2024

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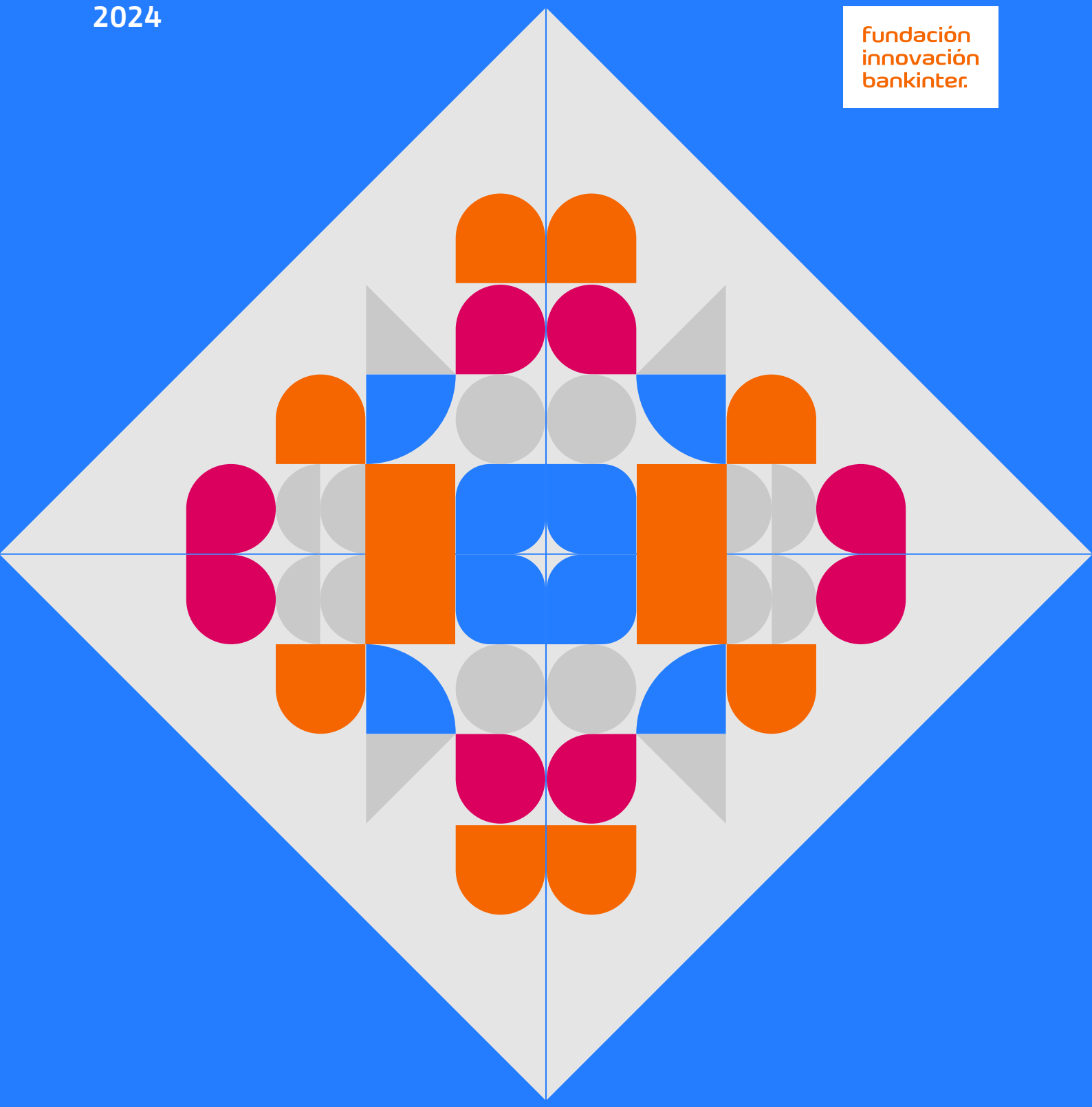

Beyond the future

Megatrends

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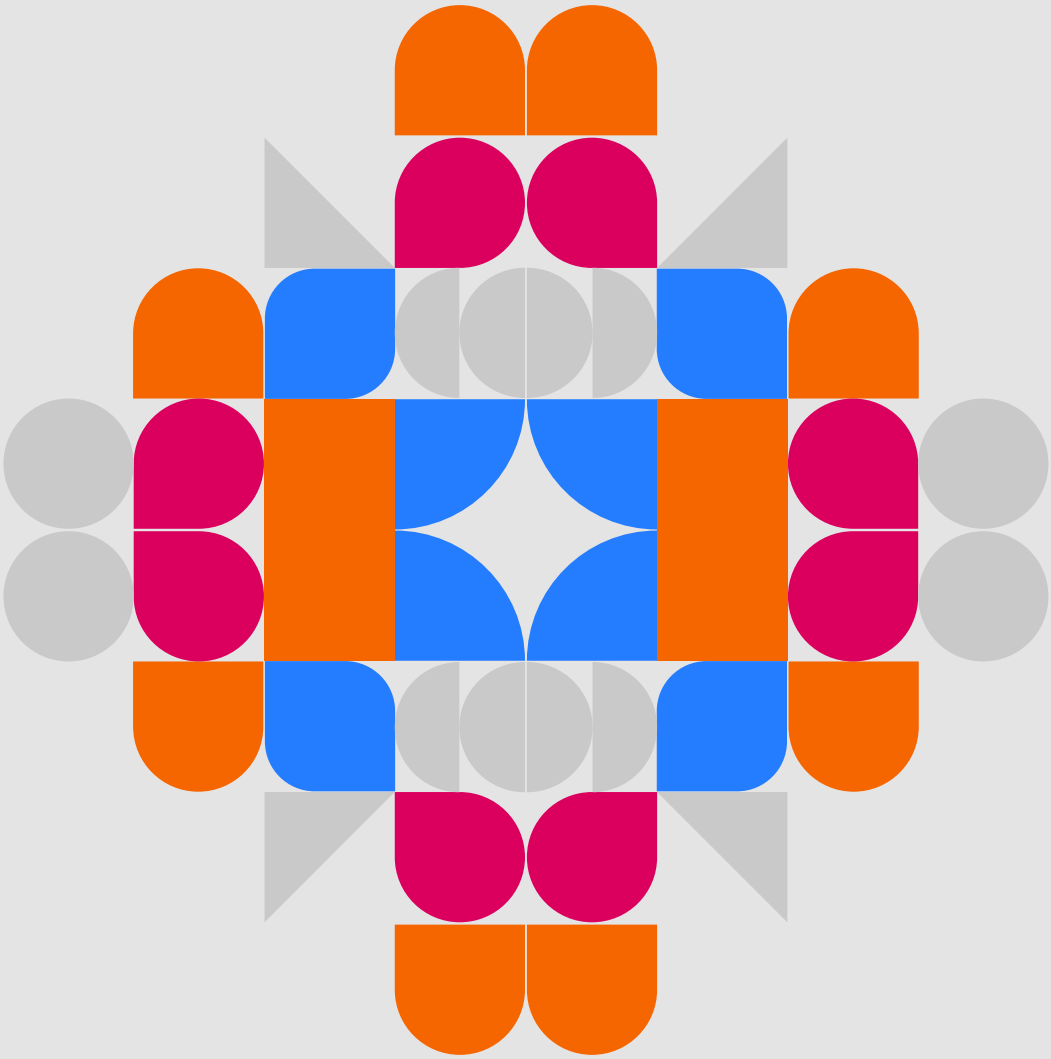
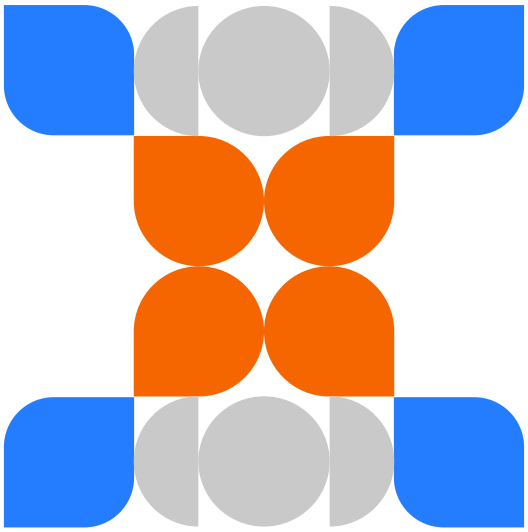


Introduction



Introduction

How far back can we trace the origin of the supercomputer? Back to the first personal computer or the Apollo 11 computer? The tabulating machine in the late 19th century? Do we go back to Ada Lovelace and Babbage's engine? To the 17th century and the first calculator? Or to the abacus, millennia ago?

