

The second category decided in the fifth edition of these international awards

## **Lotfi Zadeh, inventor of fuzzy logic, wins the BBVA Foundation Frontiers of Knowledge Award for enabling computers and machines to behave and decide like human beings**

- By equipping computers to tolerate real-world complexities and decide accordingly, fuzzy logic transforms them from mere calculating machines, and allows appliances and systems to operate autonomously
- His 1965 paper on fuzzy sets is one of the most cited of the 20th century, and has given rise to over 50,000 patents just between Japan and the United States
- Fuzzy logic is now an essential part of popular consumer technologies – like video cameras or washing machines – and other more sophisticated technologies used in medicine and the automobile and railway industries

**Madrid, January 15, 2013.-** The BBVA Foundation Frontiers of Knowledge Award in the Information and Communication Technologies (ICT) category has been granted in this fifth edition to the electrical engineer Lotfi A. Zadeh, “for the invention and development of fuzzy logic.” This “revolutionary” breakthrough, affirms the jury in its citation, has enabled machines to work with imprecise concepts, in the same way humans do, and thus secure more efficient results more aligned with reality. In the last fifty years, this methodology has generated over 50,000 patents in Japan and the U.S. alone.

On hearing of the award, Zadeh remarked that it meant a lot to him for several reasons: “First, because fuzzy logic has been somewhat controversial. Some people have greeted it with enthusiasm but others have been skeptical. It also has a special significance for me because I am a great admirer of Spain and the Spanish people. I’d therefore like to take this opportunity to express my deep

appreciation to all those who were involved in my receiving this award, particularly Luis Magdalena and Enric Trillas of the European Centre for Soft Computing in Mieres, who were among those putting forward my nomination.

Classical logic, based on class membership, imposes that an element should strictly belong or not belong to a clearly demarcated set, like for instance the set of even numbers. But reality is a lot more complex. Hence we have groups, classes and sets whose boundaries are blurred, like that of "good basketball players." To belong to this set, a basketball player must "be tall" and "shoot well", but these concepts are imprecise. A binary system would specify, for example, that "be tall" equates to "measure more than 185 cm" and discard all players below this height, regardless of their shooting prowess. But fuzzy logic, like a human coach, would find room in the set of good players for one who measures 184 cm but is an excellent shooter. In this sense, what fuzzy logic does is bridge the gap between classical logic and the real world.

This indeed is what Zadeh was seeking when he began the research that led him to fuzzy logic: "As an engineer, I was always convinced that mathematics held the answers to almost any problem, but I also realized that classical mathematics was constrained by its inability to tolerate imprecision." To get over this shortcoming, Zadeh turned to the human model: "We humans have a remarkable capability to reason and make decisions in an environment of uncertainty and incompleteness of information (...). The principal objective of fuzzy logic is the formalization of this capability."

Human beings intuitively apply fuzzy logic to their decisions, juggling imprecise data and weighing up each relevant element. Zadeh's contribution was to apply such logic to the decision-making processes of systems and computers, so they cease to operate as mere calculating machines and become capable of evaluating degrees and shades of reality and deciding accordingly in an autonomous or semi-autonomous fashion (with little or no human intervention). Think, for example, of a washing machine that can select a cycle – with its length, speed and temperature – according to the drum load and the dirtiness of the laundry. Other systems can deliver the same results, but the sensors and electronics facilitated by fuzzy logic get the job done more cheaply.

According to the jury, the contributions of Lotfi A. Zadeh (Baku, Azerbaijan, 1921) have been "enthusiastically adopted by industry, where thousands of engineers have designed a whole plethora of complex and intelligent systems (...). With several tens of thousands of patents worldwide, fuzzy control is now an essential component in a wide range of consumer products, including video cameras, washing machines and medical instruments, as well as in more complex systems such as automatic trains, wastewater treatment plants, and intelligent control of car engines."

But Zadeh's work has also changed the face of numerous industrial processes, where it has simplified design, providing more efficient products that are easier to use and more tractable to change, while bringing down production costs.

## A seminal paper

En 1965, Lotfi Zadeh articulated fuzzy sets for the first time in a paper that would come to be among the most cited of the 20th century, with over 35,000 mentions. And the next step from there was the development of fuzzy logic, a brilliant contribution to extending the frontiers of knowledge. Indeed Zadeh is defined in the jury's citation as the founder of "a new field of research which has proved powerful in many application domains."

The controversy around fuzzy logic began with the name: "The word fuzzy has a pejorative connotation in English, and this turned out to be a handicap when it came to gaining the acceptance of the scientific community. But it was the word that came closest to what I had in mind. In Asia, however, they don't have problems with the word fuzzy, so they were more receptive to my work. They also have a culture that accepts shades of grey, as opposed to the western – Cartesian – tradition where everything is either black or white."

