And the Turing Award goes to…

The 2021 A. M. Turing Award celebrates Jack Dongarra's contributions in high-performance computing, which have had a significant impact in computational science.

The A. M. Turing Award, often referred to as the 'Nobel Prize of Computing', is an annual prize awarded by the Association for Computing Machinery to recognize important developments and contributions to the computer science community. It goes without saying that, because computational models and algorithms are abundantly used as primary resources across different domains, the awarded contributions are also relevant to the entire computational science community. Past notable recipients of this award include, among many others, Yoshua Bengio, Geoffrey Hinton, and Yann LeCun for laying the foundation for deep neural networks; Tim Berners-Lee for inventing the World Wide Web; Vinton Cerf and Robert Kahn for their work on internetworking, which includes the design and implementation of the Internet's communications protocols; and Judea Pearl for fundamental contributions to artificial intelligence, including the development of Bayesian networks and a mathematical framework for causal inference. Looking back at all of the past Turing Award winners is a reminder of the many achievements in computer science that have influenced the way we work and that have made many scientific developments and breakthroughs possible.

This year, the 2021 A. M. Turing Award will be given to Jack Dongarra for his contributions to numerical algorithms and libraries for high-performance computing (HPC) software.

The significance of the 2021 award cannot be overstated. HPC has been an instrumental resource for efficiently scaling computations to a large number of processors: by allowing the processing of large amounts of data at fast speeds, HPC makes executing computationally intensive tasks more feasible — tasks that would otherwise be difficult or even impossible to perform using modest machines. The 2021 award certainly highlights the importance of HPC to computer science, and to computational science more broadly speaking, as HPC has been widely used in various domains, including weather prediction, health sciences, molecular modeling, neuroscience and quantum computing. It is worth mentioning that this is not the first time that contributions to HPC have been recognized with a Turing Award: Frances Allen received the 2006 A. M. Turing Award for her work in compiler design and machine architecture, which are at the foundation of modern HPC.

But most importantly, the 2021 award recognizes Dongarra's remarkable career of making supercomputers actually usable, to put it simply. For over five decades, hardware performance has been improving at a very fast pace, but in order to properly make use of these hardware advances, software developments have had to keep up. By designing and building numerical software that exploited the hardware architecture in order to achieve the highest performance possible, Dongarra's work allowed supercomputers to become increasingly more powerful and of practical use to scientists.

Perhaps most notably, Dongarra has developed programs and libraries that became standard in the industry. Basic Linear Algebra Subprograms, or BLAS, defined a set of fundamental operations on vectors and matrices that are the basis of scientific computing: BLAS effectively reduced matrix and vector mathematics to a basic unit of computation, which has had a significant impact in science. Dongarra was also involved in the development of LINPACK, a well-known software library for numerical linear algebra that offered a way to run complex mathematics in supercomputers back in the 70s; MAGMA, a linear algebra library for graphics processing units and hybrid architectures; and SLATE, a linear algebra package that is targeted at exascale machines, meaning, machines that are capable of calculating at least 10^{18} floating point operations per second. Many of the algorithms and libraries developed by Dongarra and colleagues have been incorporated into various programs, such as MATLAB, the R and Julia programming languages, NumPy, SciPy, and so forth, reaching a very wide range of users. As linear algebra is at the heart of computing, these algorithms have had a considerable impact within various fields, including deep learning and computer graphics.

The contributions made by Dongarra do not stop here. Another notable achievement was the design of Message Passing Interface (MPI), which defines a base set of routines for distributed-memory communication in parallel computers that can be efficiently implemented by hardware vendors. Before MPI was developed, there was no standardized interface for exchanging messages between multiple processors or workstations, meaning that parallel applications implemented for one machine could not be easily ported to other machines. MPI still remains the dominant model used for parallel processing today.

Dongarra has also contributed to establishing benchmarking mechanisms to rank the fastest supercomputers of the world. The LINPACK benchmark, based on the LINPACK library, and the HPCG benchmark have been developed and used to compile a list of the most powerful machines, known as the TOP500 list. Ultimately, this has provided a more reliable way for scientists to track and detect trends in HPC, instead of having to rely on the numbers and claims touted by vendors.

Nature Computational Science had the opportunity to talk to Dongarra about his research trajectory, his contributions to HPC, and his perspective on the future of this field. We certainly encourage our readership to check out this Q&A. ❐

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