The history of innovation has been built one milestone at a time over centuries. Each new technology or discovery that emerged appeared to be the culmination of a process, the endgame. In most cases, however, it was just another step in a series of innovations, driven tirelessly beyond by human ingenuity.

It is not easy to take perspective of this process, especially at a time of vertiginous progress in knowledge and technology. It is necessary to identify the course set by innovation and ask the right questions, check the evolution of these undercurrents to discover what awaits us tomorrow.

Since the first edition of the Megatrends report, we have been monitoring the trajectory and impact of these signs. In Megatrends 2024, we have done this exercise once again: we check the state of the art in each trailblazing field and technology.

The ten trends reflected in Megatrends 2024 thus correspond to fields of innovation that have enormous potential to change our lives. For example, artificial intelligence, neuroscience and neurotechnology, or the future of the cities we will inhabit. These are trends that intermingle and evolve year after year to shape our future.

With the help of experts from the Future Trends Forum *think tank*, promoted by the Bankinter Innovation Foundation, we are launching a foresight exercise, making forecasts based on the latest advances.

What lies beyond generative artificial intelligence? Will different computing paradigms collaborate with each other to revolutionize science? How will we take care of our health? Will technology increase our intelligence? These are some of the questions Megatrends 2024 seeks to answer.

Access the virtual assistant of each trend.
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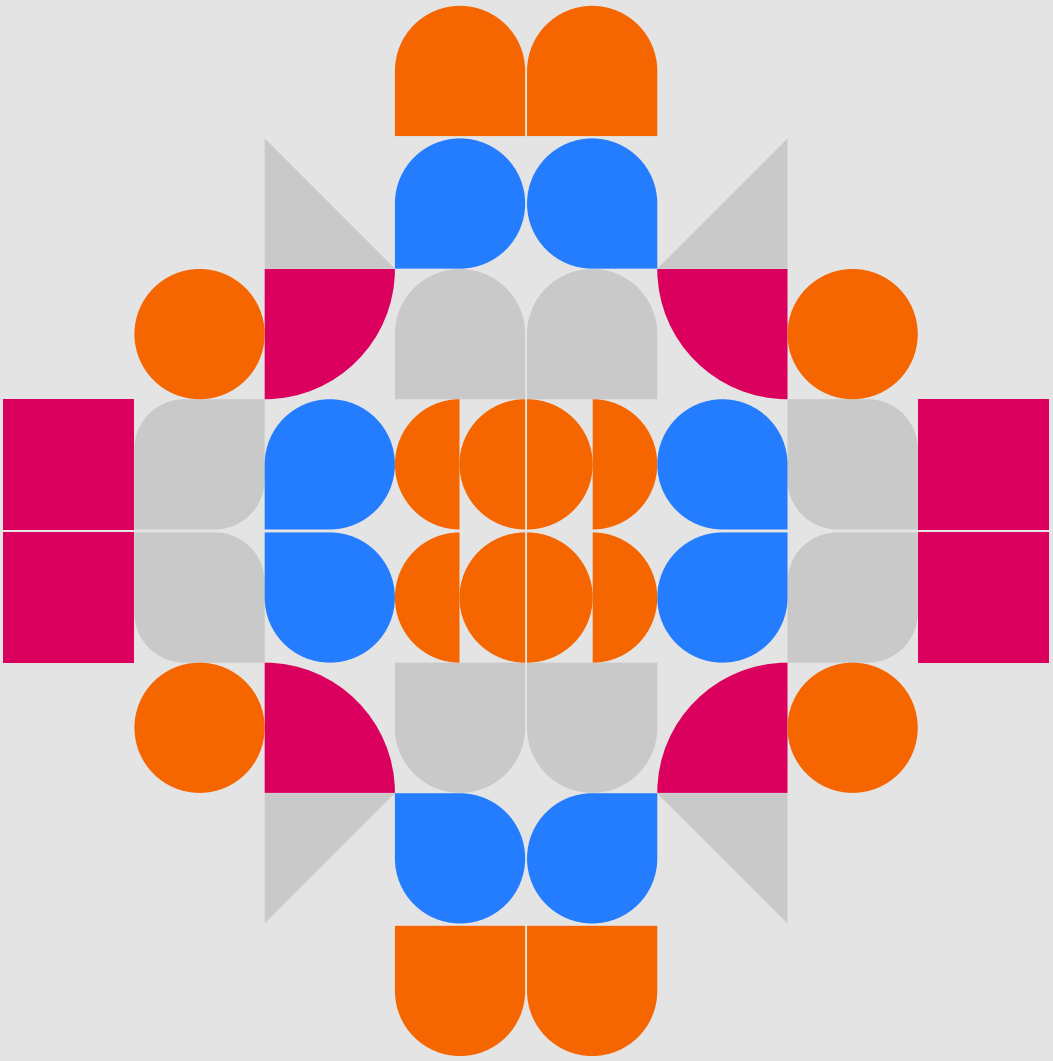
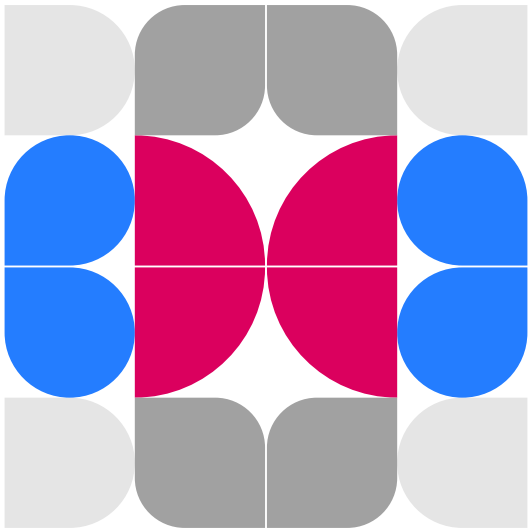


Trends



01

Artificial Intelligence: beyond generative AI

"A stylish woman walks down a Tokyo street filled with warm glowing neon and animated city signage." So began the just over four-line prompt that Open AI gave to Sora, its new tool for generating video from text. The result was a clip that clearly showed what lies ahead in generative artificial intelligence: hyper-realistic worlds that are increasingly indistinguishable from reality.

Generative artificial intelligence is the most visible part of the unstoppable advance of artificial intelligence. It is also democratizing access to this type of technology. As Megatrends 2023 warned: artificial intelligence will make it increasingly easier for us to interact with machines.

Vertical artificial intelligence

However, the tree of the great general models should not prevent us from observing the forest of the development of artificial intelligence. This technology is set to revolutionize all economic sectors and industries. It will do so, to a large extent, through vertical models tailored to each of them.

