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Medical image analysis on the frontline of clinical research

by Steve Taylor BSc, MSc
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Introduction

Expenditure on big data analytics generally in healthcare is estimated to see a compound annual growth rate of over 19% between now and 2027. By then, the sector could be worth over $95 billion.

There are a number of factors fuelling this growth including the increased adoption of data-driven decision making, the emergence of cloud-based business intelligence solutions for the industry, an increased focus on reducing costs and the emergence of mobile-based healthcare business intelligence solutions.

Specifically, high throughput image analysis (working with large image datasets or frames from video) is a rapidly growing application and its success is largely due to significant advancements in machine learning as well as the ubiquity of affordable imaging platforms.

The amount of clinical data alone that has been produced between 2013 and today has increased by over 1,400% (2) and data visualisation tools are critical to managing this, reducing costs in the medical sector and ultimately improving care and treatments.

We predict that the medical profession will be one of the biggest adopters of image analysis and data visualisation tools, and we are already working on several projects in this sector.

They include:

- **Gene therapy:** Collaborating with MRC Weatherall Institute for Molecular Medicines (MRC WIMM) Centre for Computational Biology to help clean its data and assist with the training of its machine learning models, specifically around developing a better understanding of which proteins in genes bind, and where they do this in the genome.
- **Oesophageal cancer:** After winning Cancer Research UK's Early Cancer Detection Sandpit Challenge in 2019, we are currently working with Professor Barbara Braden (Oxford University), Dr Xiohang Gao (Middlesex University) and Dr Wei Pan (Herriot Watt University) on a range of cancer projects. One such project is linked to Oesophageal cancers, most of which are detected by endoscopy when they have reached an advanced stage and treatment is less effective and patient prognosis is poor.
- **Cardiovascular diseases:** Working with Oxford University researchers to help improve its diagnosis of cardiovascular diseases such as coronary heart and aortic diseases. It will do this by applying data visualisation techniques to echocardiogram images and videos, making it easier to categorise them and identify trends and patterns.

CASE STUDY #1

Accelerating research into cardiovascular disease

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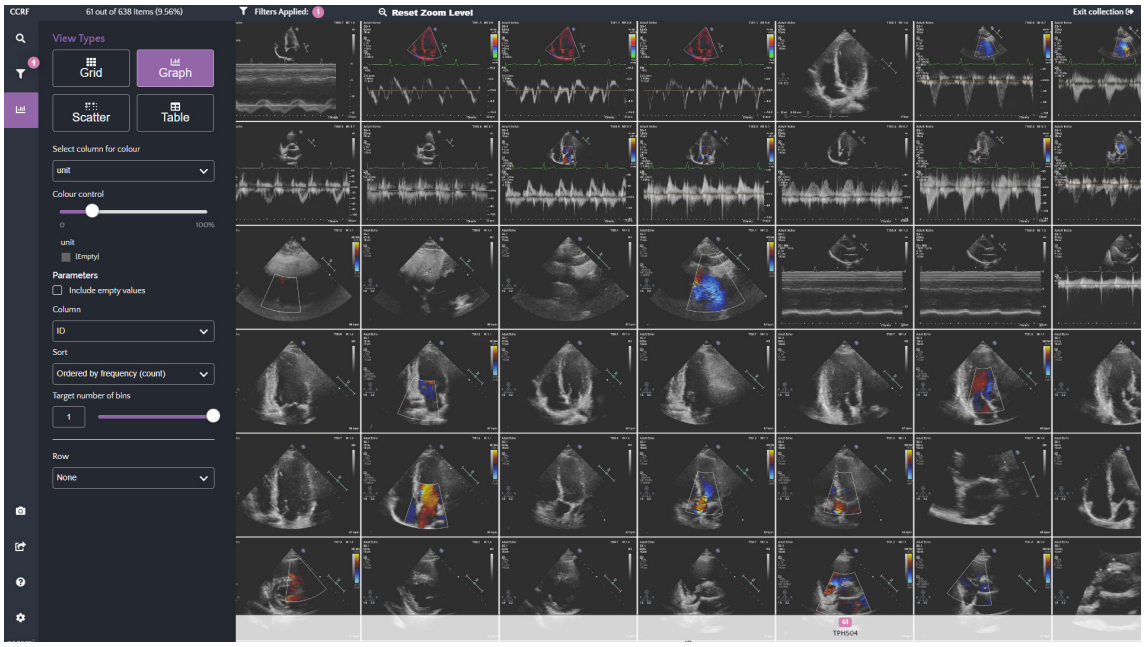
Heart and circulatory diseases cause more than a quarter of all deaths in the UK, and some 7.4 million people are living with cardiovascular conditions. Researchers at the Oxford Cardiovascular Clinical Research Facility are using Zegami to accelerate research into cardiovascular disease.