This was perhaps the reason, he speculates, that one of the earliest applications of his concept was the automated subway system in the Japanese city of Sendai. The application of fuzzy logic to the network's control system enabled trains to change speeds as if they had an experienced human driver at the wheel. Indeed acceleration and braking were more even with the new system, resulting in less electricity consumption as well as a smoother ride for passengers.

Fuzzy logic opened the door to machine understanding of such imprecise instructions as "brake smoothly" or "refrigerate until the air is cool," which would be instantly understood by any human being acquainted with the system, but is utterly impenetrable for a conventional computer program. The conceptual shift was so abrupt that Zadeh initially had to face the skepticism of many scientist colleagues, until the success of the practical applications of his theory dissipated all such doubts.

Zadeh's work has enabled us to communicate with machines through an increasingly natural, human language. In the words of jury secretary, Ramón López de Mántaras: "Rather than human beings having to take the time to learn the complex mathematical language of machines, fuzzy logic proposes a simpler language, so it is the machines that mimic human patterns of reasoning and behavior in order to solve problems."

The laureate, still working at the age of 91, sees this as the most promising research avenue in the fuzzy logic field, and hopes to author some further advance that will connect computers and systems more closely with natural language.

## Bio notes

Loffi A. Zadeh was born in 1921 in Baku, capital of the former Soviet Republic of Azerbaijan, where his Iranian father was working as a journalist. When he was ten, the family moved to Teheran (Iran), and Loffi was sent to an American Presbyterian missionary school. Due to an administrative oversight, he was enrolled in a class several years ahead of his supposed academic level, but this did not stop him from excelling in his studies, and obtaining the third highest score in the entire country in his university entrance exam.

Zadeh graduated as an electrical engineer from the University of Teheran in 1942, one of only three students to do so amid the disruption created by the Second World War. In 1943, he emigrated to the United States, where he took an MS in electrical engineering at Massachusetts Institute of Technology (MIT). Six years later, he earned his PhD in the same subject at Columbia University (New York), where he would teach for the next ten years. In 1959, he joined the Department of Electrical Engineering and Computer Sciences in the University of California at Berkeley, where he has headed the Berkeley Initiative in Soft Computing since 1991.

He published his seminal work on fuzzy sets in 1965, and in 1968 proposed his theory of fuzzy logic. More than two decades later, in 1991, he introduced another new paradigm: soft computing, a hybrid methodology embracing fuzzy logic, neural networks, evolutive algorithms and probabilistic reasoning. Author of 245 papers, his research has been cited on more than 90,000 occasions, according to Google Scholar, and the vitality and influence of the field he created is evidenced by the number of papers – around 253,000 – that include the word “fuzzy” in their titles. Zadeh has held editorial posts at 75 specialist journals and though fuzzy sets and logic have given rise to tens of thousands of patents, not a single one is in his name.

In the last 15 years, he has been concerned with the computational scenario where data and operations may be specified in a natural language, or what he calls “computing with words.”

Zadeh is a U.S. citizen but has retained his Iranian nationality.

## BBVA Foundation Frontiers of Knowledge Awards

The BBVA Foundation primarily engages in the generation and diffusion of scientific knowledge and culture, through ongoing programs in the areas of basic sciences, biomedicine, ecology and conservation biology, social sciences, literary and musical creation, and the visual arts.

Its focus on the core concerns of today's society, like health or the environment, has materialized in major research projects, including those involving the study of cancer. The Foundation's support for research, advanced training and knowledge dissemination is also manifest in a series of award families which not only honor the winners' contributions but also shed a wider light on their fields of work, the values they represent and the combined endeavors of the research and creative communities.

The BBVA Foundation established its Frontiers of Knowledge Awards in 2008 to recognize the authors of outstanding contributions and radical advances in a broad range of scientific and technological areas characteristic of our times. They are in this sense a prize family congruent with the knowledge map and central challenges of the 21st century.

The nominations received from leading universities and research and cultural centers all round the world, the independence and objectivity of the prize juries formed by reputed specialists in their respective fields, and the excellence of the laureates in their earlier editions have earned these awards, devised and organized from Spain, a firm place among the world's foremost award schemes. The BBVA Foundation is assisted in this initiative by the country's premier multidisciplinary research organization, the Spanish National Research Council (CSIC), and by the presence of Spanish scientists and creative practitioners on the international juries.

The CSIC collaborates in the appointment of Technical Evaluation Committees for each prize category made up of acknowledged experts in the relevant domain. This Committee undertakes an initial assessment of candidates and draws up a reasoned shortlist for the consideration of the juries.

