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Press release

January 21, 2025

In the Information and Communication Technologies category

The Frontiers of Knowledge Award goes to Anil Jain and Michael I. Jordan for core contributions in machine learning that have powered the development of biometrics and artificial intelligence

- **The two laureates have made "core contributions"** enabling computers to identify patterns and generate predictions from large-dimension data sets, with applications that have "far-reaching impacts on society as a whole," in the words of the award citation

- **Jain's work in pattern recognition** has been vital to the development of biometric technologies allowing individuals to be recognized through fingerprints or face ID, as applied in the security realm for both criminal investigation and for accessing mobile phones and other devices

- **The predictive algorithms created by Jordan** have laid the mathematical foundations for generative AI models like those powering ChatGPT or Amazon's recommender systems, giving rise to multiple applications that support the economic decision-making of consumers and firms

The BBVA Foundation Frontiers of Knowledge Award in Information and Communication Technologies goes in this seventeenth edition to Anil Jain (Michigan State University, United States) and Michael I. Jordan (University of California, Berkeley, United States) for what the committee calls their "core contributions" to machine learning, which have unlocked "applications of far-reaching impact on society as a whole."

Over the last four decades, the two awardees have made vital contributions enabling computers to recognize patterns and generate predictions from large-dimension data sets, powering the advance of such transformative technologies as biometrics and artificial intelligence.

Jain's research has focused on pattern recognition, leading to "monumental contributions" – in the words of the committee – in recognizing people through fingerprints or face ID, with

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technologies that are now being massively deployed in the security domain, both in criminal investigations and for accessing mobile phones and other electronic devices.

In parallel, Jordan's independent efforts in the machine learning field "provided unified algorithms for statistical and probabilistic inference," said the committee, "enabling computers to make accurate predictions from observed data." His achievements laid the mathematical foundations for generative AI models such as those powering ChatGPT, and the development of recommender systems, like the one used by Amazon, that inform the economic decision-making of both consumers and businesses.

For the committee, the contributions of Jain and Jordan have had a transformative impact "on everyday life," leaving "an indelible stamp on the fabric of today's – and tomorrow's – information-rich society."

Jain: the foundations of biometric technologies

After studying in his native India, Anil Jain began his research career at Michigan State University working on automated systems able to distinguish whether a military plane in the air was the enemy's or "one of ours." From there he went on to study questions like how to detect signs of disease in medical images, or how to use a computer to recognize the destination address of postal mail. But none of these applications of the underlying technique of pattern recognition took him as far as his work on fingerprint and face recognition, where he has become a world-leading authority.

In the 1970s, the awardee was looking at how to group data in the most illustrative way, a technique known as clustering. There were plenty of algorithms around that could do this, but none of them dealt with what he considered to be the key issue: how to check whether the result of the clustering algorithm made actual sense, i.e., whether the categories it found were meaningful. Jain not only devised a means to validate this type of algorithm, but also proposed ways to accurately visualize such data clusters.

It was in light of this work that he received a call from a colleague in the 1990s in search of a civil application for an apparatus designed by the U.S. National Security Agency. On exploring the possibilities of this new machine, Jain soon realized that it could serve to identify matches between two fingerprints some 100 times faster than any previous method. That finding would produce six patents and, in time, Jain's group would come to lead the world in fingerprint recognition.

This technology, now in wide use in the touch ID features of our mobile phones and as a forensic tool in criminal investigations, has also been key to developing an identification system for the population of India, which until less than two decades ago did not have a unified registry of

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citizens. In 2009, Jain worked with the Indian Government to set up a reliable system that would allow all citizens to access social and banking services and to exercise their right to vote, while respecting the privacy of users. "Political parties have come and gone," the new laureate remarks, "but they all believe in the system and have kept it going."

Jain was also a pioneer in quantifying the uniqueness of a person's fingerprints. Though no one thought it possible, he was able to demonstrate that the tiny distortion caused by the tip of a finger being pressed against a surface gave rise to the slight probability that two people's fingerprints could be misidentified as the same. "The resulting article, which we published in 2002, changed the perspective of forensic agencies, who could no longer take for granted that each person's prints were unique."

The awardee also looked at the stability or persistence of fingerprints over time, providing first-time confirmation with solid data of this popular belief. To do so, he used a data set of 40,000 repeat offenders stretching over 12 years, during which their fingerprints were taken on each occasion they were arrested. What he found lent substance to the unproven conjecture that they do not change over time.