The team is applying data visualisation techniques developed by Zegami to hundreds of thousands of images of the heart, making it easier to categorise them and identify new trends and patterns.

Oxford Research Echocardiography Core Laboratory supports and manages some of the largest cardiovascular trials and studies in the world, involving multiple different hospitals and countries, and millions of images. Head of the Laboratory, Cristiana Monteiro, believes that data visualisation tools address many of the problems they face when trying to navigate and make sense of these large complex imaging datasets.

Specifically, cardiovascular imaging yields large data sets, both for image analysis as well as incorporation with other clinical data. Most medical images today are stored in digital formats as pixels or voxels describing a small area or volume. Millions of pixels or voxels form one image, and data visualisation techniques can help analyse this more effectively.

Medical researchers are studying the cardiovascular health of thousands of different patients at the same time, the insights generated through data visualisation could support the development of machine learning algorithms that identify and predict heart disease in patients.



Looking for outliers in echocardigrams to predict disease.

CASE STUDY #2

Speeding up cancer diagnosis

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Much has been said and written about delays in cancer diagnosis and treatment in the UK. However, with a growing and aging population, they are under great and growing pressure. Machine learning and data visualisation has a huge role to play in terms of helping doctors make diagnoses earlier.

After winning Cancer Research UK's Early Cancer Detection Sandpit Challenge in 2019, we are currently collaborating with Professor Barbara Braden (Oxford University), Dr Xiohang Gao (Middlesex University) and Dr Wei Pan (Herriot Watt University) on a cancer project.

The oesophageal cancer, which is detected by endoscopy when it has reached an advanced stage and treatment is less effective and patient prognosis is poor. Currently, the miss rate for early oesophageal cancer during endoscopy is 25% - the cancer lesions are very hard to spot and can be life threatening if overlooked. Detecting early cancer on the other hand, offers a significantly higher chance of cure, as the tumour can be easily removed during an endoscopic examination.

We are speeding up the training of machine learning models using anonymised video footage from endoscopy. Our aim is to develop a real-time computer system which can run during the procedure (using an endoscope with inbuilt algorithm in it), highlighting areas of concern by overlaying markers to guide biopsy taking. Early detection is paramount, because the cancer is curable as long as it is defined to the mucosa whilst the 5 year survival is less than 20% in more advanced stages.

This not only helps speed up the process of detection of cancerous lesions faster, with more accuracy, and less discomfort for the patients, so reduces the chances of missing early signs of cancer, saving both time and lives.

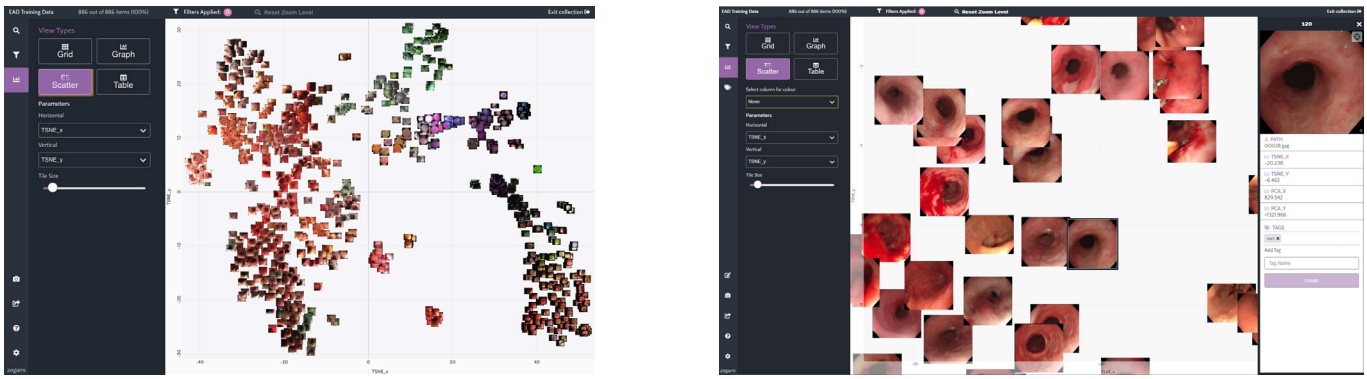

Image similarity comparison of oesophageal cancer video frames to find cancer lesions to train the ML model

