Editorial

I was delighted when Martine Barons CMath MIMA accepted the invitation to write an editorial for the June issue of *Mathematics Today*, and I found that what she wrote was both very interesting and thought provoking. Thank you, Martine, for your valuable contribution telling us about your experience as someone who came to mathematics as a second career.

Since I wrote my editorial for the April issue of *Mathematics Today*, I have chaired my first meeting with the editorial board. This is held annually in June, and it is at this meeting when outline plans are laid for future issues. I am pleased to report that the meeting went smoothly for me, and I found all the members of the board to be very friendly and supportive. They willingly offer their time, which is very generous of them.

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When I started to put pen to paper for this editorial, the Queen's Birthday Honours List for 2019 was announced. On searching the list I found that four of those honoured have mathematics in their citations. Professor Kenneth Brown FRSE, University of Glasgow, was awarded a CBE for his services to the Mathematical Sciences. Professor Duncan Lawson CMath FIMA, co-director at Coventry University of the **sigma** network for excellence in mathematics and statistics support, was awarded an MBE for his services to Mathematics in Higher Education. Peter Ransom FIMA from Southampton, was also awarded an MBE for his voluntary service to Mathematics Education. The fourth person involved with mathematics to be honoured was Lauren Shea, a 19 year-old university student from Waterlooville, Hampshire, who was awarded a BEM for services to Promoting Science, Technology, Engineering and Mathematics (STEM) to Young People. Lauren is currently studying mechanical engineering at Cardiff University.

Two other IMA members were also awarded honours. Dr Diane Crann MIMA, a former IMA Councillor and founder of the Engineering Masterclass Programme at the Royal Institution was awarded an MBE for services to Engineering Education, and Clive Humby FIMA, Chief Data Scientist at Starcount, was awarded an OBE for his services to Data and Business in the UK. I feel sure that all members of the Institute will join me in congratulating all of these award recipients for their hard work and contributions to mathematics and the profession (see page 128).

One of the many fascinations of *Mathematics Today* for me is the wide variety of articles that appear in each issue. I cannot say that I understand everything that I read, but I am always impressed by the variety of topics and the dedication of the authors to their subject. Following the review by Professor Philip Bond, knowledge exchange in the mathematical sciences is currently a hot topic. Another is the promotion of diversity, equality and inclusion in the profession, with the primary objective of making sure that no one is excluded from maths.

Yet other articles concern the history of mathematics, the mathematics that underpins the design of countless ingenious labour saving inventions, and advances in science, technology and engineering. I must also not forget to mention that considerable mathematics is needed for medicine and drug design, something that surprised me when I first realised it. All of these, and more besides, would simply not have advanced without significant mathematical input.

Advances in technology continue to appear in the news, sometimes with conflicting opinions about the value to society and what the future holds. Since writing my editorial for the April 2019 issue, artificial intelligence (AI) again seems to dominate, closely followed by robotics.

On the positive side, AI can have huge benefits if it is used to help make decisions, especially if the reasons for the decisions are revealed. This should then enable a better understanding of the processes AI uses to arrive at its decisions. An interesting application of AI called SkyNote (telmi.upf.edu/?technology=skynote) helps young violinists learning to play reduce the risk of injury. The system uses a camera to watch them play, with the video and sound fed into a computer containing AI-driven software to analyse their actions and provide feedback.

On the negative side, however, AI could ultimately lead to humans lacking the experience needed to solve problems, especially if the AI reasoning is not understood. Indeed, there was a report in the 13 April 2019 edition of *New Scientist* that DeepMind's AI failed a school-level mathematics exam taken by 16-year olds in the UK. So it appears that, unlike us, AI is not (as yet) good at mathematics.

Another report suggested that car drivers who use satellite navigation can become so reliant on the technology that they lose their ability to read maps. I conclude from this that we should proceed with caution in the use of technology to assist with decision making, at least until it has been shown that for each application it can be relied on to make good decisions without reducing our ability to make good judgements.

In industrial assembly and packaging processes, AI and cameras in conjunction with robots improve both the speed and accuracy with reduced costs. One unusual application that I came across, however,

is a robot artist called Ai-Da (www.ai-darobot.com) named in honour of the mathematician Ada Lovelace. It was she who predicted that computers could do more than just crunch numbers, and is believed to be the very first computer programmer. Ai-Da is a humanoid robot contemporary artist able to draw and paint. She can walk, talk and hold a pencil or brush. She is able to teach herself new and increasingly sophisticated art from a picture and a basic set of rules. I have to say that I'm not keen on modern art, but I do find this a fascinating and unusual application which combines AI with robotics.