Vertical artificial intelligence will accelerate innovation in multiple fields because it is based on sector-specific knowledge and expertise. Moreover, these models are designed to offer very specific features.

The applications of this type of dedicated artificial intelligence and their potential to accelerate innovation are endless. From the discovery and design of new antibiotics to more accurate diagnostics and personalized medicine. From autonomous car-based logistics to tailored educational experiences or a new frontier in financial risk analysis and fraud detection.

Doubts about the quality of results, governance challenges, regulatory scrutiny or development and maintenance costs will favor task-oriented models over general-purpose, massive and excessively expensive ones, according to experts.

New horizons in robotics

Technological advances in machine learning and artificial intelligence will mark a turning point in robotics. We have already talked about techniques such as Q-learning or reinforcement learningo, which enables systems to learn and adapt autonomously through a process of trial and error.

Autonomous vehicles, drones and industrial robots benefit from Q-learning because it teaches them how to navigate complex environments and perform specific tasks, following the trend towards vertical artificial intelligence.

Towards hybrid intelligence

As Megatrends 2023 has shown, it is becoming easier and more transparent for us to interact with artificial intelligence. Generative artificial intelligence and its ease of use have a lot to do with this.

As a result of this ease, we increasingly trust the answers it gives us. We build an artificial bond of trust between humans and algorithms that know us almost better than we know ourselves.

Just think, for example, of the trust we already place in the directions of our car's navigator or in the recommendations made by streaming platforms. The next step will come in the form of super-intelligent personal virtual assistants who know us inside out—as predicted by Mustafa Suleyman, Google's DeepMind co-founder.

The reinforcement of this bond and the coming applications of artificial intelligence itself are the steppingstone to hybrid intelligence, shared between human and machine. As a result of ever closer interaction, technology will make us smarter, and we will make technology smarter.

However, there are still many questions about the future of this technology: Are we moving towards general artificial intelligence? Will it be interactive and secure? Will it be proprietary or open source? How will regulation and investment shape it? These questions remain unanswered for now.

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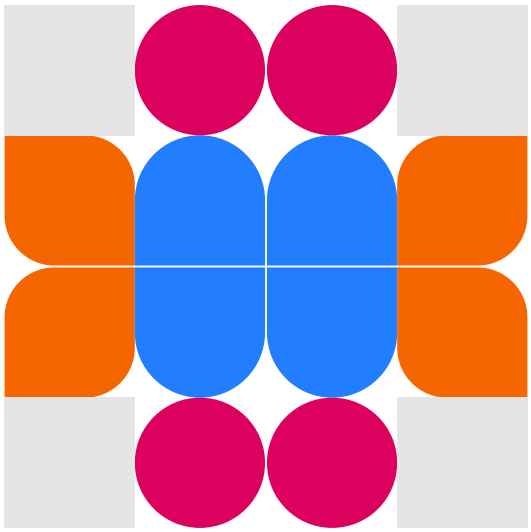

02

Virtual, augmented and mixed reality for (re) creating our world

What happened to metaverses? Generative artificial intelligence has trampled on the plans of large corporations in these immersive worlds. However, this does not mean that virtual reality, augmented reality and, above all, mixed reality are trampled to death.

Quite the contrary: in February 2024, Apple launched its Apple Vision Pro mixed reality glasses on the US market. A viewer capable of realistically superimposing digital elements on our reality or completely immersing us in a virtual walk on the Moon. We just have to choose the degree of immersion we want and let ourselves go

Minimize friction

The possibility of activating a digital icon superimposed on the wall of our living room to use an application is a good summary of what awaits us: decreasing friction between the physical and digital worlds that will enrich our reality.

This is precisely the strength of mixed reality: to realistically integrate digital elements into the real world we perceive. This technology maintains the sensory experience of reality and introduces into it the endless possibilities of the digital world.

The friction between the two spheres (physical and digital) has already begun to dissolve with Apple's new gadget to give way to the network of the future, which will be more immersive, as anticipated by Megatrends 2023.

Transforming sectors

This type of technology has the potential to change entire industries. For example, the integration of the digital and physical realms can transform the product purchase experience into a dynamic and proactive combination of advice, decision optimization and after-sales service. Brands would thus shift from being mere retailers to lifestyle partners.

Today, augmented reality is already commonly used in infrastructure construction. The superimposition of a virtual rendering of the plans on what is being built on the ground enables the detection of possible deviations in the execution or, conversely, of unforeseen obstacles. This, in turn, avoids wasted time and cost overruns caused by subsequent corrections.

On a different note, our experts point to healthcare as a field where the expansion of virtual reality can be tremendously positive. Virtual embodiment technology is already being used in therapies for motor rehabilitation, post-traumatic stress disorder and phobias.

This post already explains how mixed reality applications are used in education and training to teach anatomy and healthcare treatment modalities. It is already possible for a medical student to walk around a human body and zoom in on the areas he or she wants to examine more closely. It is also possible to gain hands-on experience with virtual patients before being confronted with a real case. All that is needed is the right headset and software to support the guidance of the teaching professionals.

The combination of mixed reality and digital twin technologies will facilitate complex and expensive tasks, such as astronaut training. Their use will enable the recreation of safe and immersive environments, where astronauts will be able to interact with vehicles, machines and spacecraft systems to test how their actions affect the environment and surrounding objects.

Generating new worlds

How will virtual, augmented and mixed reality evolve? To a large extent, the answer to this question depends on another: how (and at what pace) will the technology evolve? Without devices and applications capable of facilitating a frictionless experience at an affordable price, it seems difficult to see the widespread use of these digital realities.

In this context, generative artificial intelligence can be key. Its use in programming and in the generation of immersive videos has enormous potential to multiply the development of digital reality applications in all kinds of fields. It may be the missing lever to boost a technology that is advancing at a slow pace.

Growing doubts

Megatrends 2023 already pondered whether we are ready for a future in which the barriers between physical and digital will become increasingly blurred. A doubt that not only remains but acquires new nuances as other technologies advance.

This is the case of generative artificial intelligence and its exponential capacity to generate disinformation. The same doubt hovers over the evolution of social networks and their intent to extend the time we spend in them more and more.

How will we be affected by the confluence of increasingly immersive experiences with platforms competing to hold our attention? Will we be more vulnerable to misinformation if it merges with our perceived reality? What consequences will all this have for society? These are risks that need to be addressed now.


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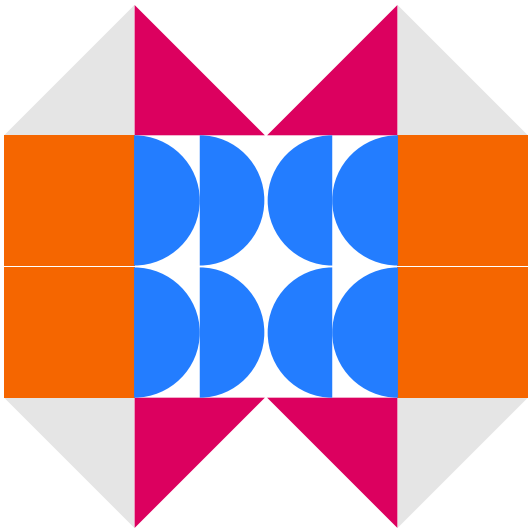

03

The urban revolution: from the smart city to the wise city

Perhaps one of the most repeated words when talking about smart cities is "data". No wonder: information about what is happening in them is essential for them to gain the intelligence we demand of them.

Another question is whether they know how to use that intelligence. In other words, that the smart city becomes a wise city, a truly sustainable environment that takes care of its inhabitants.

What do we do with so much data?

