Introduction

Professor Sir Michael Brady is Emeritus Professor of Oncological Imaging at the University of Oxford, having retired in 2010 as Professor of Information Engineering. He is co-director of the Oxford Cancer Imagining Centre. He is distinguished for his work in artificial intelligence, applying his work first to robotics and then to medical imaging. His work has transformed the diagnosis of breast, liver and colorectal cancer and is now finding application to multi-organ conditions, including Covid 19. He has combined his academic career with an extensive collection of entrepreneurial enterprises to make available the benefits of his work to those in need.

Michael's ambition has always been to "take the fruits of the science and technology that we build in the university out and to help people. If I'm working in medical technology, it's because I want to help people. Just writing papers was never enough for me. I found that big companies were very conservative, and so, if you really wanted to innovate, and you wanted to get innovative solutions out into helping people, then you have to form new companies. It's the start-ups that are generating most of the innovation."

"I have become absolutely convinced that there is a fundamental and deep relationship between working on hard problems in science and making things work 99.99 per cent of the time, 24/7, with patients. I've really believed that there is this close coupling between the hard problems that clinicians face and the kind of science that we want to do in universities. They are not separate; they are joined together."

Through the companies that Michael and his colleagues have started, they have installations in around twelve and a half thousand hospitals around the world.

A Love of AI and Image Analysis is Born

Sir Michael's first love was mathematics, but knew he wanted to something practical with his knowledge. He got involved with computer science and took a university lectureship in Essex, but after a few years, he realised that computing was a “pretty dull” except for AI and image analysis which he found “fascinating and intellectually stimulating” and allowed him to combine computing and mathematics. In 1975, after a year’s sabbatical at MIT working on image analysis and AI, Michael launched a Robotics Lab at Oxford. and ended up building mobile robots in collaboration with GEC in Rugby.” Despite the project’s success, GEC decided to close down its robotics support.

“I work in medical technology because I want to help people”

It was around the same time that Michael’s mother-in-law died of breast cancer. He says: “Given that we were being supported so much by industry and the military for doing image analysis, I found it hard that anybody could miss a tumour that was that big. I was outraged by that. I went to a whole series of hospitals to try and find out why that was the case. I realised that doctors just did not have the kind of information and imaging technology that people in industry and the military took for granted. I thought, this is just nonsense.”

Technology Has Been a Game Changer in Breast Cancer Diagnosis and Treatment

Michael believes that the growing power of computing, combined with the rise of the internet and cloud, and molecular biology, have fed off of each other over the last forty years to have an impact on his work and on the diagnostics of breast cancer.
He explains: “A mobile phone now has roughly 1,000 times the computing capacity of the computers that were on the Apollo landing craft, and that’s just a mobile phone. In my backpack when I cycle to and from home, I carry something like ten times the amount of compute power than was in my entire laboratory of 200 people at MIT 40 years ago. It’s a staggering amount of compute power and it’s getting more and more and more all the time.

“As part of that increase in compute power, has been an increase in graphics. If you look at the quality of images that we see on computers now, compared with what they were even ten or twenty years ago, it’s extraordinary, so much so that the images that clinicians can see on computer screens now are as good as they ever used to see on film thirty years ago. So, computing and imaging has reached the point where we can do things that were considered inconceivable thirty years ago, and can display the results in a way that engages with clinicians to inform their judgement to give decision support.

“The emergence of the Internet and then the cloud have created a fantastic global infrastructure of information, with not only distributed storage, but distributed compute power. That’s what the cloud gives us. So we can now, not only take one single computer which has got more, more powerful, but we can engage 100 computers in a completely geographically distributed sense. For example, my company here in Perspectum, if we want to train technology to learn new a method for segmentation, we will quite often train it on 50,000 cases, but we won’t do it on one computer. We’ll do it through the cloud on 64 to 128 computers that might be in four different continents. It's cheap, it's effortless. Almost infinite storage, almost infinite compute power, and globally distributed information.

"The world has been transformed by molecular biology. It not just looking at strings of genes, and it's not just looking at wonderful pieces of technology such as CRISPR-Cas9; it's also the wider genome, understanding amino acids and proteins, protein structure, it's understanding the role, for example, of Messenger RNA, which we have just seen so spectacularly with the development of vaccines against COVID. When you take those three technologies you end up with a totally transformative way to think about medical problems."

As an example, Michael points to the first digital mammography systems which were developed in the year 2000. Until 2000, mammography images were done via film which needed to be digitised and run offline. All of which took considerable time. Michael says: "With the advent of digital mammography images were captured digitally, this meant that we could process them digitally, which gave rise to computer-aided detection, automatic detection of tumours and microcalcifications.