"This is a well-deserved award, because Anil Jain is clearly the father of fingerprint recognition, and one of the fathers of iris recognition. Within the field of face recognition, he has sought and found solutions to frontier problems due to changes in lighting or appearance and the effects of aging," adds Javier Ortega García, Professor of Signal Theory and Communications and Director of the Digital Transformation School at the Universidad Autónoma de Madrid, who has worked with the awardee over various research stays in his laboratory.

Jordan: the mathematical foundations of artificial intelligence

Michael I. Jordan has developed mathematical and computational techniques that underpin a wealth of AI applications. From restaurant recommendation systems to generative language models like ChatGPT or decision support tools in the business domain, Jordan's advances have been instrumental in enabling their real-life application. In addition to laying the theoretical foundations for such uses, the awardee has brought several of them to market in partnership with companies.

Jordan began his research career looking at the models used to establish probabilistic relations between different variables, which are a key component of text and image analysis and recommendation systems. Back in the 1990s, he was also at the forefront of the development of so-called variational inference models, able to approximate the solution to a mathematical problem that is not solvable with available computational resources, by reducing it to an optimization problem. This technique is a core component of machine learning, particularly deep learning applications like the generative AI of ChatGPT and other language models.

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In the 2000s, Jordan turned his attention to multiplying the possibilities of machine learning by running programs on hundreds or thousands of computers instead of just one. The algorithms he devised to enable such large-scale distributed computing led to the setup of the company Anyscale, whose Ray platform is the basis for ChatGPT, numerous e-commerce firms and many other deep learning applications.

Among the awardee's more recent interests has been the application of machine learning to economics. In contexts where multiple actors are entrusting decisions to the same system, recommender systems must be able to adapt to avoid congestion. For instance, a GPS app being used in a town with hundreds of thousands of inhabitants could recommend the same route to the airport to a thousand users at once, causing traffic hold-ups. Jordan is working to develop machine learning systems that overcome this problem, reflecting people's preferences while allowing them to collaborate within the same system (for instance, choosing alternative routes so as to generate lighter traffic on each). "What we aim for is to have people and decision-making systems working together and finding solutions that are valuable or appropriate for everybody. The kind of thing that an economist would think about," he explained in an interview. "It's less about collecting vast stores of knowledge and knowing everything about the world and telling us the answer. More about making us connect better so we can get more out of each other and collaborate more effectively. I want to empower humans, not have the AI tell humans what to do."

Future challenges: to improve the precision of biometrics and economic decision-making

For Jain, the next big challenge is to coax out further improvement in accuracy, a goal he views as crucial to avoid situations where people are wrongly arrested because their fingerprints or face appear to match those found at a crime scene. Another key issue is the security of the data sets underlying biometric systems. "Any security system can be attacked. So does that mean I can enter the police's database and change one of the photos? Or can I wear a mask of another person's face so the system thinks it's them? Is the face captured on the security camera a real human face or a deep fake?" Research is also under way to ensure that comparisons of a captured facial image against the database take place in an encrypted environment, so no data gets publicly revealed: "That's a major thing, because biometrics is here to stay." The laureate is currently looking at ways to identify people from drone images, where their face may not be recognizable but other inputs might be used like the shape of their body or the way they walk.

Jordan, meantime, has taken on the leadership of the newly created "Markets and Machine Learning" research chair at the INRIA Foundation in Paris, with the collaboration of the French National Centre for Scientific Research (CNRS) and the Ecole Normale Supérieure-Université PSL, whose remit is the development of algorithms for use in industrial and business decision-making. "Today's machine learning is not that good at decision-making under uncertainty," the awardee points out. "And this is a key issue for firms, as they often operate in highly variable

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environments. Uncertainty and the need to reduce it is everywhere, from the decisions made by individual microeconomic agents in local contexts to the dynamics of global markets. Predictive machine learning must be placed in an economic and collective context, and that is going to be one of the focuses of my research in the coming years."

Optimism in the face of fearful narratives of new technology risks

Asked about the possible risks to privacy of misuse of biometric data, Jain is confident that they can be contained: "I think ultimately it boils down to who is maintaining the database, which must be encrypted." He also cites the EU's privacy act as an example to follow to ensure user consent to data collection and sharing: "The European law has really changed the ways we handle personal data; not just biometric data, but also personal health data and so on. It has made a huge impact because earlier you could just put a camera in the corridor and collect the data. You cannot do that now."