Megatrends 2023 already issued a warning: the smart city requires handling an exorbitant amount of data in real time.

Information on traffic, air quality, energy use or the influx of people in certain places at certain times. In recent years, sensors have been deployed in cities to capture the information generated in the urban environment day by day.

In the coming years, experts believe that this will evolve into applications that will shape life in cities. And this will give rise to a new range of services that will enhance it.

One example would be adaptive cities. These environments will not only provide real-time knowledge of the demand for public infrastructures: they will also be able to adapt to it.

Signals that adjust their messages on the fly to optimize traffic throughout the city. Lighting and shadows that adapt to obtain the precise visibility, safety and temperature in each street fragment in real time. These are just some of the innovations that will be possible in these cities.

They will do all this thanks to the data collected, of course, but also to the application of artificial intelligence, Internet of Things and 6G technologies, ultimately seeking to optimize the use of these infrastructures and minimize the city's carbon footprint.

Experts expect that the combination of massive data from citizens, infrastructure and vehicles with accelerated processing power will lead cities to new levels of efficiency; eventually improving the flow of people and traffic, but also the use of energy and the use of resources in circular models. These concepts are extremely necessary in urban environments that are particularly sensitive to the consequences of climate change.

A matter of priorities

The world's population will become increasingly urban: by 2050, 68% of humanity will live in cities. At the same time, climate change increases the vulnerability of urban environments to high temperatures and pollution.

Emerging technologies such as 6G promise ultra-fast speed, reliable connectivity and enhanced IoT and artificial intelligence applications. On the other hand, climate change accelerates the adoption of green technologies and adaptive urban designs, according to experts.

This confluence of factors will lead to cities that are wiser in their priorities. With sustainability, efficiency and improved quality of life increasingly in focus.

In this context, experts expect local and autonomous renewable energy grids to become the standard. The energy we will consume will then be local: it will come from our own roof or from the neighborhood we live in, and smart grids will be responsible for optimizing its management.

Cities that care for citizens

This new approach will increasingly revolve around the citizen. The wise city will take better care of them. A study published in Nature already offers guidelines for developing urban planning policies that protect the mental health of young people.

However, taking care of citizens goes beyond providing them with resources and services. Their rights must also be guaranteed in environments where their data will flow back and forth at breakneck speed. Data collection and management can easily become an invasion of privacy or surveillance.

Technological evolution requires careful consideration of the social and ethical implications. Especially with regard to privacy, data security and citizen participation. This is the only way to ensure more resilient, sustainable and livable urban environments.


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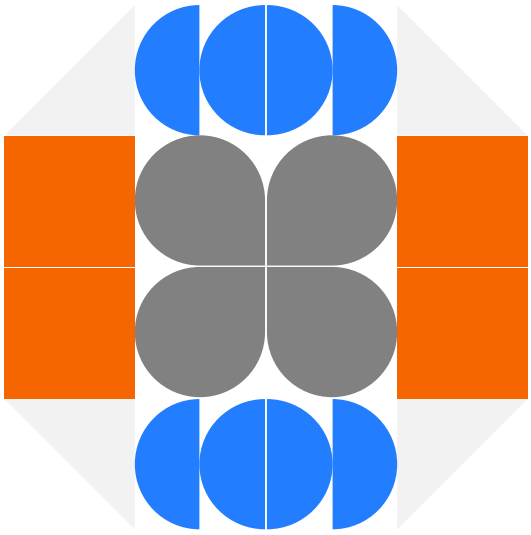

04

Precision medicine to cure the incurable

Beta thalassemia and sickle cell anemia are two potentially lethal blood diseases. They are also the ones that will open the door to a new era in medicine in the European Union: treatments based on the CRISPR gene-editing technique. This technique, which we have already discussed in Megatrends 2023, consists of some "scissors" that cut out the wrong genetic information and replace it with the correct one.

In February 2024, the European Commission approved the first of these therapies, called Casgevy, aimed at curing two diseases that, until then, were incurable.

This authorization was a further step towards the new era of precision medicine, which can harness the power of genetic and molecular data to deliver targeted and effective treatments, tailored to individual genetic profiles. It will do so supported by advances in genome sequencing, gene editing and nanotechnology, together with technologies such as CRISPR, RNA therapies or artificial intelligence.

The superpower of data

The application of precision medicine will be based, according to experts, on the ability to accumulate biological data more quickly and completely.

The combination of this information with the capabilities of artificial intelligence makes it possible, on the one hand, to know exactly what each patient needs. On the other hand, it will accelerate the discovery of new drugs and treatments.

Indeed, the answer to one of the greatest threats to the future of our health, antibiotic-resistant bacteria, may even lie in this combination of biological data and machines.

In fact, artificial intelligence, machine learning and new molecular modulation techniques are already accelerating research into new antibacterial molecules, which had remained stagnant in recent decades.

Thanks to these technologies, new antibiotics capable of keeping pathogens at bay are already being discovered, even appearing inside our own body by mining data from our proteome.

Physicians and patients with a copilot

Technological advances applied to healthcare are not limited to the exhaustive study of each patient and the discovery of new treatments. The application of therapies will also evolve to improve the life of each person and even extend it.

Experts point to the "co-pilot" model in medicine, which will reduce error rates, improve productivity and, in general, provide better and less costly care for patients. In this regard, they believe that the integration of artificial intelligence in medical care is bound to improve diagnostic accuracy, predictive analytics and patient monitoring.

Improvements in *wearables* will allow the constant measurement of multiple biological parameters of a person in a non-invasive way. All this will open the door to applications that will not only provide health advice in real time but will also help in the prevention and early detection of many pathologies.

Together, these concepts have the potential to reduce the costs associated with hyper-personalized healthcare and, therefore, to extend it to the maximum number of people worldwide.

Life extension

The amplification of public health and prevention with the GP will be key to life extension on a large scale—another expected outcome of advancements in technology and medicine.

This means a renewed focus on both individual and collective health determinants, from access to healthy food to the incidence of endemic health problems.

Precision medicine will add healthy years to our lives. This will range from designing new RNA- and CRISPR-based therapies to curing and preventing diseases, to intervening on our telomeres to make cells and organs last longer. This will be made possible by the confluence of medicine, technology and data, which is experiencing a boom and will accelerate these developments.

How will we combine health surveillance with the rights of individuals? How will society respond to a world with increasingly long-lived humans? These are the next questions we must ask ourselves.


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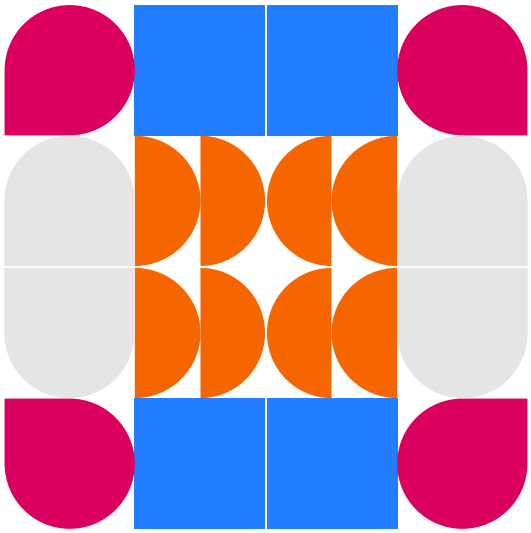

05

Educate to innovate: the future of talent

"Where do we get a million people to work on quantum technologies, if we don't start training those people now?" This is the question that came up during a webinar in which we discussed the challenges of quantum training.

Quantum computing is a good example of what awaits the talent of the future: constantly evolving disciplines in a knowledge economy that is advancing at a dizzying pace. As Megatrends 2023 has already stated, it is a question of building educational models that will be useful for today, but also for tomorrow, even if that "tomorrow" is not yet clear.

