the mid-term – try to commercialize them. But, clearly, one of the main conclusions of the FIAT project is that the potential is huge – with FIAT technology allowing us to generate quantitative medical images while limiting radiation exposure."

FACTS

NAME	FIAT
OBJECTIVE	Unlocking the potential of 'functional imaging' to quantify tumor response to treatment earlier and more accurately
TECHNOLOGIES USED	small animal benchtop MRI, CT perfusion, Quasar
TYPE	imec.icon project
DURATION	01/01/2014 – 30/06/2016
PROJECT LEAD	Julien Milles, Philips Healthcare
RESEARCH LEAD	Jef Vandemeulebroucke, imec - ETRO - VUB
BUDGET	1,853,000 euro
PROJECT PARTNERS	icometrix, Intel, MR SOLUTIONS, Philips Healthcare, UZ Brussel, Cliniques Universitaires St-Luc
RESEARCH PARTNERS	Bio-Imaging Lab and Molecular Imaging Center Antwerp (MICA) of the University of Antwerp
IMEC RESEARCH GROUPS	ETRO - VUB, IPI - UGent, VisionLab - UAntwerp

WHAT IS AN

IMEC.ICON PROJECT?

The imec.icon research program equals demand-driven, cooperative research. The driving force behind imec.icon projects are multidisciplinary teams of imec researchers, industry partners and / or social-profit organizations. Together, they lay the foundation of digital solutions which find their way into the product portfolios of the participating partners.

FIAT project partners:

intel

Universitair Ziekenhuis Brussel

Cliniques universitaires SAINT-LUC UCL BRUXELLES

icometrix IMAGING BIOMARKER EXPERTS

PHILIPS Healthcare

MR SOLUTIONS

AGENTSCHAP INNOVEREN & ONDERNEMEN

Vlaanderen is ondernemen

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