Leonardo Torres

His interests ranged from airships to cable cars, but he made a number of important contributions to the development of computing

Leonardo Torres y Quevedo, the scientist who first applied floating-point arithmetic to computers, was born in the Spanish town of Santa Cruz on 28 December 1852. He was educated at the Institute of Bilbao and the School of Engineers in Madrid, before embarking on a career as an engineer and inventor.

His powers of invention reached their height in the later part of his life. He designed the Niagara Transport Bridge and cable car, which are still in use today at Niagara Falls, and a semi-rigid airship that was manufactured during the First World War. But fundamentally, Torres was a child of his times and his main interest was in electromechanical devices. In 1906, he demonstrated a radio-controlled model boat in the harbour of Bilbao before the King of Spain, and in 1911 he invented the first automatic chess player. The machine used electromagnets beneath the table to move the pieces, and was programmed to win a simple game against a human opponent.

Floating Points
Like many of his contemporaries, Torres was a true polymath. His interests ranged from the design and construction of mechanical devices such as the airship shown here, through electromechanical calculating machines, into the realm of pure mathematics

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Torres' interest in automata derived from his experience of the assembly lines in the industrial plants of early 20th-century Europe; and all through his life he sought to separate the types of problem that required human thought from those that could be done automatically.

In 1914, he published a paper showing the feasibility of building Babbage's Analytical Engine (see page 220) using electromechanical techniques, and it was in this paper that he first suggested the use of floating-point arithmetic in any future computer. In 1920, he constructed an electromechanical calculator that used an adapted typewriter for entering the numbers and printed the results automatically. The typewriter was connected by telephone wires to the calculator, and Torres foresaw the possibility of many terminals attached to a central calculator (or processing unit).

He was honoured by the French Academy of Sciences for his work, and later became President of his country's own Academy of Sciences. Torres died in Madrid on 18 December 1936.

Floating-Point Arithmetic

A cash register displays the totals in pounds and pence (£12.25, for example), and in such a machine there is only a need for two places after the decimal point. But in a computer, greater accuracy is often required and the number of decimal places is allowed to vary or 'float' according to the needs of the problem. This is known as 'floating-point arithmetic'.

Any number can be written in a variety of ways. For example, 0.8752 metres can be expressed as 875.2 millimetres, or 0.8752 x 1000 millimetres, or simply 0.8752×10^3. This last method lends itself to an economical method of encoding for a computer. If a computer has only allocated six digit spaces to represent each number (and for the sake of clarity the decimal system is used instead of binary), then the above number can be stored as 875203: where the last two digits on the right-hand side are called the 'index' and represent the power of 10 (in this case 3) and the leading four digits are called the 'mantissa'. To give another example for this computer: the number 418302 represents 0.4183×10^2, or 41.83.

The mantissa and index are usually 'normalised' to remove any leading zeros from the mantissa. For example, the number 41.83 could be written as 004104, but would be normalised to 418302 — thus including more significant digits in the mantissa.

The index/mantissa form of floating-point arithmetic has the advantage that a wide range of numbers can be represented. For the computer suggested above, which allocates only two digits for the index, a number as large as 0.9999×10^{99} can be dealt with — or a number so small that there are 98 zeros after the decimal point before any non-zero digit is encountered.

However, the accuracy of this system remains limited to the digits allocated to the mantissa. Consequently, some numbers can be only approximately represented, and great care and ingenuity must be put into the techniques of arithmetic programming to stop errors arising. This is the reason why (1/3)*3 will give 0.9999999 on some computers, rather than the true answer of 1.