Learning to learn

Education and training are already preparing talent for what will be their main task: to innovate. A paradigm shift that will require learning new skills continuously. High-level jobs will require constant self-improvement, self-study and self-transformation to succeed.

In a future in which we will program less and less with our fingertips and more and more with natural language transmitted to a machine, it will also be more important to know what we want in order to issue the right command. And with machines progressing at a dizzying pace, lifelong learning will be essential to get the most out of them.

Experts believe that the most important skill will not be for students to learn the content itself, but to continue learning on their own. We will all need to learn how to learn because we are going to have to unlearn and relearn many things throughout our lives. To do this we will need help, and technology seems ready to provide it.

Hyper-personalized education

In this new paradigm, the application of technology to education will have a profound impact on educational pathways. They will be increasingly personalized, accessible, decentralized and from

cradle to retirement. The aim is to prepare the talent of the future to adapt to an increasingly dynamic professional career.

Artificial intelligence is already a common, personalized learning companion. For example, through adaptive platforms that adjust activities and content to each student, in addition to providing the teacher with relevant information in real time. Or intelligent tutoring systems such as Khanmigo, from Khan Academy, which guides both students and teachers in their academic work.

These are examples of how adaptive learning technologies used to personalize pathways are becoming increasingly powerful. It is only a matter of time before these advances contribute to shape the continuous, lifelong learning experience that the talent of the future will need.

Learning experiences will thus be hyper-personalized and adaptive. This means that they will be able to optimize training according to each learner's way of learning and each stage of his or her life, regardless of whether they are 5 or 95 years old.

Preservar el desarrollo del alumno

However, the impact of applying artificial intelligence to the students' analytical and comprehension capacity raises certain questions. It does so in a context in which these tools will facilitate various tasks in their development and learning that, until now, they had to solve by themselves.

It is at this point that the role of teachers will become increasingly important to stimulate the curiosity of their students and guide them effectively. Curricula and educational experiences must also be designed appropriately to preserve the development of their abilities.

On a positive note, the technology itself will free teachers' time from other tasks: they will now be able to dedicate it to increasing their interaction with students.

Ad-hoc learning and challenges

The technological impact on education and the requirements of the knowledge economy will also transform our concept of training, which will become increasingly *ad-hoc*. The immediacy of access to the exact information needed to progress in the specific area of interest will mark this evolution.

As a result, audited courses will compete more directly with traditional courses at higher education institutions. *Bootcamps* and short-term courses that teach high-demand skills to place the student directly into a job will gain increasing traction.

All this raises many questions: Will it harm our critical thinking to rely more and more on personalized algorithms? How will hyper-personalized and *ad-hoc* learning affect concepts such as humanistic reflection, debate or empathy?

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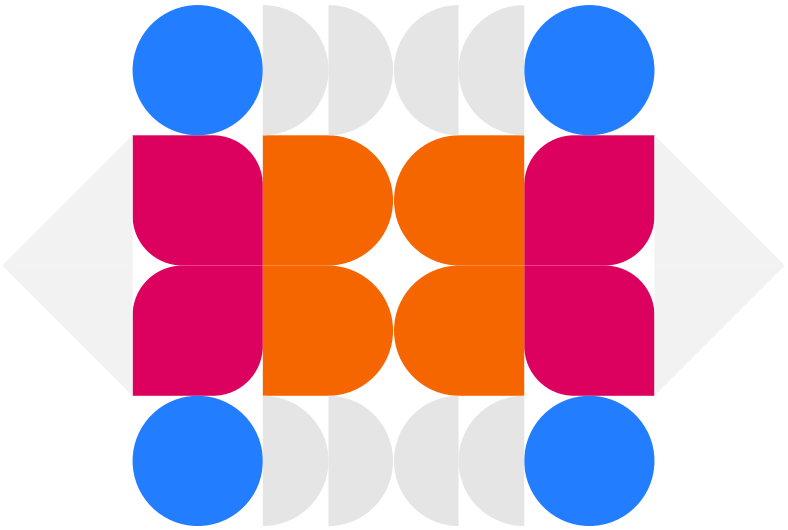

06

Connecting sustainability with today's customs

Megatrends 2023 anticipated it: the energy crisis accelerated the installation of renewable energy in an unprecedented way. 2023 data corroborate that this trend is unstoppable: around half of the electricity produced in Spain already comes from renewable sources, according to Red Eléctrica estimates.

Even though it might seem obvious that sustainability today permeates everything, the truth is that it has expanded from a sidenote in environmental protection into practically all aspects of our lives.

Renewable energies enhance environmental stewardship, but they also limit our dependence from foreign energy sources. Reducing food waste reduces the depletion of natural resources and makes a dent in feeding a growing world population. Buying a more efficient appliance contributes to combat the greenhouse effect, and also saves us some money on your electricity bill.

Today, concepts such as the circular economy help us build a better world. Connecting sustainability with today's customs is the great underlying trend. It is the one that will give us the answer to the big question: do we really have to choose between competitiveness and sustainability?

The redemption of technology

Technology was the great enabler of the industrial revolution and, with it, of the rampant increase in anthropogenic, polluting emissions that drive climate change and its consequences. It brought us an era of unprecedented economic and social progress, but it also posed serious challenges to our relationship with the planet.

Today, technology is also the great hope on which we rely not only to mitigate environmental impact, but also to respond to other challenges. For example, feeding a growing population or conserving water resources.

The development of nuclear fusion makes us dream of a future in which it will not be necessary to consume resources or pollute the atmosphere to obtain energy. Artificial intelligence-assisted robotic harvesting, which already prevents fruit from rotting on the tree, helps us meet the food challenge ahead.

Redefining competitiveness

However, this redemption of technology will not be possible without profound cultural changes. Starting with the redefinition of the concept of competitiveness.

We have already said that it will not be enough to measure competitiveness in euros, but also in terms of other key dimensions, such as land and water use, carbon emissions or social sustainability. Especially if the goal is to decarbonize the economy and conserve resources.

Resource awareness

These cultural changes are already upon us. Today we are witnessing a paradigm shift towards a more conscious use of resources and environmental stewardship.

Technology can support us in this endeavor and a good example can be found in its application to water management. We have already talked about the development of low-cost filtration and purification systems, together with improvements in rainwater harvesting and desalination efficiency.

Optimization of the urban and industrial water cycle is one of the main trends in this regard. Advanced wastewater treatment systems or recycled water technology to minimize the use of fresh water are just two examples of the progress being made in the reuse of this essential resource. Our own homes will contribute to water conservation without us even realizing it.

The key to success lies in the connection between sustainability and our daily lives. From our very core, it must extend to all aspects of our lives in order to tackle the great challenges that lie ahead..

Facing the risks

This environment is not without risks, experts point out. For example, a lower environmental footprint may end up increasing production costs and, therefore, limiting consumer acceptance of sustainable products and services.

There is also the risk that cheaper energy will lead to the emergence of cases that are not profitable today, which will end up increasing the demand for energy once again. This already happened in the Industrial Revolution with gas lighting; who could have imagined before that it would be possible to light every street in a city?

Tackling these obstacles may involve greater coordination, ensuring that both interests and efforts are aligned to develop a sustainable future. The answer may lie in supranational frameworks or bodies that have yet to be created.