In contrast to apocalyptic visions of the existential risk AI poses to humanity, Jordan contends that "it's kind of science fiction to think that robots will take over and replace humans." On the contrary, he is convinced of the benefits this technology can bring by "empowering" people with a new form of collective intelligence: "I think human beings will be able to use this technology effectively, as a tool that helps us develop our abilities to the fullest extent. Think about air travel for example. Airplanes used to be flown mostly by humans and now most are flown mostly by machines. And so the machines are making lots of decisions about how the airplane flies, and overall planes have gotten safer because of this. There are things machines can do faster and more reliably than humans, and in these domains they support and complement our intelligence."

Laureate bio notes

Anil Jain (Basti, India, 1948) holds an MS degree (1970) and PhD (1973) in electrical engineering from Ohio State University. In 1974 he took up a position at Michigan State University, where he has spent his entire career and is now a University Distinguished Professor. Author of almost 300 published papers and fifteen books, including *Introduction to Biometrics*, *Handbook of Face Recognition*, *Handbook of Fingerprint Recognition* and *Algorithms for Clustering Data*, he also has a dozen patents to his name and has served as editor-in-chief of *IEEE Transactions on Pattern Analysis and Machine Intelligence*, and associate editor of several other journals. Jain has been an Amazon Scholar since 2021, and has held visiting appointments at the International Institute of Information Technology, Hyderabad (India), Korea University, ETH Zurich and IBM's T.J. Watson Research Center. He is a member of the U.S. National Academies study on "Facial Recognition: Current Capabilities, Future Prospects, and Governance."

Michael I. Jordan (Aberdeen, Maryland, United States, 1956) holds a master's degree in Mathematics (Statistics) from Arizona State University (1980) and a PhD in Cognitive Science

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from the University of California, San Diego (1985). His career has largely been spent at the Massachusetts Institute of Technology (1988-1998), where he was a professor in the Department of Brain and Cognitive Sciences, and, latterly, at the University of California, Berkeley, where he has been Pehong Chen Distinguished Professor in the Department of Electrical Engineering and Computer Science and in the Department of Statistics and is currently Emeritus Professor. He is also a Senior Researcher at the National Institute for Research in Digital Science and Technology (INRIA) in Paris (France), where he heads the Markets and Machine Learning chair. Author of over 230 publications in scientific journals, he has served as president of the International Society for Bayesian Analysis and on the editorial boards of journals including *Statistics and Computing* and *Stochastic Analysis and Applications*.

Nominators

A total of 41 nominations were received in this edition. The awardee researchers were nominated by Francis Bach, a researcher at the National Institute for Research in Digital Science and Technology (INRIA)/Ecole Normale Supérieure (ENS), Paris (France); Sanghamitra Bandyopadhyay, a professor and director of the Indian Statistical Institute (India); Yoshua Bengio, a professor at the Université de Montréal (Canada) and winner of the 2018 Turing Award; David M. Blei, a professor at Columbia University (United States); Christoph Busch of the Norwegian University of Science and Technology (Norway); Lawrence Carin, a professor at Duke University (United States); Subhasis Chaudhuri, chairman of the board of directors of BSE (India); Jennifer T. Chayes, a professor at the University of California, Berkeley (United States); Thomas G. Dietterich, an emeritus professor at Oregon State University (United States); William T. Freeman, a professor at the Massachusetts Institute of Technology (United States); Guido W. Imbens, a professor at Stanford University (United States) and winner of the 2021 Nobel Memorial Prize in Economic Sciences; Charles Lee Isbell, Jr., a professor at the University of Wisconsin-Madison (United States); Michael Kearns, a professor at the University of Pennsylvania (United States); Neil D. Lawrence, a professor at the University of Cambridge (United Kingdom); Dario Maio, an emeritus professor at the University of Bologna (Italy); Stéphane Mallat, a professor at the Ecole Normale Supérieure (ENS), Paris (France); Xiao-Li Meng, a professor at Harvard University (United States); Pierre del Moral, a researcher at the National Institute for Research in Digital Science and Technology (INRIA)/University of Bordeaux (France); Peter Müller, a professor at the University of Texas at Austin (United States); P. J. Narayanan, professor and director of the International Institute of Information Technology (India); the National Laboratory of Pattern Recognition of the Institute of Automation of the Chinese Academy of Sciences (China); Stephanie Schuckers, a professor at Clarkson University (United States); the Security Research Lab at the University of Surrey (United Kingdom); Padhraic Smyth, a professor at the University of California, Irvine (United States); John N. Tsitsiklis, a professor at the Massachusetts Institute of Technology (United States); and Larry

Wasserman, a professor at Carnegie Mellon University (United States).

