Prof. Sir Michael Brady

Interviewed by

Elisabetta Mori

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Via Zoom

Welcome to the Archives of Information Technology. It's the 23rd of November 2021. I am Elisabetta Mori, an interviewer with the Archives of IT. Today I'll be talking to Professor Sir Michael Brady. We are recording this interview on Zoom. I am in Tuscany, Italy; Sir Michael Grady, he is in Oxford.

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Sir Michael 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 to a wide range of medical programmes, particularly breast, liver and colorectal cancer. He combined his work in oncology with a range of entrepreneurial activities, was Deputy Chairman of Oxford Instruments, and the founder of successful start-ups such as Guidance, Mirada Medical, Optellum, Perspectum Diagnostics, ScreenPoint Medical, and Volpara Solutions among others. Sir Michael was elected a Fellow of the Royal Society, Fellow of the Royal Academy of Engineers, Fellow of the Institution of Engineering and Technology, Fellow of the Institute of Physics, Fellow of the Academy of Medical Sciences, and Fellow of the American Association of Artificial Intelligence, and Membre Étranger de l'Académie des Sciences in France. In addition to his numerous academic fellowships and prizes he received a knighthood in 2004 for services to engineering.

[01:39]

Welcome Mike, it's a pleasure to talk to you again today. This is our second interview with the Archives of IT. Can you briefly recap your academic and professional career up to date, and what motivated you to pursue your path in academia and industry.

Sure. Greetings all. So I was, I was born just outside Liverpool 70-, nearly 77 years ago, in a, in a quite poor family, and none of my family had ever been to university before. So I was the first member of my family ever to go to university. And, when I went to university, I, I fell in love with mathematics, and, I also, I also fell in love with beer and with rugby, and with my wife as well, but, we're here talking about mathematics today. I also was really enraptured by a German mathematician then, Bernard Neumann, and when I finished my degree I did a PhD, I wanted to do a PhD in Bernard's lab. He had moved to Australia, so I moved to Australia with my newlyminted wife, and we spent two and a half years in Australia while I did my doctorate. So, when I finished my PhD I wanted to do something more practical than pure mathematics, and so I got involved in the then developing field of computing science. And, I got a, I was awarded a university lectureship in Essex, which was one of the biggest computing science departments in the UK at the time. And, after about three or four years I realised that, I found a lot of computing science pretty dull, except for AI and image analysis, which absolutely intrigued me. And so, it not only fascinated me, I found it intellectually stimulating, but it allowed me to combine computing and mathematics.

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In 1975 I, having spent five years on the faculty, I had a year's sabbatical. And so, I went to MIT, and while I was at MIT I met some really great people, and decided that that was, that was it for me, I was, I was going to work in imagine analysis, AI, and… So, I went back again during the 1970s, in '77, '78, '79, and finally I joined as Associate Director of the AI lab in early 1980. And, I loved MIT, it was, it was fantastic. My wife never really settled to living in the United States; she always wanted to come back to Europe. So we were a little bit torn. But then out of the blue, Oxford called me to tell me about a job in information engineering. It seemed that they didn't know what the hell that meant, but, that was OK, because I didn't know what it meant either. And asked me to apply. So, eventually, I applied for this job, came over, was interviewed, and was offered the job, newly-created job, in information engineering.