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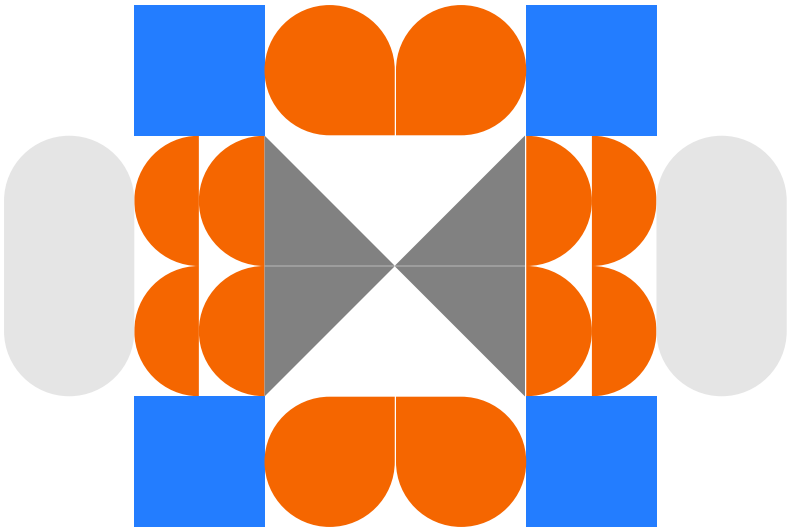

07

Researching space to improve the Earth

Who has ever dreamed of living on another planet? The writer Olaf Stapledon was already dreaming big in 1930. In *The Last and the First Humanity*, he imagined that our species would move to Venus in the face of Earth's depletion. In his novel, we would spend more time as Venusians than as Earthlings. Today, the commercialization of space is paving the way to becoming a multi-planetary species one day.

While Perseverance explores the atmosphere of Mars, the first private space mission has already reached the Moon. The powerful and efficient ion engine developed between Aerojet Rocketdyne and NASA will be key, according to the agency, to "the exploration of the Moon and beyond". Airbus Ventures is already preparing another nuclear engine to take us to Mars in 10 years in half the time.

These are the first steps that may eventually lead us to expand beyond our planet. Until that goal is reached, a large number of innovations developed to reach Mars, find life on other planets or colonize the moon may improve life on Earth.

From efficient and powerful propulsion technologies to space laboratories or omics data processing, many answers to terrestrial challenges will come from the conquest of space.

Healthy microgravity

"Will we curb disease thanks to a space laboratory?" This is one of the questions posed by Megatrends 2023. Private companies and large agencies are already developing their experiments in microgravity inside the International Space Station to find answers that will improve our health and that of the astronauts.

In March 2023, SpacePharma took a microgravity laboratory to the International Space Station to grow human skin cells and eventually initiate the development of new therapies. In January 2024, an Axiom Space spacecraft departed for the International Space Station on a mission to conduct stem cell and tumor organoid research.

This type of mission is another step on the road to the private use of the ISS. In addition to bringing advances in biomedicine with the potential to save lives, it will contribute to the development of microgravity research in low-Earth orbit.

A productive union

This precise intersection between space exploration and its terrestrial applications is driving the space market, which is taking off at the hands of the private sector. To a large extent, it will do so thanks to economies of scale, reusability, artificial intelligence-assisted spacecraft technology and operational improvements, experts believe.

All this technological development required by space exploration is already translating into important advances for our daily lives. Space technology gives us access to better and cheaper communications thanks to the use of satellites. It also helps us to learn more about our own planet and to advance on our path to sustainability.

In Spain, satellites already enable high-speed internet connection anywhere in the country. Startups like NUVIEW use LiDAR sensors to make three-dimensional maps of entire countries in a few days at a fraction of the cost of 15 years ago.

The combination of big data and artificial intelligence techniques is already leveraging the information that comes to us from the satellites that observe us. We have talked about projects that analyze images taken from space to estimate the carbon emissions of each country and find out whether or not they are complying with their duties. Or so that farmers can identify crops under water stress before the first signs are even noticed.

Traffic jams in space

The trails of satellites that SpaceX launches from time to time are a spectacle that we can enjoy with the naked eye. They also raise questions: Are we sending too many satellites up there? Will we end up causing traffic jams in space?

Whether or not the universe is infinite is a dilemma that arouses enthusiastic debate. But one thing is certain: the space where we send communication and observation satellites is. Earth-connected tools must be kept at a certain distance and their space allocation will need to be more strictly regulated, experts say.

Space debris is also a worrying reality that can seriously hinder the launching of rockets and satellites. It is possible that, just as there are space logistics companies, there will soon be cleanup initiatives to dispose of all the scrap that can no longer be used.

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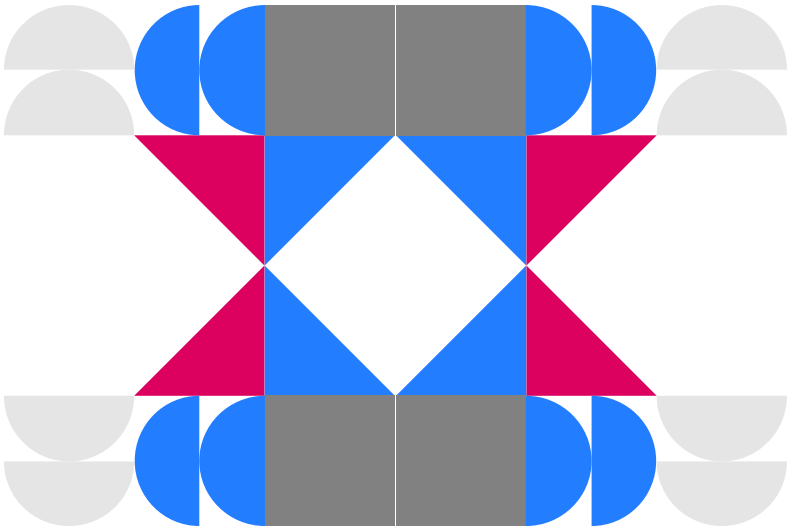

08

Neuroscience and neurotechnology to learn more about the brain

Choosing the most influential Spanish person in history is a complicated task. However, Santiago Ramón y Cajal should not be missing from any list of aspirants to that throne. In the 19th century, the father of neuroscience paved the way to understanding the most complex and unknown human organ there is: our brain.

Since then, the development of neuroscience has led to an ever-increasing understanding of the brain. This understanding, in turn, has enabled the development of solutions that today allow us to improve health, well-being and human performance from different medical and technological perspectives.

Brain-machine interfaces are already a fundamental part of these solutions aimed at improving our lives. So is the use of neurotechnology to treat neurological diseases such as Parkinson's disease or epilepsy.

From therapeutics...

As with other spearheading and innovative efforts, it is the improvement of people's health that drives advances in neuroscience and neurotechnology. They are two sides of the same coin, as António Damásio described at the Future Trends Forum on Neurotechnology for Human Wellbeing.

At the moment, brain-machine interfaces are already enabling people with a speech related disability to communicate by means of digital avatars. These avatars not only transmit words based on the brainwaves of the user, but also other nuances such as emphasis in speech or their own tone of voice.

Brain-machine interfaces also improve episodic memory in Alzheimer's patients. In this case, a solution proposed by Ana Maiques' Spanish startup Neuroelectrics facilitates the neuromodulation in users with non-invasive techniques, from their own home and in a safe manner.

Brain implants are also already changing people's lives. This technology has already proven its efficacy to control epileptic episodes and compulsive behaviors due to OCD.

...to everyday life

The evolution of these advances will lead us to increase our human capabilities beyond therapeutics. Today's support to treat neurodegenerative diseases will lead eventually to a new era of human-machine interaction and human-machine-human interaction, i.e., connected by computers.

As Megatrends 2023 forecasted, the evolution of brain-machine interfaces will allow our nervous system to connect with all kinds of external intelligence and technology. As connection techniques become less invasive—an area where progress is well under way—experts expect them to gradually open up to the rest of society, beyond their therapeutic use.