On the mathematics front it was good to learn that one of the five winning entries in the Telegraph STEM awards was Blockchain Warfare; the idea being to create an 'unhackable' database for the modern military. The winner was Nick Cawthra, a fourth year systems engineering student at Loughborough University. Blockchain is of course more widely known as the technology that underpins cryptocurrencies, and I was pleased to learn about an application of this interesting idea that isn't connected with cryptocurrencies.

Something else that I came across in the news only recently was the idea of using three memorable words to identify uniquely a location anywhere on the Earth to an accuracy of $3\,\text{m} \times 3\,\text{m}$. The report said that about $38\,500$ distinct words were needed to achieve this, and I was curious enough to investigate further. The idea is marketed under the name What3Words (what3words.com) and according to the website it is said to be simple, yet accurate and ubiquitous. The algorithm converts complex GPS coordinates into unique three-word addresses, and it means that anyone can talk about anywhere using three simple words. It is useful in areas where street addresses don't exist and provides a level of specificity when addresses are not sufficiently accurate. It was developed in 2013 and is now being used by a number of police and fire services in the UK (see photo, for example).

I calculated the number of words needed as follows, assuming the Earth to be a perfect sphere. If its radius is R, then the surface area is $A = 4\pi R^2$. In round numbers, the radius $R = 6\,371\,\text{km}$ and hence the surface area is $A = 510 \times 10^6\ \text{km}^2$. For a location accuracy $a = 3\,\text{m} \times 3\,\text{m} = 9\,\text{m}^2$, the number of distinct locations required is $A/a = 5.67 \times 10^{13}$. If there are D words in the dictionary, then the number of possible permutations for groups of w words is $P = D!/(D-w)!$. For large D and small w this is closely approximated by $P \approx D^w$. The requirement for $P = A/a$ implies that $D \approx (A/a)^{1/w}$. With $w = 3$ words per group, the result is that there will be $D \approx 38\,412$ words in the dictionary, confirming that the $38\,500$ figure that I remembered from the original news item is correct.

I was interested to find out how the total number of words required would vary for different group sizes and different accuracies. The results of my calculations based on the above are shown in Table 1.

Table 1: Number of words needed in dictionary (D) given accuracy (a) in square metres and words per location (w)

w	*a*	*D*
	9 m²	7 528 203
2	36 m²	3 764 102
	81 m²	2 509 401
	9 m²	38 412
3	36 m²	24 198
	81 m²	18 467
	9 m²	2 744
4	36 m²	1 941
	81 m²	1 585

From this it appears to me that the choice of $w = 3$ words and $a = 9\,\text{m}^2$ used in the *What3Words* scheme is an excellent compromise between accuracy and ease of remembering words required for each location. Unsurprisingly, for a given number of words to remember, less accuracy requires a smaller dictionary, and for a given accuracy, fewer words to remember will require a larger dictionary.

I don't know what algorithm was used to choose $38\,500$ or so memorable words, or how the different groups of three words were selected for each of 5.67×10^{13} locations. That's clearly a different problem. However, as a couple of examples, assuming that I've got the locations correct, 'barks.lend.dice' locates the IMA room at De Morgan House in London, and 'share.bleak.union' locates the IMA at Catherine Richards House in Southend-on-Sea.

I hope you enjoy reading this issue and find it both useful and inspiring. Inside there are articles about a variety of subjects, including: the design of a resistor-capacitor active notch filter with medical applications; an analysis of scoring in rugby union; Sir George Stokes, after whom Stokes' theorem and the Navier–Stokes equation were both named; and a note about Hermann Bondi, who developed the steady state model of the universe with Fred Hoyle and Thomas Gold. This month, Urban Maths is about fractal image compression, and Westward Ho! is about Hinkley Point power station.

The October issue of *Mathematics Today* will be a special one about medicine and biology. It will be mainly written by female authors in support of diversity and inclusion, and will be guest edited by Ellen Brooks-Pollock and Reidun Twarock.

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Mathematics Today switches to environmentally friendly wrapping

You will have no doubt noticed when you received this issue of *Mathematics Today* that we have changed the wrapping. We have moved away from plastic wrapping to a material derived from potato starch and that is entirely compostable. Please don't put the wrapping in your recycling, but instead in your compost heap, garden waste bin or food waste bin (depending on your local authority provision).