CASE STUDY #3

Creating personalised medicines with gene therapy

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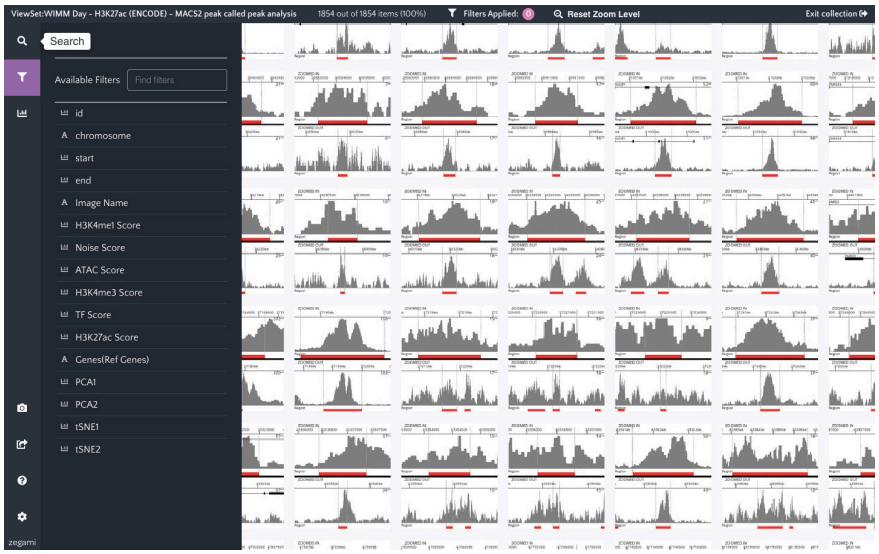
The MRC Weatherall Institute of Molecular Medicine (MRC WIMM) at the University of Oxford was founded in 1989 to foster research in molecular and cell biology, with the aim of improving human health. Through its excellent basic and applied research, it has become a leading centre for translational medicine. Its research has resulted in improved understanding, diagnosis and treatment of a wide range of human diseases.

Our partnership with the MRC WIMM Centre for Computational Biology is designed to help clean its data and assist with the training of its machine learning models. This is specifically focussed on developing a better understanding of which proteins in genes bind, and where they do this in the genome. All of this is key to the development of personalized gene therapy and medicine.

We're supporting scientists in this renowned institute by speeding up the process of training machine learning tools to find the locations of important proteins that bind to the human genome that turn genes on and off. When these genes are incorrectly activated/deactivated they can cause disease, so accurately finding their control mechanisms is vital. Existing software often gets this wrong but using machine learning the Taylor and Hughes group have trained computers to 'see' these signals to get more accurate catalogues of their positions.

The MRC Weatherall Institute of Molecular Medicine at Oxford University have already achieved significant gains through the partnership. Jim Hughes, Professor of Gene Regulation states: "Our ability to sequence and reconstruct entire genomes has transformed our approach to research and medicine. We can now investigate, on the scale of the whole genome, how and in what situations, parts of that blueprint are used. This is enhancing our understanding of how our genome works in health and disease, but it also means we are generating huge amounts of data." This an exciting opportunity for the Institutes also presents a problem in how best to ensure these data are clean, and accurate so that they can train machine learning methods effectively and efficiently to create new insights.

They use Zegami to visualize, sort, filter and label vast amounts of biological data for use in training machine learning models, solving a key challenge in this field. Zegami also allows the easy publication of all the data for scientists to understand how the models were created to help address the machine learning black box problem.



Looking for characteristic peak shape to find where proteins bind to the genome

About the author

Steve Taylor

Founder and CSO of Zegami. Steve's personal mission is to disrupt the analysis of complex data to improve the world. He wants to put powerful but easy to use analysis methods into the hands of everyone - not just computer experts - by using innovative visualisation and interaction technologies. As well as CSO at Zegami, he heads the Analysis, Visualisation and Informatics research group at Oxford working on understanding big data in genomics and health care.

About Zegami

Zegami combines advanced analysis tools with a unique visualisation interface and allows you to rapidly categorise, label and clean large image datasets, invaluable for many applications including training machine learning models.

Zegami was launched out of Oxford University in 2016, and is being used by academics and commercial leaders across the world to gain a competitive edge from their data.

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Our Clients

CANCER RESEARCH UK

Heraeus

MRC Weatherall Institute of Molecular Medicine

UNIVERSITY OF OXFORD

SIEMENS

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