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Now by that stage, while I was at MIT we had resuscitated, restarted, the Robotics Laboratory, and, I had organised conferences, created a lot of research funds; we had done some work on a whole range of projects in robotics. So when I came to Oxford, I set up the Robotics Laboratory. And I had this, I had this desire in the late Eighties, I thought it should be possible to build free-ranging mobile robots. And, the Research Councils in the UK thought this was completely nuts, they thought this would never happen within the next 50 years, but they were kind of keen to support my research. So we ended up building mobile robots in collaboration with GEC in Rugby, in the, in, just north of Oxford, and, we had a very very successful project. In fact we had two successful projects. And then… By that stage I had become Head of Engineering Science, which is, you know, a department with students and workshops and faculty of around 1,000 people, so it's a pretty full-on job. But, at that time GEC decided to close down the robotics activity, and so the people I was working with on this project were disappointed with this, and so we… So I suggested that we form a company, which we did. And, so we spun out of GEC and we spun out of Oxford, and we formed Guidance. And, Guidance eventually became three divisions in factory automation, marine, and monitoring for basically smart tagging systems. And we ended up with about 125 people. But we sold the… Eventually we sold those companies, in 2010, 2016, 2018. And that was… But that was terrific, and I really, really enjoyed working in the mobile robots, and in fact the CEO of that company is still one of my closest friends.

[08:18]

However, around that time my mother-in-law died of breast cancer, and, I, I found it almost impossible to believe, 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. To be honest, I was outraged by that. So, I went to a whole series of hospitals to try and find out why that was the case, and I realised that doctors just did not have the kind of information and imaging technology that people in industry and the military just took for granted. And I thought, this is just nonsense. So, I decided in 19-, I started doing some initial work, but then, in 1994 when my tour of duty as head of department was finishing, I decided to just quit robotics and work in breast cancer. And I must say, Oxford were fantastic about that, they, they thought, if it made sense for me, it must be OK. And they were completely supportive of this huge change. And so, I dug in to working in, in breast cancer, and that got me into medical imaging in general, with so-called deformable image registration, because it's very rarely the case that one kind of image, MRI or CT, will give you all the information you need, and you quite often have to combine. And so… Or, you need to stratify. So if somebody has a mammogram and then they go for an MRI, you want to transfer the information that you got from the mammogram to the MRI.

[10:06]

So, I started with Alison Noble building a medical imaging lab, and, as part of Robotics, and from that we went on to… So I started doing [inaud] work on breast cancer. I ended up writing a book with Ralph Highnam. And then, we tried to get our technology used by industry, and, large industry wasn't interested, they thought it was too academic. And so, I formed, [laughs] yet another company, in fact I formed two and then merged them and they became Mirada Solutions. And, actually, the thing that really drove that was the deformable image registration. Because PET-CT machines had just been launched on to the market, people needed our technology. And so in 2003 we sold Mirada Solutions to CTI Molecular Imagining in the States, and then two years after that, that became CTI Mirada. Two years later Siemens bought the whole of CTI Molecular Imaging. So that was, that was fine.

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And, then, it became clear that they weren't going to use the mammography work, which, in my original driver, and so in 2008 I met up again with Ralph Highnam and we restarted, another company, we started a new company, which is now called Volpara Solutions – Volpara Health Technologies. Volpara Health Technologies grew through the 1990s – through the Noughties, and… Sorry. Through the 2010s. And in fact in 2016 we floated it on the Australian Stock Exchange. So, I guess, Volpara has got around 250 employees, and is based in New Zealand, Australia, and the United States.

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And by this stage I had kind of got a bit of a name for starting companies based on technology, and so my, when my, when I retired, in 2010, I figured I could take on one more company: well I've ended up taking a lot more than one more company. So, first, I met a remarkable character called Rajarshi Banerjee, I was introduced by Stefan Neubauer and Matt Robson, the two guys I knew from the Oxford Centre for MRI. And, we formed this company called Perspectum, and Perspectum has grown over the past nine years, and we've got about 250 people working for Perspectum now. We started off by working on quantitative imaging of the liver, and then we branched beyond that to, not just looking at steatosis, and, and NASH, non-alcoholic steatohepatitis, which is essentially the downstream consequences of too much liver fat, but we had moved towards liver cancer, towards cirrhosis, and then to multi-organ conditions such as diabetes, and the most recent multi-organ condition is COVID, which is a viral infection that attacks in an inflammatory way a whole series of one's organs, like the liver, the pancreas and so forth. So… And then, in 2014 one of my buddies who I had made a friend in the Netherlands who worked in breast cancer, which was my original driver, Nico Karssemeijer, called me up and said he had some thoughts about starting up on second generation computer-aided detection of breast cancer. And so, we formed a company called ScreenPoint Medical, and ScreenPoint

Medical has developed, we've now got FDA clearance for both 2D and 3D mammography. We have big plans; we've just received some very substantial investment from Insight Partners in New York. So we have about 50 people working for ScreenPoint Medical. And that's growing, and it's taking more and more of my time, but I'm delighted to give it more and more of my time.