In the ICT category, Committee members were Pedro A. Serena Domingo, a researcher in the Institute of Materials Science of Madrid (CSIC) and coordinator of the Council's Materials Science and Technology Area; Ceferino López Fernández, Research Professor at the Institute of Materials Science of Madrid (CSIC); Josep Fontcuberta Griñó, Research Professor in the Institute of Materials Science of Barcelona (CSIC); and Manuel Lozano, Research Professor at the Institute of Microelectronics of Barcelona (CSIC) and coordinator of the Council's Physical Science and Technologies Area.

The Frontiers awards provide an international showcase for the best qualities of Spain and Spanish science, and have achieved the endorsement of the world scientific community, whose members have served on the juries and put forward nominations from their posts in eminent Spanish and international academic and research institutions.

In their fifth edition, the BBVA Foundation Frontiers of Knowledge Awards wish to offer support and recognition to the individuals and teams working for a better future for people through the advancement of knowledge, innovation and culture and their dissemination to society; goals and practices that are also at the center of the BBVA Group culture.

In an economic context marked by a prolonged economic crisis and the adoption of short-term measures to tackle its multiple causes and manifestations,

science, the environment and culture have dropped further down the list of public priorities. The BBVA Foundation Frontiers of Knowledge Awards, and the Foundation's broader program to foster scientific knowledge and culture, wish to drive home the message that these three areas are of transcendental importance for our collective wellbeing and individual opportunities.

The eight categories of the BBVA Foundation Frontiers of Knowledge Awards respond to the knowledge map of the early 21st century, but also to key global challenges that have never before merited a specific honor on this scale, as with the two environmental categories – Ecology and Conservation Biology and Climate Change – and the category of Development Cooperation. These stand alongside the classic categories of Basic Sciences, Biomedicine and Economics, Finance and Management. Finally, the award family is completed by Contemporary Music, an art at the leading edge of cultural innovation to which the BBVA Foundation devotes a broad-ranging support program, and where Spain is home to a wide and talented community of authors, conductors and performers.

### International jury

The jury in this category was chaired by **George Gottlob**, Professor of Computer Science at the University of Oxford (United Kingdom), with **Ramón López de Mántaras**, Director of the Artificial Intelligence Research Institute of the Spanish National Research Council (CSIC) acting as secretary. Remaining members were **Oussama Khatib**, Professor in the Artificial Intelligence Laboratory in the Computer Sciences Department of Stanford University (United States), **Rudolf Kruse**, Head of the Department of Knowledge Processing and Language Engineering at Otto-von-Guerike-Universität Magdeburg (Germany), **Mateo Varelo**, Director of the Barcelona Supercomputing Center (Spain) and **Joos Vandewalle**, Head of the SDC Division in the Department of Electrical Engineering at the Katholieke Universiteit Leuven (Belgium).

The winner in the previous edition was American electronic engineer Carver Mead, for being “the most influential thinker and pioneer” of the silicon age, and enabling “the development of the billion-transistor processors that drive the electronic devices – laptops, tablets, smartphones, DVD players – ubiquitous in our daily lives.”

The award in the third edition went to American mathematician Donald E. Knuth for “making computer programming into a science.” The work of this “giant among giants,” in the words of the jury's citation, is considered the scaffolding upon which modern computer programs are built.

The award in the second edition was granted to engineer and mathematician Thomas Kailath, for a mathematical development permitting the production of increasingly small size chips. Finally, the winner in the inaugural edition was Israeli Jacob Ziv, the mind behind such hugely popular file formats as MP3, JPG or PDF.

The BBVA Foundation Frontiers of Knowledge Awards, spanning eight prize categories, recognize research and creative work of excellence as embedded in theoretical advances, technological developments or innovative artistic works

and styles, as well as fundamental contributions in addressing key challenges of the 21st century. The Foundation has been assisted in the selection of jury members and candidates by the Spanish National Research Council (CSIC), the country's premier research organization. Nominations have been put forward by the world's most prestigious teaching and research institutions.

### UPCOMING AWARD ANNOUNCEMENTS

CATEGORY	DATE
Basic Sciences	January 22, 2013
Biomedicine	January 29, 2013
Ecology and Conservation Biology	February 5, 2013
Contemporary Music	February 12, 2013
Economics, Finance and Management	February 19, 2013
Development Cooperation	February 26, 2013

#### LAUREATE'S FIRST DECLARATIONS AND IMAGES

A video recording of the new laureate's first interview on receiving news of the award is available from the Atlas FTP with the following name and coordinates.

Server: **213.0.38.61**  
Username: **agenciaatlas1**  
Password: **amapola**

The name of the video is:  
"FBBVA PREMIO TIC"

In the event of connection difficulties, please contact Alejandro Martín at ATLAS:

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