ITEA 3

Project Results

3DPathology

A digital pathology solution for more effective and efficient treatments

EXECUTIVE SUMMARY

Fast and user-friendly multi-modal 3D digital pathology has a critical role to play in quality of life by improving the workflow efficiency and quality of decision-making in the clinical routine. The ITEA project 3DPathology has created a 3D digital pathology solution, based on a combination of multiple existing pathology modalities, for same-day diagnosis and much more personalised treatment of cancer.

PROJECT ORIGINS

The digital pathology market is set to grow from USD 546 million in 2014 to USD 3.1 billion in 2020. This growth, coupled with declining numbers of qualified pathologists, represents a tremendous challenge for pathology departments of clinical and pharmaceutical organisations, and increases the urgency for higher quality diagnostic information to enable more effective and efficient treatments. To accomplish this, a fully digitised pathology pipeline needs to be created to address the integration aspects of clinical workflow and the standardisation of data storage and exchange. The definition of a 3D digital pathology ecosystem would provide a platform to tackle the dimensions and challenges of 3D image manipulation at the scale of tissue sub-structures as well as enable higher quality diagnosis through the visualisation of multi-modal pathology in 3D.

In order to overcome the anticipated challenges and to achieve this multi-modal 3D quantitative pathology analysis platform, the project had to come to terms with solving five major technological challenges. The first was the 3D acquisition of data using multiple imaging modalities in a fast and automated way. Secondly, the acquired data had to be amalgamated by different modalities (size, resolution, storage format, spectral bandwidth), including the incorporation of techniques like co-registration, alignment and reconstruction. Then the aligned 3D data from different modalities had to be analysed to improve the quality of diagnosis. This was achieved by extracting and combining the relevant data, using techniques such as quantification, segmentation, machine learning and data mining. Furthermore, the project came up with the development of new 3D visualisation and interaction technologies (equipment and algorithms) optimised for multi-modal 3D pathology. And finally, an IT backbone was created to deal with data of tremendous size, produced by the individual imaging modalities (data sets in the range of Tera- to Petabytes). A consortium headed by Barco and Philips along with knowledge partners and university hospitals collaborated on formulating the solutions.

3D pathology image from demonstrator

TECHNOLOGY APPLIED

The development of 3D digital pathology is founded on innovative hardware and software solutions. Adapting existing hardware to 3D requirements (quantitative analyses, automated alignment of large series of 2D images) and managing image big-data at different levels. This latter incorporates efficient and high quality compression methods, high-parallelisation for spectral data treatments, intensive calculation for 3D data tracing and reconstruction, visualisation and interaction tools and equipment as well as advanced statistical methods for data mining from large 3D image databanks. The technology solutions derived from the project include State-of-the-Art (SotA) analysis made possible by improvements in hardware and software capability and capacity. The 3D quantitative imaging with mass spectroscopy was achieved with state-of-the art 3D MSI-based molecular pathology that results in superior 3D visualisation, and 3D multimodal imaging that uses a combination of techniques to produce 3D images. In terms of the hardware, improvements were made to HT scanners, MSI systems, 3D displays and data-servers while software development outputs enhance data handling, image databanks, image visualisations and image manipulations.

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A 3D multi-modal pathology demonstrator, the first of its kind in the world, enables unique features such as access to the microscopic organisation of tissue sub-structures in 3D, providing complete chemical information and access to unexplored dimensions of histology. By scaling up 3D microscopic images of bio samples, a better understanding is gained of the relationship between the morphological structures and the molecular, biochemical and metabolic information of tissue while the extraction of quantitative data enhances the molecular/chemical parameters ratio with respect to the structured components of a tissue. Finally, the 3D visualisation of, and interaction with, the relevant data from multiple imaging modalities optimises the presentation of the relevant views and parameters, and allows the huge amounts of data (e.g. storage, transfer, processing, rendering) to be handled.

MAKING THE DIFFERENCE

The 3DPathology project has had a significant impact on JPEG XS standardisation, which focuses on near-lossless, low-latency coding of high-resolution data. Intensive collaboration between imec, ETRO and VUB resulted in the launch of a new extension of JPEG 2000, namely part 15 High-throughput JPEG 2000 that particularly reduces the computational complexity and memory footprint of the EBCOT component of the JPEG 2000 standard, which makes it very interesting for the pathology use case.

By exposing pathologists to more efficient workflows and faster learning, their knowledge and experience increase, enabling them to be more efficient. Increasing the accuracy in pathological examination practice and interpretation has a significant impact on improving quality of life due to personalised treatment, limiting re-occurrence as a result of better treatment outcomes and a decrease in the cost of healthcare from less readmissions. Added benefits of workflow efficiency are less burden on pathology labs, reduced healthcare costs and mitigation of the lack of qualified pathologists in the future.

In respect of exploitation, Philips has been given FDA clearance in the US to market its IntelliSite Pathology Solution for primary diagnostic use there. Philips expects the results of the project to help bring a new pathology scanner on the market and an innovative multi-layer bright field imaging solution to increase its market share of the bright field pathology. Increased usability range and robustness will address the needs for both small labs and large medical centres. Barco is developing display systems that address a variety of pathology lab needs for review, positioning of samples and other non-diagnostic purposes.

MAJOR PROJECT OUTCOMES

Dissemination

- More than 20 publications (e.g. SPIE 2017, Medical Image Computing and Computer-Assisted Intervention 2018, Publication in the 'World Journal of Urology' 2018).
- Presentations and demonstrators at conferences/fairs (SPIE 2017, Meet In Italy for Life Sciences 2016, presentation at SIIM 2018).

Exploitation (so far)

New products:

- 3D web-based viewer of pathology medical data
- Development of TXM prototype machine

Standardisation

Publication of WP44 MIWG ICC:

- Barco prepared a White Paper for the Medical Imaging Working Group of ICC. This White Paper describes the importance of color calibration for medical imaging and also describes the perceptual color calibration. The White Paper is a first step to the standardisation of medical color imaging.
- iMinds contributed to the standardisation of formal evaluation methodologies to assess the performance of visually lossless compression systems, for still images and video sequences, and for high dynamic range content, as part of JPEG's AIC activity (ISO/IEC 29170-1 and ISO/IEC 29170-2). These methodologies can be used as a basis to design a clinical validation test for the compressed 3D pathology data, in cooperation with Barco.

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July 2015

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