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And then, two of my graduate students, Timor Kadir, Václav Potěšil, asked me to get involved with them in their little company called Optellum that was doing assessment of lung nodules to either malignant or benign. And so, Optellum is growing very rapidly at the moment, and we have about, I don't know, 35, 40 people, something like that.

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Meanwhile, Mirada restarted, part of it, we did a management buyout coming out of Siemens for the third party business. That has now specialised in radiation therapy planning. And so, Mirada Medical, which is also in Oxford, has got about 75 people working for it. And then, I guess, most recently, a couple of guys in Cambridge, namely Will Briggs and Ameera Patel, called me up, and I've gotten involved with a little company called Naitive Technologies, which is about using AI to look at [inaud] systems of [inaud]. So… And one final thing that's happened to me. About, late 2018 I got a phone call from one of my former PhD students, a guy I know, Ling Shao, who told me he had been appointed to direct an AI lab in Abu Dhabi, and, he had never run a lab that big, and would I help him, would I be an adviser? And of course I'll never turn down a graduate student. So, I went out to Abu Dhabi, and then, long story short, I ended up being on the board of trustees of a new graduate college which is called the Mohamed bin Zayed University of AI, MVCUAI, in Abu Dhabi. And, I've become very friendly with them. A president was appointed a year ago; I spent a year being interim president. We've now appointed a president, Eric Xing, and, we're taking on about 100 students a year from something like 43 countries. And, the university is growing very rapidly. We expect to be around 70 faculty within the next four years.

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So, one way and another, I find myself at my ripe old age being involved with, Perspectum, ScreenPoint, Optellum, Naitive, MVCUAI, a little bit with Oxford University still, and with Mirada and with Volpara. So, it's a good job that I've got lots of energy, because I still cycle to work every day, and I swim, and I read, and my wife and I love to hike in the mountains. And that's… I forgot the most important thing about my life. I've got, I met my wife 57 years ago, and I've got two daughters and five wonderful grandkids. And that's me in a nutshell.

[18:13]
Thank you very much. So, today it will be nice to discuss the impact of your research and the technologies developed by the start-ups you built. So, for instance, it would be nice if you could help us understand the consequences of some of your work in particular. What changed in the diagnostics of breast cancer since you first approached the matter? What changed also in society, and what was the impact of your specific work?

Yes. So I guess first and foremost, I have always wanted 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. And so just writing papers was never enough for me. And, 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. So I found myself, curiously, when I was nearing 50, becoming an entrepreneur, which I had never done in my life before, and since then I've, once I started, I couldn't stop. So… 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. So, I… So, 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. And I think that they are not separate. I think they are joined together.

[20:57]
What has happened over the past, 35, 40 years, has been, I think, three things which have fed off each other. The first obviously is the power of computing. 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. We walk around… I carry now, 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. And, 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 years ago, or 20 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 30 years ago. So, computing and imaging has become, has gotten to the point where we can, we can do things that were considered inconceivable 25, 30 years ago, and can display the results in a way that engages with clinicians to inform their judgement, to give decision support.

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The second thing that's happened is that the emergence of the Internet, and following the Internet, the cloud. So we now have a fantastic global infrastructure of information, and, with, not only distributed storage, but distributed compute power. And 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. So, for example, my company here in Perspectum, if we want to train technology to, for example to learn new a method for segmentation or whatever, we will quite often train it on 50,000 cases, but we won't do it on one computer. We'll do it by, we'll do it through the cloud, on, 64 to 128 computers that might be in four different continents. And it's cheap, it's effortless. So, almost infinite storage, almost infinite compute power, and, globally distributed information.