The use of neurotechnology to improve the memory of people with cognitive problems is the first step towards a future in which we will be able to expand our memory in the same way we use a card to extend the memory of our smartphones. It will be a matter of merely connecting our brain to a cloud or a virtual assistant to achieve this immediately.

Another possible evolution extends to augmented intelligence, where our brain would connect with others, just like in a beehive, to increase our capabilities.

Risks and opportunities

These advances will lead us to increase our human capabilities beyond therapeutics and will put the spotlight on risks and opportunities that we must begin to address now.

Such advances open the door to a revolution not only in our interaction with technology, but also in our interaction with other humans mediated by machines. Aspects such as cybersecurity and ethics will reach new dimensions as knowledge of our brains and bodies evolves.


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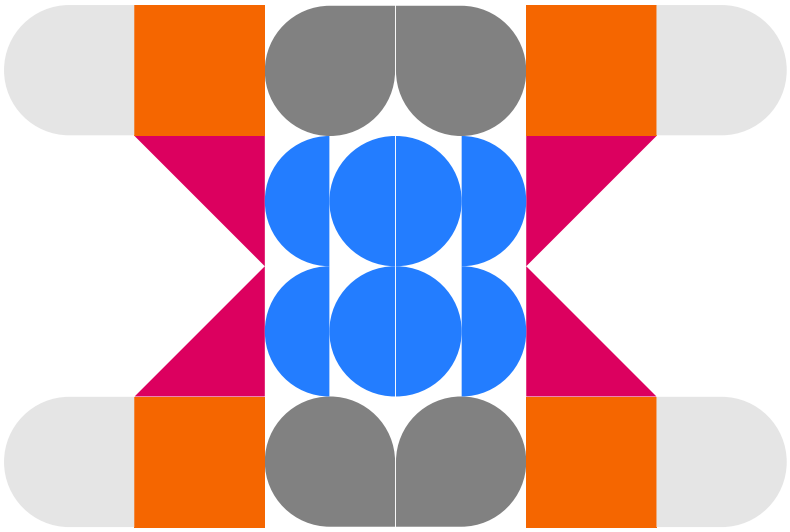

09

Digital security in transformation

On New Year's Eve 1999, many people held their breath. Following the countdown, and after realizing that neither the nuclear weapons had gone off on their own nor the ATMs had gone haywire, they breathed a sigh of relief. Many even doubted that the famous Y2K bug that had been so much talked about was real.

What happened was that thousands of people around the world had worked tirelessly before that New Year's Eve. System analysts, programmers and other IT professionals racked their brains to make the machines digest the change of digits from 1999 to 2000.

Y2K was a real threat that was defused through hard work before it could occur. That anticipation is what experts are now calling for. Action must be taken before a quantum computer is used to break current encryption systems.

A race between good and bad

History teaches us that security has always been a race between good and evil players. Practically the day after the safe was invented, someone was already looking for a way to crack it. Digital security is no exception.

Cybersecurity is one of the requirements that brings with it the increased connection of people and devices, as Megatrends 2023 reminded us. Major advances in this area often bring with them equally broad developments in hacking techniques and digital crime.

A good example is the use of artificial intelligence in IT security, one of the big trends we will see in the coming times. The scale, speed and sophistication of cyberattacks increased in 2023 at the same pace as the development of this technology. However, it is also already being used by national security agencies to detect and prevent them.

In the case of biometrics, it allows people to be identified securely and accurately through facial recognition or fingerprinting. However, generative artificial intelligence and biometric capture can be used to easily create *deepfakes* that could fool standard security protocols. Reinforcing them with multifactor and/or proof-of-life systems is already essential, as will be anticipating the next threat.

The quantum horizon

Other pioneering cybersecurity areas are *blockchain*, which has revolutionized the way we store and share data, or IoT, due to the vulnerability of connected devices. All of them pose challenges, but also steps forward in the task of securing our connections and our identity.

The next big stage in the race between guardians and criminals is already on the horizon. As soon as quantum computers become sufficiently robust and accessible, they will immediately threaten standard cryptographic security protocols and, at the same time, enable new and more robust forms of encryption.

That threat is a real problem: cryptographic robustness is the basis of information integrity in *blockchain*. Also, the metaverse depends on the ability to carry out transactions and identify people securely, as Megatrends 2023 exposed. And this, in turn, depends on reliable encryption.

In this environment, quantum cryptography is emerging as one of the major trends in cybersecurity. This discipline has already begun to take its first steps towards offering greater security than that provided by current encryption systems.

In fact, there is already talk of how to prepare for post-quantum cryptography. That is, the one that will be necessary at the very moment when a sufficiently stable and powerful quantum computer can break the RSA-2048 cipher. If and when that happens.

Back to physical security

Faced with a scenario of quantum advantage, scenarios are already being envisaged in which software will no longer be able to protect us and we will have to return to physical security. In these scenarios, hardware and physical security layers will become increasingly robust and necessary.

Authentication through inimitable physical functions and unique identifiers would then become the norm. Although post-quantum algorithms will continue to evolve, a paradigm shift toward full quantum physical security should not be ruled out.

In any case, experts are calling for the security of the 2030s to be practiced today. It is a matter of ensuring that the major threats of the future remain just a chill, as was the case on New Year's Eve 1999.


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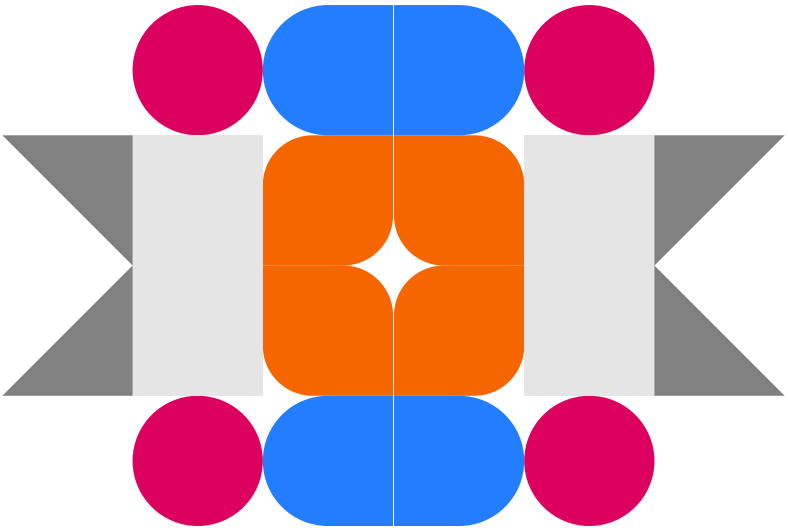

10

From classical to hybrid computing

The Apollo 11 mission reached the Moon thanks to a computer that guided it. Without it, the astronauts would not have been able to perform the calculations necessary to make adjustments during the flight. They would not have been able to land on the moon because they would not have been able to control the spacecraft without this artificial brain.

It is often said that today's *smartphone* is more powerful than the computer that traveled on Apollo 11. However, the Apollo Guidance Control (AGC) was a watershed moment in the use of technologies that are today as essential, such as chips.

Today's AGCs are called Mare Nostrum, Condor or Loihi. They are the names of a supercomputer, a quantum computer and a neuromorphic chip. Devices that are based on different computing paradigms and are called to help us take the next big step for humanity.

Towards hybrid computing

Computing is advancing at a rapid pace and under different approaches. Advances in classical, quantum, neuromorphic or photonic computation are not destined to compete with or replace each other.

On the contrary: the different forms of computing will collaborate with each other. They will do so in hybrid systems capable of taking advantage of their strengths. The key, as Daniel Granados says, will be the transducers that will interconnect all the technologies involved.