"However, the bad news was that the algorithms weren't very good; they created huge numbers of false positives, and as a result there was over-diagnostics. There were far too many false recalls with that. All of that was just 20 years ago. However, starting seven years ago with ScreenPoint, and in South Korea, with iCAD, not only in 2D mammography, but 3D mammography which would have been infeasible without compute power, we can now outperform automatically all but the best breast radiologists, at a time when the number breast-specific radiologists in Europe is reducing.

"So although it's mandated that all mammograms are read by two radiologists, in practice even twenty years ago that became one radiologist and one technologist or radiographer. Quite often now it's two radiographers. However, what we have shown is that if you take one reader, plus our transparent technology, that that will outperform both the radiologists by themselves, or the technology by itself. Every single radiologist, no matter what their skill level, has their ability improved. That's game-changing. It also tells me that we're beginning now to be able to take 2D, 3D mammography, and link it to MRI, to look at things like, for example, breast hormonal composition, breast density, and to look at following the progression of breast cancer over years.

"So, computers, plus the Internet, cloud, plus biology, have completely revolutionised how we detect, how we treat, how we choose treatments, how we monitor the treatment of breast cancer."

"We've Barely Started"

Breast cancer is just one example of a condition which has been and is being transformed by technological advance, Michael says: "We've barely started yet, there's a vast amount more that will be done, can be done. But the same is true for liver disease and heart disease. We are beginning to move now from treating people who are sick to beginning to anticipate disease, to treat people when we find, perhaps even incidentally or accidentally, the earliest stages of disease and intervene when the prognosis will be vastly better.

Michael says that the longer he has worked in the field the more he cares about taking the science into the real clinical work, the real world of drug development, and in what people call impact. He adds: "You would never have impact with any technology unless it works essentially all the time, and to make it work all the time, when you're dealing with the diversity of humans, with the diversity of pathology, you can only achieve that kind of result if the technology is based in really deep science. There is this combination between deep science and impact."

How Can AI Help in the Current Pandemic and in the Future?

In looking at how AI can help in the current situation, Michael is keen to differentiate between machine learning and AI. He says: "Machine learning is only one tiny piece of AI. The two terms, AI and machine learning, are used as though they're the same thing and that's just nonsense, they're not." Michael is currently involved in a project called COVERSCAN to help pull together information needed to help manage COVID care.

He explains: "COVID is a very complex viral pathology which impacts upon multiple organs. The major impact of COVID that we have seen so far is in inflammation of the heart, myocarditis, but it's also been an inflammation of the pancreas, and of the liver. It is in fact a classic instance of a multi-organ condition. COVID, just like type 2 diabetes, is a paradigm of a multi-organ condition. In fact, you quite often get the same thing with metastatic cancer as well. So more and more we are beginning to see chronic multi-organ conditions. "That's a challenge for the medical profession, because medicine has become more and more and more specialised. You don't get general internists; you'll get liver specialists, pancreas specialists, kidney specialists, heart specialists, or lung specialists. COVID impacts all of them. "Therefore, we need methods that can provide, in the first instance, information about all of these various organs to a team of clinicians who will work collaboratively. If you have COVID, and long COVID particularly, and your version of long COVID happens to be mostly impacted on your pancreas, it's not going to be helped that much if you see a cardiologist who knows nothing about the liver and nothing about the pancreas.

"AI and image analysis, first of all can play a role in pulling together the information from these different organs. That, in essence, is what we've been doing with the COVERSCAN, a project now, a product, which is cleared by the UK authorities, and is now being cleared by the FDA in the United States. We expect to roll out COVERSCAN as a product in Europe and the USA over the next twelve months.

"AI is not just about machine learning. Machine learning can find a whole series of relationships. It can detect things, but it can't find relationships. Very much like in statistics we find correlations, but correlations are weak. What we really need to do is to understand the causal structure that underlie many of these complex multi-organ conditions. Each of the chains of causality that we see is what is known as an aetiology, a disease course. For example, in the case of diabetes, there are something like five, six major different aetiologies.

"There are now methods for building formal methods for causality. Combining them with image analysis and machine learning will be the next wave of AI in medicine. I have two colleagues here at Perspectum who are working on applying these causal methods, one to diabetes, and one to primary liver cancer; hepatocellular carcinoma. I think that causal reasoning, plus machine learning, plus signal and image processing, brought together, will be the next great wave of AI in medicine."

Can Technology Level Up Health Care Across the Globe?

Michael says: "The technology of AI, of image analysis, of biology, compute power, and the Internet/cloud, have the potential to take all of these technologies and distribute them through the world to level up the awful discrepancies there are between, for example, Sub-Saharan Africa, and Europe and the United States. Will they do that? That's not a question for technology; that's a question for politics and social, and the international political community.