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And the third thing that's happened of course is, within biology, the world has been transformed by molecular biology. We… And 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, it's also the wider genome, it's understanding amino acids, and proteins, and it's understanding, it's understanding 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.

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Now when you take those three technologies of increasing power of computers, and, and the algorithms of AI that are driving and needing that technology, and the Internet, and biology, and you pull those together, you end up with a totally transformative way to think about medical problems. And that's in a nutshell what has happened. So if I just take two examples. One example. In breast cancer, the first digital mammography systems were developed in the year 2000, just 21 years ago. And at the time, what that did…   Sorry. What that did was, it meant that if we wanted to provide any form of detection of, for example, ductal carcinoma in situ, or of a, a tumorous mass within the breast, until then, until 2000, we had to take film and digitise it, and then run it offline. This took forever. And computers were just, because mammograms are huge, it took a long, long time. It's infeasible. So, the advent of digital mammography, so images were captured digitally, meant that we could process them digitally, which gave rise to computer-aided detection, automatic detection of, of tumours and microcalcifications. Now the bad news was, the algorithms weren't very good. They had huge numbers of false positives, and as a result there was kind of, overdiagnostics. There were, there were far too many false recalls with that. That was just 20 years ago. And starting seven years ago with ScreenPoint, but also in South Korea with [inaud], with iCAD, there is now the case that, in fact I'm giving a tour next week at the RSNA, Radiological Society of North America, in which I will show that 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 of radiologists in Europe, breast-specific radiologists, is reducing. So although it's mandated that all mammograms are read by two radiologists, in practice even 20 years ago that became one radiologist and one technologist or radiographer. Quite often now it's two radiographers, and there are parts of, for example the Nordic countries, where it's simply infeasible to have two people. 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 themselves. So the two, the person plus transpirer, outperform any… Every single radiologist, no matter what their skill level, has their ability improved. So, that's game-changing. It also tells me that, that also tells me that the, 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.

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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. Right. So, the companies that we've started now, I've got installations in around twelve and a half thousand hospitals and [inaud] around the world. Breast cancer is one example of a, a condition that has been transformed, and is being transformed, but we've barely started yet. There's, there's a vast amount more that will be done, can be done. But the same is true for liver disease, the same is true for 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 the, perhaps even incidentally, accidentally, the earliest stages of disease and intervene when the prognosis will be vastly better.

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So, the more, the longer I've worked in this field, the more I have cared, not just about doing the basic science, but the taking that science out into the real clinical world, or the real world of drug development, and in what people call impact. But I stress again, you would never have impact with any technology unless it works essentially all the time, and it, to make it work all the time, when you're dealing with the diversity of humans, with the diversity of pathology, you can only do that if, you can only achieve that kind of result if the technology is based in really deep science. So there is this combination between deep science and impact.

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What do you think AI do for the current COVID situation? There is a project at the National Consortium of Intelligent Medical Imaging in the UK. So what do you think, what are you doing and what do you think is going to be the contribution to AI to healthcare in the future?