Information and Communication Technologies committee and evaluation support panel

The committee in this category was chaired by **Joos Vandewalle**, Honorary President of the Royal Flemish Academy of Belgium for Science and the Arts and Emeritus Professor in the Department of Electrical Engineering (ESAT) at KU Leuven (Belgium), with **Ron Ho**, Corporate Vice President, R&D Hardware, at Lattice Semiconductor (United States) acting as secretary. Remaining members were **Oussama Khatib**, Professor of Computer Science and Director of the Robotics Laboratory at Stanford University (United States); **Rudolf Kruse**, Emeritus Professor in the Faculty of Computer Science at Otto von Guericke University Magdeburg (Germany); **Mario Piattini**, Professor of Computer Languages and Systems at the University of Castilla-La Mancha (Spain); **Daniela Rus**, Andrew (1956) and Erna Viterbi Professor of Electrical Engineering and Computer Science and Director of the Computer Science and Artificial Intelligence Laboratory (CSAIL) at Massachusetts Institute of Technology (United States); **Bernhard Schölkopf**, Scientific Director of the ELLIS Institute Tübingen and Director of the Empirical Inference Department at the Max Planck Institute for Intelligent Systems (Germany), and 2019 Frontiers of Knowledge Laureate in Information and Communication Technologies; and **Alicia Troncoso**, President of the Asociación Española para la Inteligencia Artificial (AEPIA) and a Professor and Head of the Data Science and Big Data Lab at Pablo de Olavide University (Spain).

The evaluation support panel was coordinated by **Elena Cartea**, Deputy Vice-President for Scientific-Technical Areas at the Spanish National Research Council (CSIC), and **José Javier Ramasco Sukia**, Deputy Coordinator of the Materia Global Area and Research Professor at the Institute for Interdisciplinary Physics and Complex Systems (IFISC, CSIC-UIB), and formed by **Luis Fonseca Chácharo**, Research Professor and Director at the Institute of Microelectronics of Barcelona (IMB-CNM, CSIC); **Alberto Ibáñez Rodríguez**, Tenured Scientist at the Leonardo Torres Quevedo Institute of Physical and Information Technologies (ITEFI, CSIC); **Felip Manyà Serres**, Scientific Researcher and Vice-Director at the Artificial Intelligence Research Institute (IIIA, CSIC); and **Teresa Serrano Gotarredona**, Research Professor and Director of the Seville Institute of Microelectronics (IMSE-CNM, CSIC)

About the BBVA Foundation Frontiers of Knowledge Awards

The BBVA Foundation centers its activity on the promotion of world-class scientific research and cultural creation, and the recognition of talent.

The BBVA Foundation Frontiers of Knowledge Awards, funded with 400,000 euros in each of their eight categories, recognize and reward contributions of singular impact in science, technology, humanities and music, privileging those that significantly enlarge the stock of knowledge in a discipline, open up new fields, or build bridges between disciplinary areas. The

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goal of the awards, established in 2008, is to celebrate and promote the value of knowledge as a global public good, the best instrument we have to confront the great challenges of our time and expand individual worldviews. Their eight categories address the knowledge map of the 21st century, from basic knowledge to fields devoted to understanding the natural environment, by way of other, closely connected domains like biology and medicine, economics, information technologies, social sciences and the humanities, and the universal art of music.

The BBVA Foundation is aided in this endeavor by the Spanish National Research Council (CSIC), the country's premier public research organization. CSIC appoints evaluation support panels made up of leading experts in the corresponding knowledge area, who are charged with undertaking an initial assessment of candidates and drawing up a reasoned shortlist for the consideration of the award committees. CSIC is also responsible for designating each committee's chair across the eight prize categories and participates in the selection of remaining members, helping to ensure objectivity in the recognition of innovation and scientific excellence.

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