The convergence between the different branches of computation will depend on these interpreters. And, from this, the development of an efficient and sustainable artificial intelligence or the simulation of the physicochemical properties of proteins.

Productive advances

Before such collaboration is achieved, each of the computational paradigms will follow its own path. They will do so with advances that will help us solve multiple challenges. Thus, the next breakthroughs in digital twins will come from the collaboration between supercomputing and artificial intelligence.

These technologies will enable building digital twins of cities that will stir a revolution in urban planning, as well as replicas of our bodies to accurately predict disease risk, test drugs and therapies, or generate tailored lifestyle changes. The development of virtual replicas of the planet will help us predict the effects of climate change and search for answers. Scientists and technicians are already looking for ways to achieve this thanks to Mare Nostrum, the supercomputer at the Barcelona Supercomputing Center.

Maximum efficiency

Beyond classical computing, new computing paradigms are called upon to help us decipher the undecipherable in an efficient and planet-friendly manner.

The search for maximum efficiency involves different approaches. Mimicking the functioning of the human brain is the neuromorphic computing approach. Using photons instead of electrons is photonics.

We have already explained how Intel uses its Loihi neuromorphic chip to experiment with autonomous learning systems, such as traffic pattern optimization and advanced robotic control. IBM uses its own, TrueNorth, in applications such as detecting patterns in health data and processing sensor data in real time.

Advances in photonic computing will also contribute to develop faster and more efficient machine learning. The goal: to overcome the physical limits posed by Moore's Law.

The quantum future

IBM has already set a date for its first quantum hardware capable of correcting its own errors. It will be in 2029, according to the company's roadmap.

If it succeeds, it will have unlocked the main challenge for this technology to develop its full potential and take all kinds of fields to a new dimension. Medicine, industry, finance or neuroscience will never be the same again when quantum computing really enters the scene.

Pending commercial viability, progress in this paradigm goes beyond computing itself. Quantum communications and sensors are advancing, foreshadowing future applications in a variety of sectors. The latter will replace GPS where it cannot be used or improve the sensitivity of magnetic resonance imaging.

For their part, the new quantum materials will help overcome some of the more complicated challenges of quantum computing, such as the stable storage and manipulation of cubits.

Will we have systems capable of harnessing the virtues of all computations? What will the combination of quantum computing and artificial intelligence entail? The influence of these developments on innovation and society, together with their ethical implications, merit in-depth analysis.

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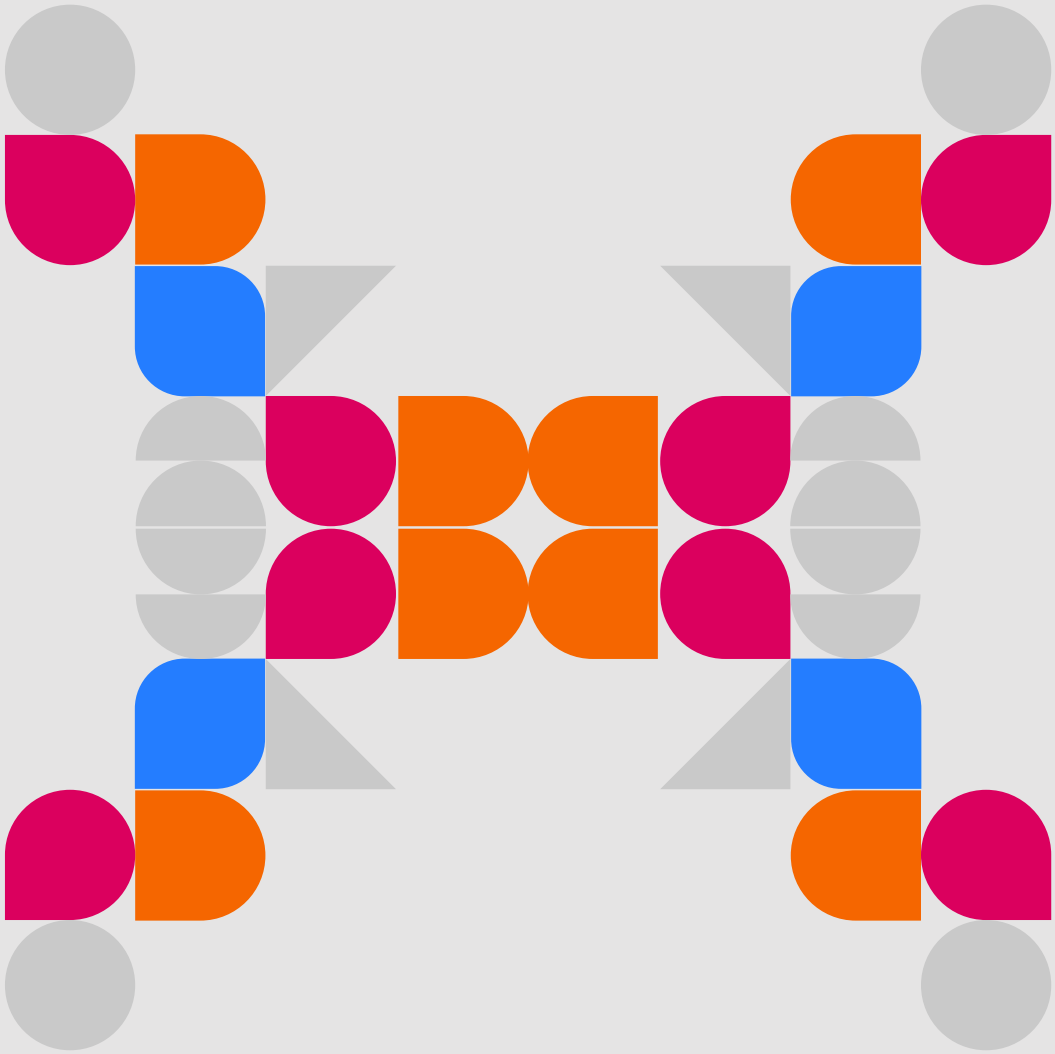

Editorial

2024

On the verge of the future

As stated by Megatrends, 2023 was the year to ground expectations. To test whether, indeed, precision medicine, space commercialization or virtual worlds would be able to gain traction with significant breakthroughs.

Well, it was the year: CRISPR gene-editing tools can now be used in Europe to cure diseases, and private operations in the International Space Station are already facilitating the discovery of new therapies. Meanwhile, a commercial Apple device immerses us in our own family recordings to take us back to our childhood.

The milestones in innovation and their real-world applications keep coming and coming. This places 2024 as a decisive threshold on the way towards a future in which innovation will shape our lives.

It will be in that future when a virtual twin of our body, which is taking shape today in a supercomputer in Barcelona, will become our best ally to preserve our health, along with precision medicine that will help us add healthy years to our lives. At the time, we may also connect our brain to a cloud to remember the title of a song that escapes us. This is the vision we share at the Bankinter Innovation Foundation with our Future Trends Forum experts.

In education, learning experiences will be increasingly personalized, adaptable to the learner and their needs at any given moment. Space will give us an answer to some of our big questions, and people will increasingly be at the center of increasingly wiser cities.

Vertical artificial intelligence will accelerate innovation in multiple fields and industries. Meanwhile, sustainability will increasingly pervade our day to day. Cybersecurity will move towards a post-quantum reality and mixed reality will be our gateway to new worlds.

That future is already being built in a rapid succession of discoveries and breakthroughs. Each technological ceiling becomes the foundation for the next innovation. Each milestone we reach in science is prologue to the next. Such is the road we have traveled for millennia to push our frontiers, and such will be the road ahead.

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2024

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