OK, let's, let me make one thing very clear. At the moment there's a huge amount of buzz around AI, and the buzz around AI has predominantly been about machine learning. Machine learning is only one tiny piece of AI, OK? At the moment, the two terms, AI and machine learning, are used as though they're the same thing, and that's just nonsense, they're not. Of course learning is an important part of human cognition, but, and human perception, but it's not the only… So, I think, I think that one of the things that's going to happen is, although AI is having a very considerable impact, it's not only machine learning that is going to have an impact as we go forward, and that's some of the things that we've been working on. So, I think, [inaud] specifically in COVID. COVID is a, a very complex viral pathology which impacts upon multiple organs. Initially we saw lots and lots of people being rotated in their beds because of their lungs, because of difficulty in breathing. But actually, 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. And it is in fact a classic instance of a multi-organ condition. Now 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, or pancreas specialists, or kidney specialists, or heart specialists, lung specialists. And here you've got something that impacts all of them. And so, what we need to understand is, we need methods that can provide, in the first instance, information about all of these various organs that can supply as mentioned to a team of clinicians that will work collaboratively. So, if you have COVID, if you have long COVID particularly, the chronic version of the disease, it's… and, and your version of long COVID happens to be mostly impacted on your pancreas, then there's not much… you know, that's, that's going to be, it's not going to be helped that much if you are shipped off to see a cardiologist who knows nothing about the liver and nothing about the pancreas. So, 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. And AI, and image analysis, first of all can play a role in pulling together the information from these different organs. And, that's in essence what we've been doing with the COVERSCAN, a project which now, a product which was cleared by the UK authorities, and is now being cleared, is now being cleared by the FDA in the United States. And I, we expect to roll out COVERSCAN as a product in Europe and the USA over the next twelve months.

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Now, I said that AI is not just about machine learning. Machine learning can find a whole series of relationships. It can detect things, but it can find relationships. Very much like in statistics we find correlations. But correlations are quite frankly, and my statistician friends hate me for saying this, but, yeah, correlations are weak. So for example, there is a strong correlation between people who are ill and people who go to see their doctor. Therefore, if you want to prevent people from getting ill, what you do is, you fire the doctors, you know? That's, that's a ridiculous, of course, conclusion of correlations. What we really want is that there is a fundamental asymmetry. People who are ill causes them to go to see a doctor. Being a doctor does cause people to be ill. So, actually what we really need to do is to understand the causal structure that underlie many of these complex multi-organ conditions. And each of the chains of causality that we see is what is known as an aetiology, a disease course. And we know that, for example, in the case of diabetes, there are something like five, six major different aetiologies. I think that AI… Well, AI has developed ever since the brilliant work of a guy named Judea Pearl in California in, about, 30, 35 years ago. There are now methods for building formal methods for causality, and combining them with image analysis and machine learning, that will be the next wave of AI in medicine. And I have two colleagues here at Perspectum who are working on applying these causal methods, one to diabetes, and one to liver cancer, primary liver cancer, hepatocellular carcinoma. And 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. And happily, I'm still a young guy, so I'll still be able to work in that.

[39:51]

Thank you. Do you think that AI in particular can also help, you know, these technologies are complex, so, do you think this can also help to some kind of democratisation of healthcare also in underdeveloped communities, or is this something… I mean, is this an issue, or is this a, something that can help?

No. It's a great thing to, to stop on, because I have to, I have to finish in a couple of minutes, but… The technology of AI, of image analysis, of the three things I mentioned, are biology, compute power, and, 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. All the evidence over the past 30 years has been that despite the emergence of these technologies, that the gap between the wealthiest in our society and the poorest in our society has gotten bigger. It has not shrunk. And that's true whether you look in France, the UK, United States, Italy, Germany. In every single place, the gap has gotten bigger. We have seen that most recently with lockdowns following COVID, where governments simply assumed that everybody in society will have the Internet, multiple computers in their homes. And have been surprised to find out that the poorer parts of society don't have Internet, don't have computers, don't have lots of iPads. And it shows just how totally out of touch most politicians are of the reality of life amongst the poor people where I was born into. So, can the technology… The technology is completely neutral about levelling up. It provides the potential for it. Politics, I'm afraid, will drive it in exactly the opposite direction.

OK. Let's hope this is not going to happen. [laughs]

I hope so too, but I'm afraid…

Yeah. We both do, right?

Elisabetta, I have to jump out now.

It was lovely to talk… Yes. It was lovely to talk to you today. And, thank you.

It's always a pleasure. And good luck with the archive.

Thank you very much.

Bye now.

Bye bye.

Bye.

[End of Interview]